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UNIVERSITY OF NOVI SAD
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# *Foreword*

*Dear Readers,*

*It is my great honor and pleasure to present to you the proceedings of the First International Conference FUTURE-BME 2024 (Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges). This conference is dedicated to current issues in business, management and economics engineering, through an interdisciplinary approach. A large number of papers and authors from different countries around the world speak of the importance of the topics to which the conference is dedicated.*

*I express my sincere gratitude to all the authors who contributed to this conference with their research papers. Your contribution is crucial for the FUTURE-BME conference, while the results of your research are of great importance for the scientific and professional community. I also express my special gratitude to all the institutions that helped in various ways to make the FUTURE-BME conference possible, including The Institute for Artificial Intelligence, Graz University of Technology, Swiss School of Business and Management Geneva, Production and Management Faculty Trebinje, University of East Sarajevo, as well as our sponsors, NIS a.d. Novi Sad, APTIV, Ling Mobility Solutions, Montop, Avene consulting, and friends of the conference: Colas, RICO Training Centre, and Vinarija Veritas. We are very grateful for the help provided by the Ministry of Science, Technological Development and Innovation, the Provincial Secretariat for Higher Education and Scientific Research, as well as to the projects that supported us.*

*The proceedings of the FUTURE-BME conference will be published every two years (biennially).*

*Editor*

# INVITED LECTURES

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-001 Invited lecture

# INSIGHTS INTO SUSTAINABILITY INTEGRATION AND TOP PRIORITIES FOR GREEN AND DIGITAL TRANSITION IN LOGISTICS

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***Abstract***

*This paper explores the findings from a survey conducted among 615 logistics companies in Slovenia, investigating the priority areas for employee training in the logistics sector. The study focuses on two critical areas: digital skills and the green transition. The goal is to identify the specific skills logistics companies require to adapt to digital transformation and sustainability challenges. The research highlights priority areas of automation, artificial intelligence, circular economy and sustainable energy self-sufficiency to ensure competitiveness in business logistics. Furthermore, the paper emphasises the importance of lifelong learning and upskilling initiatives in bridging existing skills gaps and equipping employees with the necessary tools to meet technological advancements and environmental sustainability goals.*

***Key words:*** *green transition, digital skills, logistics priorities, supply chain management.*

## 1. Introduction

The logistics industry faces unprecedented challenges, with technological advancements and sustainability imperatives reshaping business operations. The evolving demands require a well-trained workforce to manage digital transformation and green practices. Logistics companies must prioritise equipping their employees with digital competencies and green transition skills to stay competitive.

Digital transformation is reshaping the logistics industry. The growing use of automation, artificial intelligence (AI), and robotisation requires employees to develop new competencies that enhance operational efficiency and streamline supply chain activities. According to a recent survey, 72 % of logistics companies have prioritised digitising business processes, and 58 % focus on automation

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(Kemper et al., 2020). This trend emphasises the need for logistics professionals to develop skills in data management, digital workflows, and the application of advanced technologies. As Benton-Short and Merrigan (2016) have shown, sustainability education creates opportunities for interdisciplinary efforts across sectors, which is particularly important in logistics, where environmental issues and digital innovation are interdependent.

However, a significant skills gap exists, particularly among decision-makers who completed their formal education over a decade ago. These individuals may not have had adequate exposure to the latest technological developments, making it difficult to adapt to the rapidly changing logistics landscape. Lifelong learning programs help employees keep up with technological advancements and effectively implement digital tools in their daily operations (Wamsler, 2020). Training in digital competencies must focus on the following (Hofmann & Strietska-Ilina, 2013):

- Data management and analytics: ensuring employees can interpret and act on real-time supply chain data.
- AI and machine learning: developing skills in automation tools to enhance decision-making processes.
- Digital process optimisation: streamlining workflows to improve efficiency and reduce costs.
- These skills and priority focus are critical for competitiveness in an increasingly reliant digital technology industry.

The environmental impact of logistics is significant, with the sector accounting for 24 % of global CO2 emissions, a figure expected to rise to 40 % by 2050 if no substantial changes are made (Glavič, 2006). As a result, green logistics practices are becoming a priority, with 59 % of companies indicating the need to adopt circular economy models and 55 % emphasising sustainable energy solutions (Priyadarshini & Abhilash, 2020). Training in green skills should also focus on eco-friendly practices such as renewable energy adoption, route optimization, collaboration in supply chains, and reverse logistics, which are essential for minimizing waste and reducing emissions (Copperdigital, 2022). Additionally, collaborative efforts between stakeholders within the supply chain can promote shared resources and innovative sustainable solutions (Adecco Group, 2022).

Training programs focused on green logistics should equip employees with the knowledge and skills to implement sustainable practices across the supply chain. This includes (Valderrama-Hernández et al., 2019):

- Circular economy practices: minimising waste and promoting the reuse and recycling of materials.
- Energy efficiency: reducing the carbon footprint of logistics operations by optimising energy use and integrating renewable energy sources.
- Resilience to environmental disruptions: preparing for climate-related challenges and mitigating the risks of natural disasters.

These skills are essential for companies aligning with global sustainability goals, including the European Union's Green Deal, which aims to achieve climate neutrality by 2050 (Valderrama-Hernández et al., 2019). In addition, training in

green skills helps logistics companies reduce their environmental impact and enhance their reputation in an increasingly eco-conscious market (Global Opportunity Forum, 2023).

As the logistics industry continues to evolve, lifelong learning plays a crucial role in ensuring employees can adapt to the demands of both digitalisation and sustainability. According to SDG 4 of the United Nations Sustainable Development Goals (SDGs), education must promote sustainability across industries, and logistics is no exception (United Nations, 2015). Lifelong learning programs ensure that logistics professionals are equipped to manage digital transformation and green logistics efforts (Hofmann & Strietska-Ilina, 2013). These programs must focus on (United Nations, 2015):

- Continuous upskilling: providing employees with ongoing opportunities to learn new technologies and sustainability practices.
- Cross-disciplinary education: encouraging collaboration between digital and sustainability experts to develop integrated solutions for logistics challenges.
- Leadership training: ensuring decision-makers can lead their companies through the digital and green transitions.

Kopnina (2020) advocates for a broader approach to education that incorporates ecocentric frameworks and degrowth models. These models encourage companies to align their operations with global sustainability goals and adopt practices that respect planetary limits. Training employees in these alternative frameworks can help logistics companies take meaningful action toward sustainability.

### 1.1 Methodology

This study is based on a mixed-method approach, incorporating quantitative data from a survey conducted among 615 logistics companies in Slovenia. The study aimed to identify the priority areas for employee training, focusing on digital skills and the green transition. Additionally, a comparative analysis of relevant literature and case studies was conducted to assess current best practices in logistics training.

The survey was designed to collect data on digitalisation needs (including automation, AI, and process digitisation) and green transition requirements (focusing on sustainability, circular economy practices, and energy efficiency). Respondents included a diverse mix of size and industry companies, with key representatives such as logistics managers, supply chain leaders, and HR professionals participating in Slovenia. The survey sample covered small to large enterprises, ensuring that findings would apply across various business contexts.

The questionnaire consisted of two sections; the first section focused on digital skills, with questions related to the importance of AI, robotics, data management, and automation in logistics. The second section focused on the green transition, asking respondents about their focus on circular economy practices, sustainable energy solutions, and the impact of environmental sustainability on their operations. Participants were asked to rate the importance of each skill or

training on a Likert scale from 1 (not important) to 5 (very important), with an additional section for qualitative comments.

## 2. Results

Based on the responses collected from the survey, two key graphs were created to highlight the priority areas for training in digital skills and green logistics. The data from the survey has been essential in identifying the areas where companies need to focus their training efforts, and the graphs provide a clear visualisation of these findings. By examining these trends, we can better understand the evolving demands in logistics and the growing need for digital and sustainable practices within the sector.

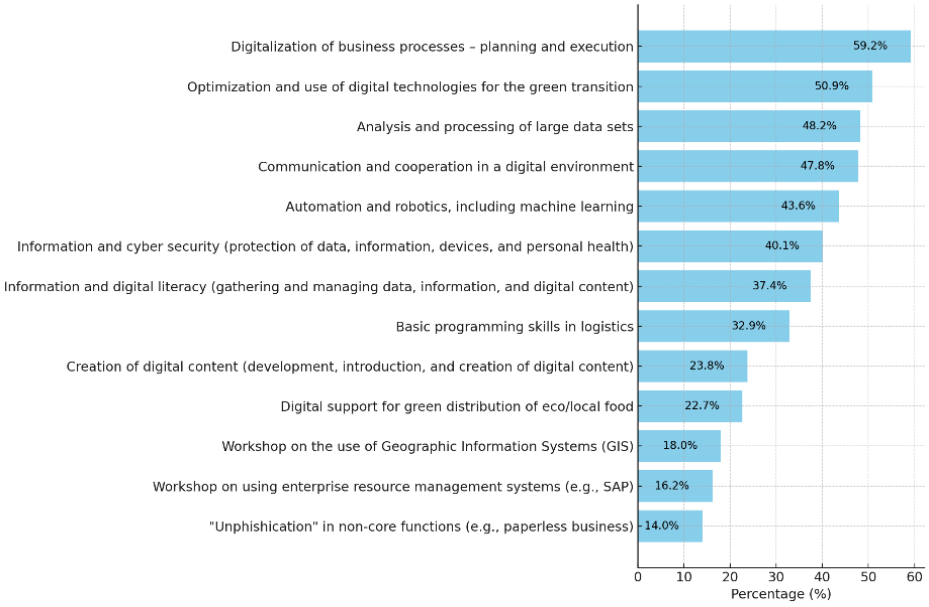


*Figure 1: Necessary skills in the field of digitalisation according to the Slovenian logistics and production sector (economy)*

The first graph highlights the emphasis companies place on digital transformation in logistics. Notably, 72 % of surveyed companies indicated that digitising business processes is a critical priority, demonstrating a significant shift toward automated, technology-driven systems. This transition reflects the increasing use of digital tools to enhance supply chain operations, reduce manual processes, and improve decision-making through real-time data analytics and the application of AI.

The graph also reveals that 58 % of companies prioritise automation within their supply chains. The result indicates a growing reliance on robotic process automation (RPA), AI-driven solutions, and machine learning to streamline

repetitive tasks and increase efficiency. The focus on automation highlights the industry's commitment to improving productivity and minimising human error through advanced technologies.

In addition, 54 % of companies emphasise the need to reduce transportation costs through digital solutions. That can be achieved by adopting AI-based route optimisation tools and transport management systems (TMS), which enable real-time tracking and efficient resource allocation to optimise logistics processes.

Interestingly, 48 % of companies indicated a focus on aligning digital transformation with sustainability initiatives. Recognising digital tools' role in reducing emissions and optimising energy use, such as using digital platforms to minimise fuel consumption in transport operations, is therefore important.

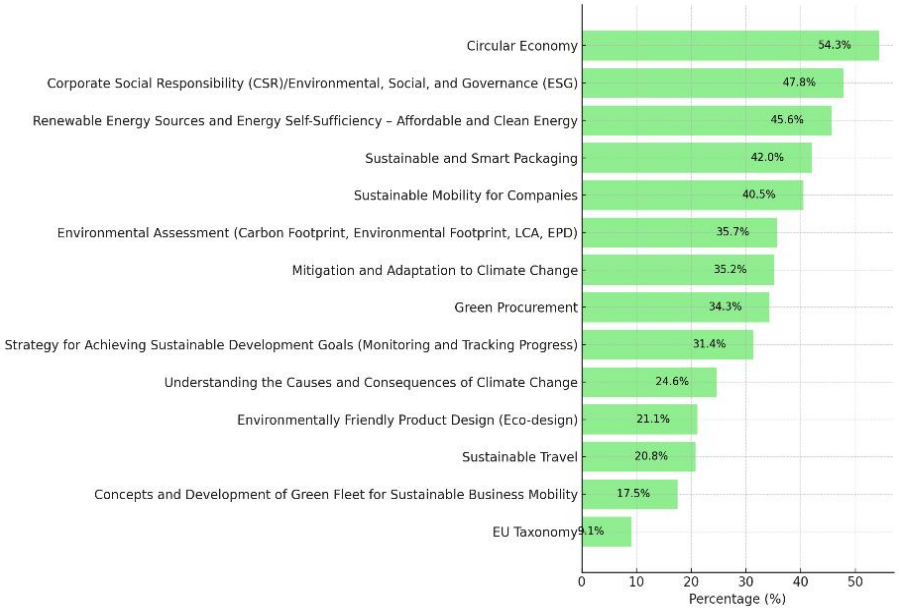


*Figure 2: Necessary skills in the field of green transition according to the Slovenian logistics and production sector (economy)*

The second graph illustrates the growing importance of green transition priorities within logistics, with 59 % of companies identifying circular economy practices as top priorities. Results demonstrate a strong commitment to reducing waste, enhancing resource efficiency, and promoting the reuse of materials within the supply chain.

Moreover, 55 % of respondents emphasised sustainable energy solutions as a priority area for training. So, logistics operations need energy optimisation, with companies increasingly adopting renewable energy sources and energy-saving technologies to reduce their carbon footprint.

53 % of companies also focused on building resilience to natural disasters, reflecting an understanding of the potential risks climate change poses to logistics

operations. Training in risk management and supply chain resilience is critical for companies as they seek to adapt to increasingly unpredictable environmental conditions.

In addition, 47 % of respondents prioritised sustainable mobility, focusing on reducing the carbon emissions of transportation fleets. Those actions involve training employees in using electric vehicles, alternative fuels, and green logistics infrastructure to support more environmentally friendly transportation solutions.

## 3. Discussion

The findings from the survey provide valuable insights into the current priorities of logistics companies, particularly in terms of green and digital skills. These results align with the broader theoretical frameworks that emphasise the increasing importance of technological advancements and sustainability in logistics operations.

As indicated by 72 % of companies, the strong focus on digitising business processes highlights the industry's shift towards integrating advanced digital tools and technologies, consistent with the theoretical discussion of AI and automation in logistics (Bell et al. 2020; Kemper et al., 2020). The theory suggests that AI-driven decision-making and robotic process automation (RPA) can enhance efficiency and reduce human error, reflected in the findings that 58 % of companies prioritise automation in their operations.

The emphasis on real-time data management and AI-based route optimisation tools also ties back to the theoretical discussions on the transformative impact of data analytics and machine learning in optimising supply chain operations (Wamsler, 2020). The theory indicates that the logistics sector's reliance on these technologies will only increase as companies seek to streamline processes and improve decision-making capabilities, supported by 54 % of companies focusing on reducing transportation costs through digital solutions.

Moreover, the finding that 48 % of companies are integrating sustainability into their digital transformation efforts reflects the theoretical argument that digital tools can serve a dual purpose: enhancing operational efficiency while reducing environmental impact. The connection between digital transformation and sustainability practices, as discussed in the theory (Glavič, 2006), is evident here, where companies increasingly leverage digital tools to track and optimise their carbon emissions and energy use.

The survey findings strongly support the theoretical emphasis on green logistics—particularly the integration of circular economy practices and sustainable energy solutions. The 59 % of companies prioritising circular economy practices reflect the theory's call for logistics to adopt sustainable models that reduce waste and enhance resource efficiency (Valderrama-Hernández et al., 2019). The findings align with the concept that logistics operations must transition towards more sustainable practices to meet global sustainability goals such as the European Green Deal.

The fact that 55 % of companies prioritise sustainable energy solutions further supports the theoretical argument that the logistics sector must focus on reducing its environmental footprint through energy-efficient technologies and adopting renewable energy sources (Priyadarshini & Abhilash, 2020). As the theory discusses, companies must train their employees to manage energy-saving technologies and adopt renewable solutions like solar-powered logistics facilities and battery storage systems, which are essential for reducing the sector's carbon emissions.

Furthermore, the theory highlights the importance of building resilience to environmental risks, which is directly supported by the 53 % of companies focusing on training in resilience to natural disasters. This finding reflects the industry's recognition of the risks posed by climate change and aligns with theoretical discussions on the need for supply chain resilience and disaster preparedness (Kopnina, 2020). As the frequency of extreme weather events increases, logistics companies are acknowledging the importance of preparing their workforce to handle disruptions caused by these environmental challenges.

The focus on sustainable mobility, with 47 % of companies prioritising this area, is closely linked to the theoretical framework around green logistics and carbon emissions reduction (Daub et al., 2020). The theory discusses the proposed adoption of electric vehicles, alternative fuels, and green logistics infrastructure, which is reflected in the priorities expressed by the surveyed companies, highlighting the logistics industry's broader commitment to reducing the environmental impact of its transportation fleets.

The survey findings reinforce the theoretical discussion on the role of lifelong learning and upskilling as key strategies for addressing the skills gap. Both digital transformation and the green transition require continuous employee development, as outlined in the theory (Wamsler, 2020). Companies must ensure that employees are trained in the latest digital tools and equipped with the knowledge to implement sustainable practices, as the findings indicate that companies are prioritising training in both areas.

The need for cross-disciplinary education, as discussed in the theory, is particularly relevant here. The survey results show that logistics companies increasingly recognise the importance of integrating digital and green skills into their training programs, a reflection of the broader industry shift towards sustainability-driven digital solutions (Brudermann et al., 2019). The theoretical framework around ecocentric learning and holistic educational models ties into the industry's recognition that technological and sustainability goals must be addressed simultaneously.

## 4. Conclusions

The findings from this study highlight the critical importance of green and digital skills for the future of the logistics sector. The survey conducted among 615 logistics companies in Slovenia underscores that companies are prioritising the digitisation of business processes, with automation and AI-driven solutions

emerging as key areas for operational efficiency. At the same time, the growing emphasis on sustainability – evidenced by the focus on circular economy practices and sustainable energy solutions – reflects the sector's need to address environmental challenges in line with global sustainability goals.

However, the results also reveal significant challenges in implementing these priorities focused skill training. The persistent skills gap requires urgent attention (especially among decision-makers and employees who may not have had exposure to modern technologies and sustainability practices.) Companies must invest in comprehensive training programs that combine digital skills and green transition knowledge to ensure that their workforce is prepared for the rapidly evolving demands of the logistics industry.

The study highlights the need for lifelong learning initiatives to bridge this gap and facilitate continuous employee development. Such programs will enable companies to remain competitive by equipping their workforce with the necessary tools to navigate technological advancements and sustainability challenges. Integrating cross-disciplinary training that address digital transformation and sustainability practices will be essential for future of logistics companies.

In conclusion, the logistics industry is at a pivotal moment, with the dual priorities of digitalisation and sustainability shaping the future of employee training. Companies that proactively invest in upskilling their workforce in these areas will enhance their operational efficiency and contribute to the broader goal of achieving a sustainable and digitally optimised supply chain.

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# THE INTEGRATED QUALITY MANAGEMENT SYSTEM IN FUNCTION OF ENVIRONMENTAL PROTECTION: MONTENEGRO AS A CASE STUDY

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***Abstract***

*The paper was created with the main target of environmental protection through the quality improvement and establishing an optimal approach for the integration of few quality management systems. Subject under consideration is a very important natural area in Montenegro, with all available resources and the existing organizational structure. The data base for analysis, from where experimental data arise, comes from 28 firm in area of Lake Skadar, as well as from general organisational structure of National parks in Montenegro. In this paper, methods of expert analysis and multicriteria decision tools are applied in order to finding optimal approach to integration, defining areas and measures for improvement in function of integrated environmental protection. The paper also analyses the world experiences in the application of integrated quality management systems, as well as other management systems, and on the basis of the mentioned methodology, an original approach for implementation and improvement environmental protection for the considered subject, and similar world areas, has been established.*

***Key words:*** *Integrated quality management systems; Resurs; Environment protection; Multicriteria decision.*

## 1. Introduction

This paper deals with the possibilities of developing an integrated quality management system at one of the most important area in Montenegro and in the function of generating profits for a wider range of stakeholders. Namely, the complex systems and natural resources that Lake Skadar area in Montenegro has at their disposal, represent an excellent basis for analyzing the possibilities of

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implementing an integrated management system, which leads to a model of overall performance and process management in order to continuously monitor performance indicators, continuous system upgrading and improvement from the aspect not only tourist, but also any other economic and socio-economic valorization of this area. In that direction, the best world experiences in the implementation of integrated systems were considered, with the aim of identifying the optimal conditions for valorisation and systematic management of natural resources and potentials of mentioned area.

In this sense, there are examples that many municipalities or cities implement and certify integrated management systems. For example, in the Montenegro neighbourhood, according to the requirements of the QMS were certified municipalities of Novi Beograd, Vračar and others. More broadly, examples are the city of Pula in Croatia or the city of Vienna in Austria that have a certified integrated management system. Precisely, in this paper we want to point out the contemporary approaches, advantages and disadvantages of implementation of integrated systems, with the aim of improving the management of natural resources, based on systemic approach in order to create a system of measurable perfomances, that is, systematic and continuous improvement.

The importance and necessity of establishing an integrated lake basin management system, due to identified problems of pollution, erosion, endangered flora and fauna and others, has been recognized on the example of Lake Toba in Indonesia, primarily through the activities of establishing educational centers, and better communication of the administration at the local and state level (Saragih, Sunito, 2001). The integrated quality management system, also contributed to better control of water pollution, reduction of costs and efficiency of water resources use, for example, in Ingjing Lake in China (Zheng, Jiao, Zhang, Sun, 2017). Additionally, integrated management systems must also have processes related to cost management and risk analysis, as well as to use modern information and communication technology for efficient resource management (Arabatsis, Manos, 2005). For Lake Trasimeno in central Italy, using computerized decision support system, enable to monitor the quality of water flowing into the lake, but also the use of water resources, depending on the needs of different stakeholders and in that sense to do one optimization through an integrated management system (Casadei, Pierleoni, Bellezza, 2016). Also, for the subject under consideration, environmental policies should be developed in a contextual decision-making process regarding local environmental concerns emphasizing the economic, technical, social and institutional considerations (Kardel, Mirosła-Świątek, Chormański, Okruszko, Wassen, 2009).

The goal of this paper is to provide the basic prerequisites for achieving the excellent performance of a single system, and to define priority measures and guidelines. In general, the aim of the paper is to point out the importance of integrated management systems, analyze and select the optimal implementation approach and recognize the contribution to improving the performance of the system - subject under consideration.

## 2. Experimental

The data base for analysis, from where experimental data arise, comes from 28 firm in area of Lake Skadar, as well as from general organisational structure of National parks in Montenegro.

A significant number of literature sources indicate that there are three strategies for the implementation of integrated quality management systems: the first implementation of QMS, EMS and other, either first EMS or QMS or at the same time both or more system (Karapetrovic, Willborn, 1998). Additionally, the literature sources indicate that the first strategy is most applied, but also that the third strategy gives the highest degree of integration and the most efficient system (Santos, Mendes, Barbosa, 2011 and Bernardo, Casadesús, Karapetrovic, Heras, 2012). Other sources point to two approaches in the integration of different management systems (Shahin, Dabestani, 2011, Vicencio-Ortiz, Kolarik, 2012, Zelnik, Maletič M, Maletič D, Gomišček, 2012 and Pho, Tambo, 2014). Following the first approach, the process is carried out through documentary implementation in accordance with the similarity of individual standards, while the second approach is to adopt the concept of total quality management that integrates all elements of individual standards into itself. According to this scenario and in one of the presented ways, QMS, EMS and OHSAS are first implemented, and then other systems potentially and where necessary could be join, for example the next:

- Energy management system (ISO 50000),
- Food Safety Management System (ISO 22000),
- Road traffic safety management systems (ISO 39000)
- Information Secure Management System (ISO 27000),
- Social responsibility system according to ISO 26000 standards and other.

Some authors (Mohammad, Osman, Yussuf, Sani, Jalil, 2013) suggest experiences in implementing integrated systems through two approaches:

- First implementation of individual standards, and subsequently their integration or
- Parallel implementation and integration of all systems from the beginning.

In this approach, experience indicates a significant dominance of the first, and additional experiences individually for each of these approaches are shown in Table 1.

In the process of implementing integrated management systems, it can also be said about integration at different levels, for example, at the level of processes, goals and resources.

Then we can speak of the degree of integration, that is, of full integration at all levels or of partial integration at only some of the predicted levels (Karapetrovic, 2003 and Bernardo, Casadesús, Karapetrovic, Heras, 2003).

Regarding to the implementation of integrated systems, many authors emphasize integration levels. In this sense, strategies from two (Simon, Karapetrovic, Casadesus, 2011) to five (Wilkinson, Dale, 1999) levels of integration are highlighted.

*Table 1. Approaches and experiences in the implementation of integrated management systems*

| Implementation approach | Benefits | Common sequences in the integration of the management system |
|---|---|---|
| Individual implementation of the standards, and then their integration | When an organization has experience in implementing a single system, it can more easily associate others<br>This approach requires less time | First implement the QMS, then EMS and join it, then OHSAS |
| | | First implement individually QMS, EMS i OHSAS. Then integration. |
| | | Start by implementation at least two systems, for example, QMS and EMS in particular, and at the same time. Then their integration, and after that implementation OHSAS and join it. |
| | | First implemented EMS and OHSAS, as separate systems and at the same time. Then their integration, and after that implementation of the QMS and join it with previous system. |
| At the same time, the integration and implementation of individual systems from the beginning | Significant synergistic effect is obtained<br>It is not necessary to implement an individual implementation at the beginning | Integrate QMS, EMS, OHSAS simultaneously from the beginning |
| | | Integrate QMS and EMS simultaneously from the beginning, and then join OHSAS |
| | | Integrate EMS and OHSAS simultaneously from the beginning, and then join to this system QMS |

In this way, an interesting scale has been developed that shows the levels of maturity, i.e. the scope of integration (Table 2) (Abrahamsson, Hansson, Isaksson, 2011).

Implementation of integrated systems can also be carried out based on the harmonization of the norms defined in the QMS approach, with the approach of total quality management, especially emphasizing the process model, decomposition and accountability, as well as strong IT support that especially relies on the databases (Benhima, Reilly, Benhima, 2012). Certainly, the method of implementation and the number of individual systems that make up the integrated system depends on the object singularity. For example, a number of organizations are implementing integrated systems with a special emphasis on EMS and OHSAS norms as well as a risk management system (Rebelo, Santos, Silva, 2015). In general, and especially important from the point of view of this study, the implementation of integrated management systems brings significant profit for all stakeholders, in the broader sense so in Table 3 it is also shown on the example of profit, individually in relation to different stakeholders (Rebelo, Santos, Silva, 2014).

*Table 2. Levels or scope of integration*

| Level of integration | Description | Comment |
|---|---|---|
| 0 | Processes and organization management are not based on any standard | |
| 1 | An integrated management system has not been established, but organizations operate on the basis of individual standards | Individually implemented e.g. QMS, EMS and OHSAS |
| 2 | Process identification has begun and around 30% (thirty percent) of identified risks are managed through an integrated management system | |
| 3 | An overview of all risks in the organization has been adopted and they have been identified. With more than 70% (seventy percent) of all identified risks being managed within an integrated management system | For example integration of QMS, EMS and OHSAS |
| 4 | More than 90% (ninety percent) of all identified risks are managed through an integrated management system | |
| 5 | All aspects of stakeholders are managed and controlled through an integrated management system | |

According to the fact, mentioned above, it can be concluded that, literature sources indicate that integrated management systems are established primarily in the implementation of the main standards in terms of the needs of organizations or systems, such as: QMS, EMS and OHSAS, by different approaches. Primarily, integration is carried out on these standards, because they are very similar in structure, and subsequent integration of other standards is carried out. Also, the authors agree that there is no single method, model or standard for the implementation of integrated systems. Also, in the literature, it is often possible to find harmonized attitudes that point to the fact that there is no complete consensus on what is actually the integration of the management system and what is the unique methodology.

For the purposes of analyzing and selecting an optimal solution for the implementation of the integrated system, and according to the specificities of the considered subject, the AHP methodology (Analytic Hierarchy Process) and the associated Expert Choice software were applied in creating approach for integrated management system in the function of Lake Skadar valorisation.

Most of the world scientistics considered this approach as most efficient Decision Support System (DSS) and in the background of this approach, there is a mathematical mechanism based on 4 axioms: the reciprocity axiom, the homogeneity axiom, the axiom of dependence, and the axiom of expectations (Saaty, 1987, Harker, Vargas, 1987, Alphonce, 1997 and Eslaminasab, Dokoohaki, 2012).

*Table 3. Significance of integrated management systems from the aspect of different interested parties*

| Interested parties | Benefits |
|---|---|
| Society | Business continuity and innovation, compliance with legal regulations, social responsibility, positive attitude towards tax and regulatory policy, environmental protection and social status, transparency, energy efficiency and others. |
| Customers | Guaranteed and harmonized product quality, competitive price |
| Employees | Motivation, employee satisfaction, transparency, fairness and the conduct of an ethical codex |
| Owners | Continuous orientation to improve performance, continuous improvement of partner relationships, productivity and financial stability, inventiveness development |
| Competitors | Guarantee of respect and relation to ethical principles |
| Partners | Strengthening cooperation on the principle of mutually beneficial relations, governing ethical principles and secured continuity |

## 3. Results

According to the researched literature mentioned above, mentioned experimental data base and in relation to the goal for research object, and on the way of benefits for all stakeholders, as well as the efficiency and effectiveness of the integration process, 7 (seven), so-called alternatives (A – aleternative), are defined. They are:

- (A1) First implement the QMS, then EMS and join it, then OHSAS and ISO 39001
- (A2) First implement individually QMS, EMS, OHSAS and ISO 39001. Then integration.
- (A3) Start by implementation at least two systems, for example, QMS and EMS in particular, and at the same time. Then their integration, and after that implementation OHSAS and ISO 39001 and join it.
- (A4) First implemented EMS and OHSAS, as separate systems and at the same time. Then their integration, and after that implementation of the QMS and ISO 39001 and join it with previous system
- (A5) Integrate QMS, EMS, OHSAS and ISO 39001 simultaneously from the beginning
- (A6) Integrate QMS and EMS simultaneously from the beginning, and then join OHSAS and ISO 39001
- (A7) Integrate EMS and OHSAS simultaneously from the beginning, and then join to this system QMS and ISO 39001

Additionally, in order to make an assessment of the alternative, for the Lake Skadar area, 4 criteria (C - criteria) are defined (Table 4). From the aspect and the aims of this paper, and because importance of wider range of staceholdel, under fourth criteria, additionally 5 subcriteria (SC – subcriteria) for the Lake Skadar area

was defined (Table 4). Then was initiated an assessment for the subject of the research and his specificity. The assessment was conducted particularly and independently in the following way:

- Evaluation of the sub-criterion in relation to the goal,
- Evaluation of criteria in relation to the goal and
- Evaluation of alternatives in relation to criteria and sub-criteria, in accordance with the defined goal (one example in Table 5).

*Table 4. Criteria and sub-criteria for research subject*

| CRITERIA | SUB-CRITERIA |
|---|---|
| (C1) Easy of implementation | (SC1) Impact on society |
| (C2) Effectiveness | (SC2) Impact on users |
| (C3) Efficiency | (SC3) Impact on employees |
| (C4) The importance of stakeholders | (SC4) Impact on owners |
| | (SC5) Impact on partner |

During the process, a continuous assessment of the consistency of the decision-makers reasoning was carried out. At all stages, it was noted that the parameters are within the permissible tolerance limits. Based on the above methodology, Figure 1 shows the relationship between criteria and related alternatives, taking into account main goal.

*Table 5. Example of evaluation alternatives in relation to criteria and sub-criteria*

| Crit. / Alter. | C4 | | | | | C1 | C2 | C3 |
|---|---|---|---|---|---|---|---|---|
| | SC1 | SC2 | SC3 | SC4 | SC5 | | | |
| A1 | 2/1/2/1 | 3/1/2/2 | 3/1/3/1 | 2/1/1/1 | 2/1/1/2 | 3/3/3/2 | 3/2/2/2 | 3/3/1/1 |
| A2 | 1/3/2/2 | 1/3/3/2 | 1/3/2/1 | 2/3/1/2 | 2/3/1/1 | 1/1/2/2 | 1/1/2/1 | 1/1/1/1 |
| A3 | 1/2/2/2 | 1/2/2/2 | 1/2/2/2 | 2/2/2/2 | 2/2/2/1 | 1/1/2/1 | 1/1/2/1 | 1/1/2/2 |
| A4 | 1/3/1/2 | 1/3/1/1 | 1/3/1/2 | 2/1/2/1 | 2/1/2/1 | 1/1//1 | 1/3/2/1 | 1/2//1 |
| A5 | 2/3/2/3 | 3/3/3/2 | 3/3/1/3 | 3/3/3/2 | 3/3/3/3 | 3/1/1/1 | 3/3/3/2 | 3/2/3/2 |
| A6 | 2/3/2/2 | 2/3/2/2 | 2/3/2/2 | 2/3/2/3 | 2/3/2/3 | 2/2/1/2 | 2/3/3/2 | 2/3/2/2 |
| A7 | 1/3/2/2 | 1/3/2/1 | 1/3/2/2 | 1/2/2/2 | 1/2/2/2 | 1/2/1/2 | 1/2/3/2 | 1/1/2/1 |

Legend:
rating for every singular alternatives in sense of impact to the every single sub-criteria (1- low, 2 – good, 3 - excellent)
facilitator/participant1/participant2/participant3

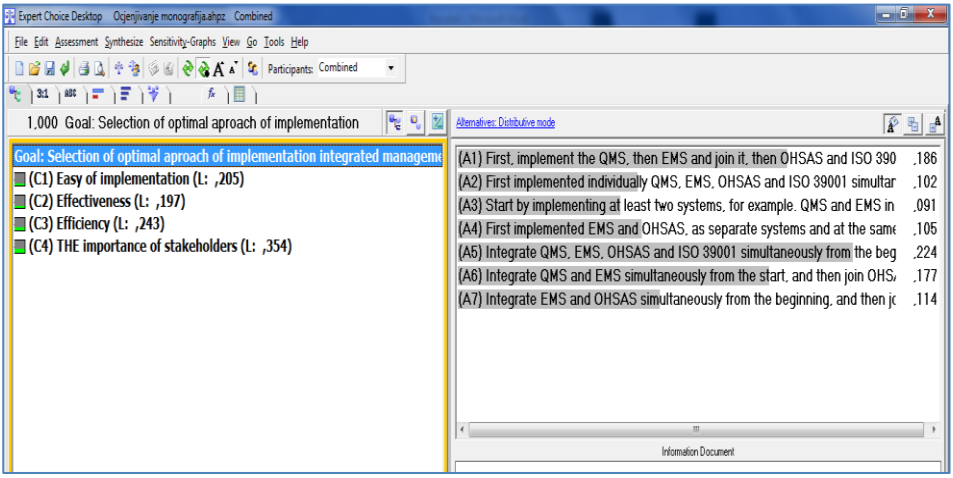


*Figure 1. Criteria and alternatives in the applied methodology*

After the calculation, the results, ie. coefficients of significance for each of the alternatives, criteria and sub-criteria are shown in Table 6.

*Table 6. Coefficient of significance by alternatives, criterias and sub-criteria*

| | C1 | C2 | C3 | C4 | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | SC1 | SC2 | SC3 | SC4 | SC5 |
| A1 | 0,851 | 0,554 | 0,582 | 0,285 | 0,493 | 0,582 | 0,225 | 0,285 |
| A2 | 0,285 | 0,225 | 0,164 | 0,494 | 0,642 | 0,434 | 0,494 | 0,434 |
| A3 | 0,225 | 0,225 | 0,285 | 0,345 | 0,345 | 0,345 | 0,405 | 0,345 |
| A4 | 0,225 | 0,434 | 0,285 | 0,434 | 0,373 | 0,434 | 0.285 | 0.285 |
| A5 | 0,373 | 0,851 | 0,703 | 0,703 | 0,851 | 0,791 | 0,351 | 1,000 |
| A6 | 0,345 | 0,703 | 0,554 | 0,554 | 0,554 | 0,554 | 0,703 | 0,703 |
| A7 | 0,285 | 0,494 | 0,225 | 0,494 | 0,434 | 0,494 | 0,345 | 0,345 |

By analyzing the obtained results, it can be concluded that, as an optimal approach for Lake Skadar, from the aspect of the specificity of the subject of research, as well as to the importance for a wider range of stakeholders, it is necessary to adopt an approach in the implementation of integrated systems, which consists of, simultaneously from the beginning, implementation of the following structurally complementary standards and that, QMS, EMS, OHSAS and ISO 39001 (alternative A5) with Coefficient of significance: 0,224. Further, by analyzing the obtained results, using Pareto methodology, or better say ABC analisis and 70/20/10 distribution, taking into account the specificity and state of the implementation of the subject systems in our environment, it can be concluded that the approach, which is very close to the previous approach, is the following: First implement the QMS, then EMS and join it, then OHSAS and ISO 39001 (alternative A1) with Coefficient of significance: 0,186. Bearing in mind the criteria and sub-criteria, and in relation to the identified priority approach to implementation, based

on the applied methodology, the situation can be analyzed according to the results shown in Table 7.

*Table 7. Impact factors of the chosen alternative to criteria and sub-criteria*

| Alternatives | Criteria | Sub-criteria | Impact |
|---|---|---|---|
| A1 | C1 | | 0,049 |
| | C2 | | 0,024 |
| | C3 | | 0,037 |
| | C4 | SC1 | 0,005 |
| | | SC2 | 0,010 |
| | | SC3 | 0,008 |
| | | SC4 | 0,003 |
| | | SC5 | 0,004 |
| A2 | C1 | | 0,016 |
| | C2 | | 0,010 |
| | C3 | | 0,011 |
| | C4 | SC1 | 0,009 |
| | | SC2 | 0,013 |
| | | SC3 | 0,006 |
| | | SC4 | 0,006 |
| | | SC5 | 0,005 |
| A3 | C1 | | 0,013 |
| | C2 | | 0,010 |
| | C3 | | 0,018 |
| | C4 | SC1 | 0,007 |
| | | SC2 | 0,007 |
| | | SC3 | 0,005 |
| | | SC4 | 0,005 |
| | | SC5 | 0,004 |
| A4 | C1 | | 0,013 |
| | C2 | | 0,019 |
| | C3 | | 0,018 |
| | C4 | SC1 | 0,008 |
| | | SC2 | 0,008 |
| | | SC3 | 0,006 |
| | | SC4 | 0,004 |
| | | SC5 | 0,004 |
| A5 | C1 | | 0,021 |
| | C2 | | 0,037 |
| | C3 | | 0,045 |
| | C4 | SC1 | 0,013 |
| | | SC2 | 0,017 |
| | | SC3 | 0,011 |
| | | SC4 | 0,011 |
| | | SC5 | 0,013 |
| A6 | C1 | | 0,020 |
| | C2 | | 0,031 |
| | C3 | | 0,035 |

| Alternatives | Criteria | Sub-criteria | Impact |
|---|---|---|---|
| | C4 | SC1 | 0,011 |
| | | SC2 | 0,011 |
| | | SC3 | 0,008 |
| | | SC4 | 0,009 |
| | | SC5 | 0,009 |
| A7 | C1 | | 0,016 |
| | C2 | | 0,022 |
| | C3 | | 0,014 |
| | C4 | SC1 | 0,009 |
| | | SC2 | 0,009 |
| | | SC3 | 0,007 |
| | | SC4 | 0,004 |
| | | SC5 | 0,004 |

Hence, by applying simultaneous and from the beginning integration of all four systems (Alternative A5), it can be concluded that this is approach that will be primarily efficient (Impact factors is 0,45), i.e. that it will immediately give indisputable results in the environment, and that its secondary aspects are effectiveness and ease of implementation.

Also, in relation to the identified stakeholders, this recommended optimal model will primarily contribute to users (Impact factors is 0,17), and then to all other stakeholders, i.e. on society and partner, after that on employees and owners.

Very close approach is: first implement the QMS, then EMS and join it, then OHSAS and ISO 39001 (Alternative A1) which is much more easy for implementation, and also it will primarily contribute to the users (Impact factor is 0,010), and then to all other stakeholders.

## 4. Discussion and conclusions

The application of integrated management systems in developed economies is inevitable, and the benefits of such approach are multiple. This is evidenced by many scientific and expert papers that emphasize the importance of implementing such a management system, starting from the benefits for a wider range of stakeholders, the benefits for the organization and employees, to the proven profit of a financial nature.

Based on the available literature on the Lake Skadar, as well as the findings from practice, and from database from 28 firms in area of Lake Skadar, indicate that the mentioned approach of integration of several management systems based on some approach was not applied. On the contrary, they can even identify: non-systemic and non-standardized production approaches, insufficiently good environmental impact indicators, inadequate system of internal and external communication of stakeholders, then aspects of equipment management, infrastructure, workforce, and others. This state and conditions, with the additional demands of international organizations, as well as the experience of prestigious destinations in the world, must be an incentive to change the situation in the

direction of implementation of integrated management systems, based on internationally prescribed norms.

Application of integrated management systems in the Lake Skadar area is a way to improve the existing situation and create conditions for: improvement of business processes, risk reduction, systematic environmental management, improvement of parameters of protection of health and safety, traffic safety, as well as to provide greater recognition and trust on the international plane.

In this sense, there are different approaches to implementation, and from the aspect of efficiency, effectiveness and profit for a wider range of stakeholders. Namely, each of the approaches listed in the literature and applied in practice gives different results and benefits to stakeholders, but also has different parameters in terms of implementation costs, financial indicators, efficiency and effectiveness.

In this study we revealed that the best model for implementation integrated management system is one which is selected like Alternative A5, an it is: implementation QMS, EMS, OHSAS and ISO 39001 simultaneously from beginning.

Given the peculiarities of national conditions, a very good alternative to this approach is: first implement the QMS, then EMS and join it, then OHSAS and ISO 39001, selected like Alternative A1. Priority approach will immediately give the benefit to the environment, and from the aspect of the process, in the second plan will be its effectiveness and ease of implementation. Also, this recommended approach will primarily contribute to users, and then to all other stakeholders. Second alternative is much more easy for implementation but also it will immediately give results to users.

This approach will ensure that the area of Lake Skadar gets a systematic approach in the continuous improvement of business processes, guaranteed and harmonized quality products, employee motivation, ethics, transparency and fair approach to workforce management, continuous improvement of partnership relations, strengthening cooperation with partners on the basis of principles on both sides useful relationships, constant systematic analysis of aspects and environmental impacts and improvements in this regard, control and monitoring of risks in terms of safety and health, as well as business risk, greater safety in transport, greater international recognition and credibility, and more.

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## Declaration of interest statement

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CAN ESG PRINCIPLES CONFLICT WITH CENTRAL BANK POLICIES?*

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***Abstract***

*Today, the implementation of ESG principles has become a topic of great importance, discussed in expert forums, political events, national economic policy debates, the media, and elsewhere. International institutions, non-governmental organizations, legislators, the media, and others are exerting significant pressure for the implementation of these principles. Generally speaking, Central banks are among the leading institutions in the implementation of ESG principles.. They adhere to them not only to maintain financial stability but also to manage reputational risk and set a good example. However, what is often overlooked is that the implementation of these principles carries numerous challenges and even risks for central banks. There can be a conflict between policy objectives and ESG objectives. Therefore, the question arises as to how central banks can reconcile these two objectives or how to find a trade-off. Very few studies address this issue. Therefore, the focus of this paper is on a balanced consideration of the need to implement these principles in central banks, the challenges their implementation brings, as well as the risks and potential conflicts with the core mission of central banks.*

***Key words****: central banks, ESG principles, chalenges, policy goals***.**

## 1. Introduction

Environmental, Social, and Governance (ESG) principles have become increasingly important in the financial sector, including central banking. Integrating ESG principles in central banking involves considering environmental sustainability, social responsibility, and sound governance in formulating and implementing

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monetary policy, ensuring financial stability, and supervising banking operations. These principles are gaining importance as central banks play a crucial role in maintaining financial stability and promoting sustainable economic growth.

**Environmental (E):** This principle involves addressing ecological issues such as climate change, pollution, conservation of natural resources, and biodiversity. Central banks can influence the reduction of environmental risks by adjusting their investment portfolios, supporting green financial instruments, and promoting sustainable practices among financial institutions.

**Social (S):** This principle pertains to social issues such as labor rights, equality, health, and social security. Central banks can contribute to social responsibility through initiatives that promote financial inclusion, support minority and marginalized groups, and encourage the financial system to support balanced and sustainable economic development.

**Governance (G):** This principle encompasses corporate governance issues such as transparency, accountability, integrity, and ethics. Central banks can enhance corporate governance by applying strict standards in their operations and promoting the same standards throughout the financial system.

The key challenges that central banks face in implementing ESG principles include: lack of specialized knowledge and skills; insufficient, comprehensive, reliable, and granular comparable data; lack of standardization; lack of awareness of ESG concepts; and difficulty integrating ESG concepts with organizational culture (Magalong & Chamoun 2024). The challenge also lies in the traditional internal structure of central banks, which needs to be further integrated with engineering expertise, the collection of new data, the establishment of internal bodies dedicated to the ESG agenda, as well as increasing management's knowledge of these issues.

Today, there is a growing number of international organizations dedicated to implementing these principles in central banks and the financial system, such as the Network for Greening the Financial System, the Financial Stability Board, the International Financial Reporting Standard Foundations, the Task Force on Climate-related Financial Disclosures, and the Sustainable Banking and Finance Network, among others.

The primary goal of this paper is to analyze whether the implementation of ESG principles might conflict with the mission of the central bank and to offer appropriate recommendations. This issue has been rarely explored in the literature, and when it has, it has been almost exclusively from the perspective of the impact of climate change and the central bank's investment policy. Other aspects, to the best of the authors` knowledge, have hardly been extensively analyzed.

This paper consists of five parts. After the introductory remarks, the second part discusses the impact of ESG principles implementation on monetary policy and key central bank functions. The third part of the paper deals with social responsibility, while the fourth part provides some policy recommendations, and The final part of the paper presents concluding considerations.

## 2. Monetary Policy and Implementation of ESG standards

*Inflation* – Central banks primarily focus on short-to medium-term price stability, which can conflict with the long-term horizon of ESG goals. A focus on ESG can lead to substantial investment in green technologies and infrastructure, potentially at the expense of more traditional industries. While this can promote long-term sustainability, the short-term impact may include increased costs and price volatility.

For instance, transitioning from fossil fuels to renewable energy sources can raise production costs, which may be passed on to consumers, leading to higher inflation. Companies adjusting their supply chains to align with ESG standards might face disruptions and increased costs, affecting the prices of goods and services. This can also result in volatility in financial markets and shifts in asset prices, impacting overall economic stability and price levels.

However, from a long-term perspective, abandoning ESG principles can lead to even higher inflation and increased costs. For example, continuing to use fossil fuels may result in higher costs for mitigating the consequences caused by their production (higher healthcare costs, more expenses for recovery from frequent natural disasters, higher environmental protection costs, etc.). On the other hand, with greater adoption of green technologies, their further development will occur, thereby reducing their costs.

Central banks might need to balance the trade-off between supporting ESG goals and maintaining price stability. For example, if inflation rises due to ESG-related cost increases, the central bank might face a dilemma between raising interest rates to control inflation and supporting investment in green technologies, which might require lower interest rates. Achieving this balance will be crucial for central banks as they navigate the evolving landscape of sustainable finance and its implications for economic policy.

*Investment policy* – As part of their investment policies, central banks may choose to invest in ESG bonds. However, investing in these bonds presents numerous challenges for central banks. Firstly, there is no clear classification of what constitutes an ESG bond, as standardized data on the “greenness” of both issuers and assets is lacking. The absence of a clear definition increases the risk of greenwashing. Additionally, the liquidity level of these bonds is significantly lower compared to traditional bonds. This can conflict with central banks' investment policies, which require a high level of liquidity for a significant portion of their portfolios to ensure the smooth implementation of monetary policy instruments. According to OMFIF (2019), these bonds account for less than 2% of global debt issuance. Furthermore, due to their nature, these bonds are often issued with very long maturities, which may be too long relative to the investment policies of central banks. Lastly, these bonds frequently offer lower returns compared to traditional bonds. The World Bank`s primer (2021) suggests that ESG investment strategy incorporated into the reserve management framework should align with institutional objectives and apply to the existing set of eligible asset classes. We believe that potential trade-offs between central banks` investment policies and

these investment challenges can be managed by allocating a portion of the central banks investment portfolios to green bonds, continually reviewing this portfolio, and setting interim targets.

*Climate change* – Climate change represents one of the most significant global risks. Estimates indicate that the consequences of climate change will have an increasingly negative impact on annual GDP, ranging from up to 3.3% by 2060 to 12% by 2100 (Fabris & Luburić, 2022). While there may have been past debates about whether climate change falls within the mandate of central banks, today there is no doubt about it as climate change can be a source of financial risks, and managing all types of financial risks falls under the mandate of central banks in their role of preserving financial stability. Central banks have the responsibility to identify climate-related risks, ensure that these risks are incorporated into banks` risk management policies, and monitor the resilience of banks to climate risks. As socially responsible institutions, central banks also aim to influence and raise social awareness about climate risks.

In 2019, the European Central Bank (ECB) identified climate risks as one of the key threats facing the banking sector (OMFIF, 2019). In November 2020, it published the Guide on Climate-Related and Environmental Risks for banks, along with stress testing focused on climate-related risks. The European Banking Authority has recently published its roadmap to enhance ESG regulations in progress. Over a three-year horizon, this roadmap aims to incorporate all ESG principles into the regulatory frameworks for banks (Delgado, 2023).

The first step in supervising these risks is to understand their source, size, and likelihood. Climate change impacts the banking system through four channels, three of which are negative (physical, transition, and indirect) and one of which can have a positive impact.

**Physical Risk**: This occurs with weather-related events. Financial institutions can be affected directly by physical risk through the reduced value of assets and collateral, increased insured damages, or disruption of their own business operations. They can also be affected indirectly through their portfolios as credit risk and market risk.

**Transition Risk**: This financial risk arises from adjusting to new environmentally acceptable business techniques or the introduction of business restrictions for companies that contribute to greenhouse gas emissions.

**Indirect Risk**: This risk, often overlooked in scientific studies, occurs in companies whose business is not directly affected by climate change, but whose key partners are at risk.

**Positive Impact**: The transition path poses challenges but also opportunities. Positive impacts can occur through the emergence of new companies that become leaders with their innovations, displacing companies using environmentally unacceptable standards. This channel can also result from increased social awareness, leading the population to avoid producers who use techniques and technologies contributing to climate change.

The following figure illustrates the interdependencies and channels of the climate change impact on the banking system and economic growth.

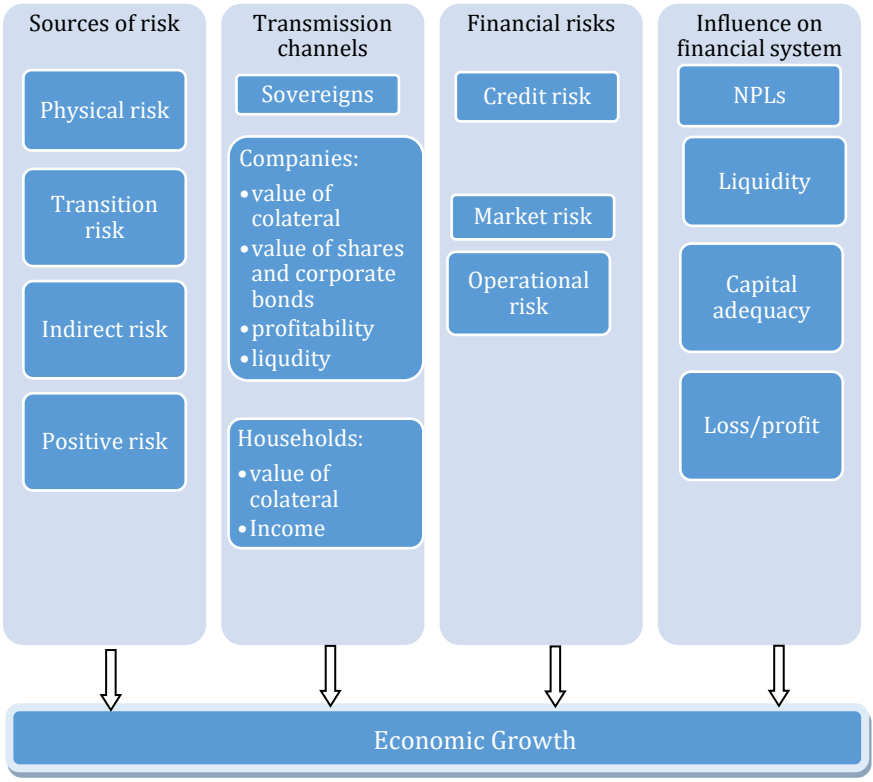


*Figure 1: Climate change impact on the banking system*

Source: Fabris, 2020.

Climate change can negatively affect the transmission mechanisms of central banks. It can make banks less willing to extend credit to the economy. In such cases, a reduction in the interest rate might be insufficient to stimulate the economy if inflation is below target (UNCTAD, 2023). Given that there is no doubt that climate risks must be managed, the following graph presents a climate risk management model.

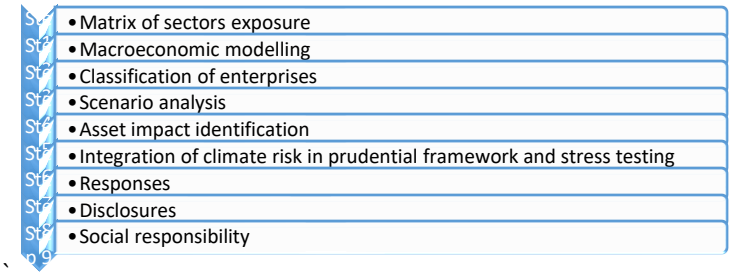


*Figure 2: Climate risk management model*

Source: Fabris, 2020

Central banks, in their role as regulators, can require financial institutions to disclose ESG risks and incorporate these risks into their lending and investment decisions. This can lead to a more resilient and sustainable financial system. Due to their capacity, independence, and overarching role, central banks should take on the role of coordinating the implementation of ESG principles in the financial sector and beyond. This would also imply a certain departure from the traditional position of central banks.

## 3. Social Responsibility and Governance

Central banks are institutions that place significant emphasis on social responsibility. In this segment, apart from a few minor exceptions, there is no conflict with the ESG agenda. Central banks can support inclusive growth by ensuring that monetary policies promote employment and equitable access to financial services. Addressing income inequality and fostering financial inclusion can enhance social stability and economic resilience.

Central banks have a role in promoting financial literacy and consumer protection, which are essential for the well-being of the community. The level of financial literacy is very low in many countries, making it common practice for central banks to act as umbrella institutions that develop strategies to enhance financial literacy. Financial education helps to promote financial inclusion, boost the economy, reduce the level of unmanageable debts, and reduce poverty levels (Luburić & Fabris, 2018).

Incorporating social considerations into central banking policies can also mean advocating for fair labor practices and human rights, indirectly influencing broader financial and corporate sectors to adopt similar standards. Additionally, social responsibility for central banks means that they should engage in supporting a wide range of civil society projects, which may not be directly within the central bank's mandate but have a significant impact on civil society development.

Initiatives to improve wages and working conditions can also lead to increased production costs. While beneficial for social welfare, these costs might be transferred to consumers, potentially causing price increases. If wage increases are aimed at ensuring a normal standard of living for vulnerable groups, central banks

should not view this as conflicting with their mission. However, if wage increases exceed productivity as a result of a political agenda, then a clear conflict arises. Additionally, implementing and maintaining high governance standards can entail significant compliance costs, which might again be reflected in consumer prices.

Moreover, adopting ESG principles promotes greater transparency and accountability in central banking. The importance of transparency in central banking is immense, and more people are recognizing that transparency represents a new and distinct instrument of monetary policy (Fabris, 2006; Kohn & Sack, 2003; Bernhardsen & Kloster, 2002). This involves clear communication of policy decisions and their impacts, ensuring that the public and other stakeholders are well-informed and can hold the central bank accountable.

## 4. Policy Recommendations for central banks

It is evident that the implementation of ESG principles can lead to potential conflicts in the pursuit of central bank policy. To mitigate these, central banks and policymakers can:

**Integrate ESG considerations into monetary policy frameworks:** By understanding and incorporating the long-term benefits of ESG into their analysis, central banks can better balance short-term price stability with long-term sustainability.

**Promote transparency and gradual implementation:** Ensuring that ESG policies are implemented gradually and transparently can help mitigate sudden inflationary shocks.

**Coordinate with fiscal policy**: Central banks can work closely with government fiscal policies to ensure that ESG initiatives are supported without compromising price stability.

Central banks should continuously consider how climate change and other ESG factors might affect economic outlooks, inflation, and financial stability. Additionally, it is important to incorporate ESG risks into regulatory frameworks to ensure that financial institutions adequately manage these risks. Central banks must also require commercial banks to make climate-related disclosures. In some jurisdictions, this reporting is mandatory, but in most, it is still voluntary. This measure is also supported by the European Central Bank (2023). According to the Task Force on Climate-related Financial Disclosures: “Imposing mandatory climate-related disclosures based on an internationally recognised framework will increase the availability of information in the financial markets on how climate change will impact the risks and opportunities faced by companies or their assets” (Central Banking, 2021). Introducing this requirement is certainly a significant challenge, but it appears that there is a greater cost to not having the information and data available to enforce appropriate risk management. However, as highlighted in the Bank of Finland`s annual review (2021), “Good reporting builds trust, promotes openness, and supports the organisation’s work. This is why it also plays a key role in a central bank’s communication.”

Significant global cooperation and coordination are essential, as no single central bank can solve the problem alone. The current approach, where numerous international institutions work individually, is insufficient. Global coordination helps harmonize ESG standards and practices, making it easier for multinational financial institutions to comply and for central banks to compare and assess the effectiveness of their ESG policies. Therefore, we propose that central banks establish an ESG Board to address the following areas:

**International Standards in the ESG Area**: Developing and aligning global ESG standards.

**International Cooperation and Coordination**: Enhancing collaboration among international entities.

**Status of ESG Implementation**: Monitoring and reporting on the progress of ESG initiatives.

**Key Performance Indicators**: Defining and measuring the success of ESG policies.

**Compliance Requirements**: Setting and enforcing regulatory expectations.

**Challenges and Risks**: Identifying and mitigating potential issues.

Effective governance requires engaging with a wide range of stakeholders, including governments, financial institutions, international organizations, civil society, and the public. This inclusive approach enables central banks to better understand and address the diverse needs and concerns of different groups.

## 5. Conclusion

While ESG principles aim at long-term sustainability, the benefits might not be immediately apparent. There can be trade-offs between different ESG goals, data limitations, and potential conflicts with traditional central banking objectives. Central banks, by adopting ESG principles, can play a pivotal role in steering the global economy towards a more sustainable and equitable future.

The paper demonstrates that the implementation of ESG principles in certain aspects of central banking, particularly in the short-term, may conflict with the central bank's objectives. The authors believe that, in the long-term, their implementation will benefit both central banks and society as a whole, and that careful and coordinated policy design can help balance these objectives, ensuring that long-term sustainability does not come at the expense of short-term economic stability. However, political myopia and the frequent emphasis on achieving short-term goals could negatively impact the implementation of these principles.

Regarding the primary objective of central banks, which is to maintain price stability, the implementation of ESG principles in the short- or medium-term may be conflicting. Central banks may face a dilemma: whether to tolerate higher inflation to encourage green investment or to strictly adhere to their primary objective. We believe that a trade-off should be sought, and that the implementation of ESG principles will bring long-term benefits to society as a whole.

When it comes to investment policy, investing in green bonds can also be conflicting, as these bonds often have lower yields, less liquidity, and a longer investment horizon compared to the investment policies of central banks.

In the context of climate change, the implementation of ESG principles is fully compatible with the mission of central banks, as climate change threatens financial stability and interferes with the functioning of the monetary policy transmission mechanism. Therefore, central banks must ensure that climate change risks are adequately assessed, properly disclosed, and integrated into the risk management of financial institutions.

Central banks are institutions that have traditionally paid attention to social responsibilities. They traditionally promote employment and equitable access to financial services, foster financial inclusion, support financial literacy initiatives, and numerous civil society projects, which is compatible with ESG principles.

The paper also provides recommendations on how to overcome these conflicts more easily, their gradual implementation, and other challenges that may arise.

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# SUSTAINABLE BUSINESS PRACTICES

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE ROLE OF DATABASES IN EFFECTIVE NONCONFORMITY MANAGEMENT IN INDUSTRY 4.0

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*Abstract*

*In the context of rapid digital transformation, Industry 4.0 poses new challenges in managing nonconformities in manufacturing processes. This paper explores the role of databases in effective nonconformity management in Industry 4.0. In addition to reviewing current technological solutions and best practices, authors analyze the advantages that databases provide in processing, storing, and analyzing nonconformity-related data. Furthermore, authors discuss the perspectives and challenges of using databases in this field, considering factors such as scalability, security, and integration with other technologies. Through this paper, authors explore how databases can be optimally utilized to enhance nonconformity management processes and achieve better performance within Industry 4.0.*

***Key words:*** *Industry 4.0, nonconformities, databases, digital transformation, Data Management.*

## 1. Introduction

Industry 4.0 has revolutionized how industrial operations are managed, driving innovation by integrating advanced technologies such as automation, the Internet of Things (IoT), big data analytics, cloud computing, and artificial intelligence (AI). This new wave of digital transformation has reshaped industrial ecosystems, making them more connected, efficient, and data-driven. However, with these advancements come new challenges, particularly in managing nonconformities—instances where products, processes, or services deviate from established standards or specifications.

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Nonconformity management is a critical aspect of quality control and continuous improvement within any industrial setting. Effectively identifying, tracking, and resolving nonconformities is vital for maintaining compliance with industry standards, optimizing production processes, and ensuring customer satisfaction. In an Industry 4.0 context, the speed, accuracy, and volume of data involved in nonconformity management have increased exponentially, making traditional paper-based or isolated digital systems inadequate for modern demands.

At the heart of this digital transformation lies the role of databases. Databases serve as the backbone for capturing, storing, processing, and retrieving vast amounts of information in real-time. They enable organizations to efficiently handle large datasets, facilitating the tracking of nonconformities from detection to resolution. Furthermore, databases provide a centralized platform that integrates with other systems, such as enterprise resource planning (ERP), manufacturing execution systems (MES), and IoT-enabled devices, ensuring that data flows seamlessly across different operational layers.

In the context of Industry 4.0, modern database systems must not only manage nonconformities efficiently but also leverage data analytics to predict and prevent future occurrences. By utilizing advanced algorithms and machine learning techniques, databases can generate predictive insights, helping organizations to anticipate potential quality issues before they escalate into costly disruptions. This shift from reactive to proactive nonconformity management is a hallmark of the Industry 4.0 paradigm, emphasizing the importance of data-driven decision-making.

Moreover, databases in Industry 4.0 environments must support high levels of scalability, security, and accessibility. With the increasing reliance on cloud-based platforms and the distributed nature of industrial operations, databases need to ensure that data is available in real-time across global supply chains while safeguarding sensitive information. This makes the design and implementation of robust, secure, and scalable database systems an essential component of effective nonconformity management in the digital age.

This paper aims to explore the critical role of databases in managing nonconformities within the framework of Industry 4.0. It will analyze how the integration of advanced database technologies enhances the tracking, analysis, and resolution of nonconformities, ultimately leading to improved quality control and operational efficiency. Additionally, the paper will discuss how predictive analytics, facilitated by modern database systems, contributes to the early detection and mitigation of nonconformities, aligning with the goals of continuous improvement and competitive advantage in the industrial sector.

## 2. Literature Review

The management of nonconformities in manufacturing and industrial settings has become increasingly complex with the rise of Industry 4.0 and the proliferation of big data. Various frameworks, technologies, and methodologies have been proposed to handle these challenges efficiently, with a strong focus on integrating data-driven approaches and quality management principles. In this

review, we will explore key contributions from recent literature, particularly focusing on how databases, machine learning, and risk management tools enhance nonconformity management in the context of Quality 4.0.

The study by Gonzalez Santacruz et al. (2023) presents an Integrated Quality 4.0 Framework (IQ4.0F) that combines Six Sigma and machine learning (ML) techniques aimed at achieving zero-defect manufacturing (ZDM). The framework is built around Six Sigma's DMAIC (Define, Measure, Analyze, Improve, Control) methodology, with a specific emphasis on the "Analyze" phase, where ML techniques are used to enhance the understanding of process variables that influence product quality.

A key contribution of this work is the introduction of supervised and unsupervised learning techniques, such as Principal Component Analysis (PCA) and K-means clustering, as tools for multivariable analysis. These methods help identify critical process parameters that impact defect rates, thereby offering a predictive dimension to nonconformity management. By leveraging databases capable of storing and analyzing vast amounts of process data, the framework empowers quality managers to implement proactive strategies for defect prevention. Moreover, the integration of machine learning within the Six Sigma methodology provides a systematic approach to continuous improvement in manufacturing processes. This aligns with the broader goals of Industry 4.0, which seeks to automate and optimize production through data-driven insights. The IQ4.0F, validated through a case study in the automotive industry, demonstrates the practicality and effectiveness of this approach, making it a valuable contribution to Quality 4.0 research.

In the work of Djordjevic et al. (2023), the authors address the challenges of nonconformity management in small and medium-sized enterprises (SMEs) within the Industry 4.0 paradigm. Their approach focuses on the development of a software solution that utilizes edge devices and a MEAN (MongoDB, Express.js, Angular, Node.js) stack to detect, report, and manage nonconformities in real-time. By leveraging interconnected frameworks and databases, this solution enables SMEs to implement nonconformity management systems affordably, without the need for large-scale, resource-intensive infrastructure. Đorđević, A., Stefanovic, M., Petrović, T., et al. (2024) presented a JavaScript MEAN stack software solution for real-time nonconformity detection and management, specifically designed for small and medium-sized enterprises (SMEs). The solution leverages databases for storing and analyzing nonconformities related to ISO 9001:2015 standards. By integrating edge devices and real-time classification systems, the study demonstrates the benefits of automated nonconformity detection and the efficiency of database systems in managing large volumes of data related to quality issues.

Ravoy and Parmet (2023) propose a novel approach to nonconformity management that focuses on the prioritization of nonconformities based on risk management principles. Their NC 4.0 framework introduces a model designed to prioritize nonconformity events by quantifying the risk they pose, thus providing a structured tool for decision-making. By transforming qualitative assessments of nonconformities into quantitative risk scores, this framework enables organizations

to address the most critical issues first, optimizing resource allocation and minimizing the financial impact of unresolved nonconformities. The model was tested in a real production environment and showed significant improvements in nonconformity management by reducing the financial impact of defects. Additionally, a survey of quality experts revealed strong support for the model, particularly its ability to provide a clear, data-driven method for prioritizing nonconformities. The use of databases in this context is essential for storing and processing the risk data associated with each nonconformity, further reinforcing the importance of data management in effective nonconformity resolution. This approach reflects the shift toward more data-driven and risk-informed practices in Quality 4.0, where managing large volumes of data is critical to ensuring timely and effective responses to nonconformities. The incorporation of risk management tools into nonconformity management highlights the growing importance of predictive analytics and decision support systems in modern manufacturing environments.

The evolution of quality from traditional methods to Quality 4.0 is a significant theme in the current literature, emphasizing how digital transformation is reshaping quality management across industries. Broday (2022) discusses how traditional quality tools, such as control charts and Pareto diagrams, are now being enhanced by digital tools like Big Data and AI in Industry 4.0. The shift towards Quality 4.0 incorporates faster and smarter operations, building on Total Quality Management (TQM) principles but also introducing new tools for digital performance improvement. Saihi, Awad, and Ben-Daya (2021) provide a systematic review of Industry 4.0's impact on quality management, mapping recent studies on how technologies like the Internet of Things (IoT), Big Data, and Machine Learning improve predictive quality and decision-making. They highlight research gaps, particularly the need for more case studies and an economic analysis of the integration of ISO 9001 with Industry 4.0 features. Each of these articles reflects on how modern quality concepts are evolving, driven by advances in technology, emphasizing the transition from TQM to a more connected and intelligent quality framework, with an eye toward the future of Quality 5.0 where human factors play a crucial role.

While technological advancements in nonconformity management are well-covered in existing research, the human factors involved remain underexplored. The interaction between employees and automated, database-driven systems is critical in Quality 4.0 environments, particularly as organizations increasingly rely on data analytics to inform decision-making processes. Korherr and Kanbach (2023) emphasize that human-related capabilities play a vital role in the successful implementation of BDA. Their work presents a taxonomy of five key dimensions: Personnel Capability, Management Capability, Organizational Capability, Culture and Governance Capability, and Strategy and Planning Capability, which together form the foundation for effective human-technology interaction in data-driven organizations. This framework could be adapted to nonconformity management systems, where human input remains essential for interpreting data and making informed decisions based on predictive analytics.

Moreover, the technological progress of BDA has outpaced the corresponding development of social and organizational capabilities, leading to gaps in how employees interact with these advanced systems. Caputo et al. (2019) argue that while algorithms and hardware continue to evolve, organizations still struggle to fully harness the potential of BDA due to insufficient attention to human capabilities. Their findings suggest that to optimize the use of database-driven management systems, it is necessary to develop a comprehensive framework that integrates human factors into the decision-making process. By enhancing employees' skills and understanding of these systems, organizations can bridge the gap between technological advancements and human decision-making, ensuring more effective management of nonconformities in real-time.

The fragmented theoretical base surrounding human capabilities in data-driven contexts has also been identified as a major barrier to the effective implementation of BDA systems. Gupta and George (2016) highlight that many studies have focused on isolated aspects of human interaction with BDA, but a holistic framework is still lacking. This is particularly relevant in the context of Quality 4.0, where nonconformity management relies not only on the automation of processes but also on human oversight and decision-making. Developing a comprehensive understanding of the human factors involved, as proposed by Scholz (2017), is crucial for ensuring that employees can effectively collaborate with automated systems. Future research should therefore investigate how human-related capabilities can be integrated with database-driven systems to support better decision-making and improve overall performance in nonconformity management.

Donauer, M., Peças, P., & Azevedo, A. (2013) introduced a methodology that adapts Knowledge Discovery in Databases (KDD) to help analyze the root causes of nonconformities (NCs). The focus is on using pattern identification to extract valuable insights from data stored in databases, where traditional Total Quality Management (TQM) tools fall short. The Herfindahl-Hirschman Index (HHI) is used as a data mining tool to detect patterns in automotive industry databases. By utilizing these databases, the methodology makes hidden information accessible, leading to more accurate root cause analysis of NCs. Similar to their previous work, Donauer, M., Peças, P., & Azevedo, A. (2015) applied KDD methodologies to databases to identify root causes of NCs, this time focusing on more robust applications in manufacturing. The Herfindahl-Hirschman Index (HHI) is employed to detect patterns within the stored data. The results emphasize that databases, when used in combination with data mining techniques, can reveal patterns that are crucial for understanding the underlying issues in quality management systems.

Ndikuriyo (2015) explores nonconformity management in the context of the European Rail Traffic Management System (ERTMS) by simulating the implementation and collecting nonconformities in databases. The study reveals that inefficiencies in database management led to delays and loss of information, stressing the need for better tools to track and manage nonconformities. This work underlines the importance of database systems in managing and analyzing nonconformities in large-scale industrial projects.

The study by Marques et al. (2019) applies Internet of Things (IoT) technologies for automatic nonconformity detection in a Portuguese metalworking SME. Data is collected and stored in cloud-based databases, which are part of the C2NET project aimed at enhancing enterprise interoperability. The paper discusses the use of the Data Collection Framework (DCF) for real-time detection of NCs, highlighting the role of database systems in managing and analyzing the data collected from various manufacturing processes to improve quality control.

To successfully address scalability challenges in large-scale manufacturing systems, it is essential to consider key factors such as data latency, interoperability, and security, particularly in the era of Industry 4.0, where machine-generated data is integral to optimizing production processes. Gamero et al. (2022) highlight the trade-offs between SQL and NoSQL database systems, demonstrating that NoSQL systems like AWS DynamoDB can reduce latency for known access patterns, while SQL systems such as AWS Aurora MySQL provide greater flexibility for complex queries. High-fidelity load testing can reveal these trade-offs as systems scale from prototypes to full production. In a complementary approach, Vimal et al. (2021) propose reducing latency in smart manufacturing systems through edge computing, which processes data closer to the source rather than relying solely on cloud-based infrastructure. This localized data validation can improve system efficiency, especially in geographically distributed manufacturing environments.

Further exploring scalability, O'Donovan et al. (2015) emphasize the importance of robust big data pipelines in supporting continuous data integration and analysis in large-scale smart manufacturing environments. These pipelines allow for fault-tolerant, scalable processing of data from a wide range of industrial equipment, ensuring real-time decision-making and system uptime. The rapid growth in data volumes generated by Internet of Things (IoT) devices and smart sensors underscores the need for such scalable infrastructure, as noted by Wang et al. (2022), who argue that big data analytics (BDA) plays a central role in empowering intelligent manufacturing systems. They stress the importance of integrating data-driven methodologies to handle the growing complexity and scale of modern manufacturing ecosystems. By incorporating distributed databases, edge computing, and advanced big data pipelines, manufacturers can address the critical scalability challenges, while enhancing performance, reducing latency, and ensuring data security across the entire production lifecycle.

The reviewed literature highlights the pivotal role of databases in enabling effective nonconformity management in Industry 4.0. Across different approaches, from the IQ4.0F framework to real-time management systems for SMEs, and the NC 4.0 risk prioritization model, databases are central to managing the influx of data generated by modern manufacturing processes. They provide the necessary infrastructure for storing, analyzing, and retrieving data that drives continuous improvement efforts, predictive analytics, and decision-making processes. Moreover, the integration of machine learning techniques within nonconformity management frameworks, as demonstrated by Gonzalez Santacruz et al. (2024), showcases the growing reliance on advanced data analytics to optimize quality control processes. The application of risk management tools, as seen in Ravoy's NC

4.0 model, adds another layer of sophistication by enabling organizations to prioritize nonconformities based on their potential impact, further underscoring the importance of data in managing quality. Taken together, these works illustrate how the combination of databases, machine learning, and risk management tools is transforming nonconformity management, moving it from reactive to proactive, and ensuring higher levels of quality in Industry 4.0 environments.

## 4. Conclusions

The application of databases within the context of Industry 4.0 plays a pivotal role in managing non-conformities, enhancing both efficiency and transparency in quality management processes. By integrating Big Data technologies, organizations can collect, store, and analyze vast amounts of data from various stages of production and quality control. This data-driven approach enables the early detection of non-conformities, allowing predictive analyses and AI algorithms to proactively address potential issues. As a result, databases not only support improved quality control but also facilitate faster and more accurate decision-making, minimizing the risk of human error and ensuring greater adaptability in resolving non-conformities.

However, despite the clear benefits, several challenges remain. The implementation of databases in Industry 4.0 requires significant investment in infrastructure, skilled personnel, and cybersecurity measures. Moreover, the integration of ISO 9001 requirements with Industry 4.0 technologies still lacks comprehensive studies, particularly in mapping these standards to digital quality management systems. Future research should focus on developing case studies and use cases that detail specific applications of databases and digital tools in managing non-conformities, as well as conducting thorough economic analyses to justify the substantial investments required.

Another key area for future investigation is the expansion of quality management tools beyond traditional quality control. While databases and predictive quality techniques have been successfully applied in areas such as defect detection and process optimization, there is a gap in the literature regarding the use of these technologies for holistic quality management, including continuous improvement, cost management, and strategic decision-making. Additionally, the integration of spiritual and social dimensions, as proposed in Quality 5.0, highlights the need for research into how emerging AI and data analytics can enhance not only operational processes but also employee well-being and organizational culture.

Addressing these gaps will be crucial for fully realizing the potential of databases in Industry 4.0 and for advancing towards a more socially oriented and sustainable approach to quality management in the future.

Future research should focus on the development of machine learning algorithms specifically tailored to small and medium-sized enterprises (SMEs). Djordjević et al. (2023) highlight the potential of scalable solutions, such as the MEAN stack, for real-time nonconformity management. This is crucial for SMEs, which lack the resources to implement large-scale infrastructure systems. By

utilizing edge devices and databases like MongoDB, this approach offers a cost-effective way for SMEs to automate nonconformity management in line with Industry 4.0 standards.

Additionally, further research should explore the integration of artificial intelligence (AI) with existing database systems. Gonzalez Santacruz et al. (2023) demonstrate how combining Six Sigma's DMAIC methodology with machine learning techniques can enhance nonconformity management through predictive analytics. Integrating AI into such frameworks can further automate the identification and analysis of critical process parameters, enabling SMEs to proactively prevent defects. Moreover, the work by Ravoy and Parmet (2023) on nonconformity prioritization based on risk management principles introduces a new perspective. Future research could investigate how AI can improve these risk management frameworks, allowing for more precise quantification and analysis of risk factors, particularly when dealing with large datasets.

The technical challenges related to the integration of AI and machine learning into existing database systems also require further research. Donauer et al. (2015) emphasize the importance of Knowledge Discovery in Databases (KDD) methodologies for identifying patterns within large datasets. As more SMEs adopt big data and AI technologies, future research should focus on optimizing these database systems to effectively handle the growing complexity and volume of data. This could include the development of hybrid databases that combine the flexibility of NoSQL systems with the robust query capabilities of SQL databases.

In conclusion, future research should be directed towards (1) the development of machine learning algorithms tailored to SMEs, (2) exploring the integration of artificial intelligence with existing database systems for improved nonconformity management, and (3) investigating hybrid database solutions to address the increasing complexity of data in industrial environments. These recommendations provide a clear path for advancing quality management systems and driving innovation in manufacturing processes for both large enterprises and SMEs.

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# THE INTEGRATION OF LEAN, GREEN AND SUSTAINABLE BUSINESS PRACTICES: FROM LITERATURE REVIEW TO THE DEVELOPMENT MODEL

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***Abstract***

*The lean approach is based on more efficient use of resources and eliminating all kinds of waste that do not add value for customers. Lean manufacturing is considered a necessary strategy for generating financial performance and sustainable finance. There are positive links between lean and green paradigms, so the connection has strength in business communities, industry and academia. One of the main aims of this paper is to explore and highlight lean and green synergies and sustainable practices. In addition, this approach is a catalyst for total waste reduction, so the interdisciplinary aspects of sustainable production and consumption are attracting increasing interest. The research describes public policy and institutional conditions for the establishment and development of an integrated waste management system in the Republic of Serbia until 2031. Special attention is to the models which propose the integration the green-lean solutions and the circular economy concept. Through the principle of continuous improvement business entities can enhance the environmental and resource performance aspects.*

***Key words:*** *sustainable finance, lean approach, waste management system, green transition, circular economy.*

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# 1. Introduction

In the corporate world, lean methodology and the green transition are not distinct concepts. The interdependence of lean methodology, green transition and sustainable production and consumption is a leading subject in both academia and industry. Integration of lean-green provides a means to addressing issues faced by manufacturing industries for improved competitiveness. To achieve business excellence and mitigate environmental concerns, companies must implement the right tools and consider the critical success factors. By applying appropriate tools and models, the businesses can achieve a reduction in cost significantly (Elemure, Dhakal, Leseure & Radulovic, 2023).

The integrative approach requires a comprehensive alignment with public policy and institutional conditions. The establishment and development of an integrated waste management system necessitate supportive regulations, policies, and infrastructure to promote sustainable practices. Public policies need to encourage businesses to adopt lean and green principles by offering financial incentives, creating a conducive regulatory environment, and providing access to resources for implementing sustainable waste management systems. Additionally, institutional frameworks play a crucial role in facilitating coordination between various stakeholders, monitoring compliance with environmental standards, and fostering collaborations among industries to align their operations with sustainable practices. By incorporating public policy initiatives and strengthening institutional capacities, the Republic of Serbia can advance towards achieving its waste management goals and transitioning towards a more sustainable and environmentally conscious ecosystem (Waste management program in the Republic of Serbia for the period 2022 – 2031. „Službeni glasnik RS", broj 30/18).

This paper is organized as follows. After introduction, the paper presents a brief theoretical background. Section 3 explains the research design. Subsequently, Section 4 discusses the main findings and recommendations. Lastly, Section 5 highlights the main drivers and barriers for integration lean and green concepts and gives conclusions.

# 2. Theoretical background

Examining the connection between Lean and Green goes back to the early days of Lean the manufacturing process (Martinez & Jirsák, 2024). The integration of Lean and Green in business practices is considered one of the great solutions to balancing operational gains and environmental sustainability. It is condition sine qua non for sustainable finance and development. Lean and green concepts can be integrated as shown in Figure 1.

*Figure 1: Lean and green integration*
*Source: Elemure, Dhakal, Leseure & Radulovic, 2023.*

The latest research shows that Lean and Green are synergistic in most business practices, but they must be managed according to the Operations Strategy, especially as their focuses are essentially different and trade-offs may occur. Figure 2 gives a framework for Lean Green integration and emphasizes some integrated tools such as 7s which is, 5s plus S (safety) and S (sustainability) and Green Lean Six Sigma (Cherrafi, Elfezazi, Chiarini, Mokhlis & Benhida, 2016). There are some systematic studies that focus on integrated approach which can obtain the maximum operational performance without compromising the environment (Leong, et al.,2020).

*Figure 2. Relationships between the concepts, method and results*

*Source: Queiroz, Delai, Alves Filho, Santa-Eulalia & Torkomian, 2023.*

Complementary, holistic understanding of these relationship enables the transition to sustainable business (Caldera, Desha & Dawes, 2019). Some authors

demonstrate that Lean aims to reduce waste in the value chain, to reduce costs and defects and to increase resources efficiency (Garza-Reyes, Kumar, Chaikittisilp & Tan, 2018). Large firms have gained collaborative synergy in the correlation between green practice and sustainability performance of supply chain, however, small and medium-sized businesses (SMEs), who are important stakeholders should also be encouraged to use lean and green practices to support the larger companies in the supply chain (Kosasih, Pujawan, Karningsih & Shee, 2023).

## 3. Research Design and Methodology

This paper integrates both qualitative and quantitative approaches to provide a comprehensive analysis of the integration of lean, green, and sustainable business practices. Data Collection Methods involved primary and secondary data collection methods. Primary data will be gathered through in-depth interviews and observations, while secondary data will be collected from existing relevant literature and reports. The sample size was determined on the concept of data saturation. A comprehensive review of existing literature on lean, green, and sustainable business practices will be conducted to understand the current state of research and identify gaps in knowledge. In addition, a conceptual framework will be developed based on the findings of the literature review to guide the integration of lean, green, and sustainable business practices. The described interdependence could be validated through expert reviews and feedback from industry practitioners to ensure its applicability and relevance in the real-world business environment. The paper gives some recommendations for organizations looking to enhance their business practices through the integration of lean, green, and sustainable initiatives, as well as recommendations for potential directions for future study. By following research design, the paper aims to contribute to the understanding of how organizations can effectively integrate lean, green, and sustainable practices for long-term market success.

## 4. The main findings and recommendations

Table 1 compares the Lean and Green paradigms regarding several aspects: focus of the concept and philosophy, organizational culture, process orientation, performance measurement, management and employee involvement, and supply chain involvement. The analysis shows that the concepts display similarities at the level of resource productivity, organizational change, and source reduction, but implementation can lead to trade-off situations. The main reason is a different generic focus, so this duality needs to be managed in business processes. In this regard, table 1 also systematizes the benefits that companies can expect if they follow the principles of lean and green paradigms in their daily production and service systems.

*Table 1: Lean versus Green Paradigm*

| *Characteristics* | **Lean Paradigm** | **Green Paradigm** |
|---|---|---|
| *Focus and Philosophy* | Waste elimination and continuous improvement. Long term thinking | Reduction of environmental impact and priority to sustainability. Long term thinking |
| *Organizational Culture* | Use of horizontal organizational structure | Reduce environmental impact through cross functional relations |
| *Process orientation* | Improving processes | Develops a sustainable process. Focus on both process and products |
| *Performance Measurement* | Resolves problems through feedback | Evaluation through green reporting |
| *Management Involvement* | Involves top management involvement and satisfaction | Involves management commitment |
| *Employee involvement* | Training and empowerment of employees | Employees should be educated |
| *Supply chain involvement* | Customer focus and close cooperation with suppliers | Involvement of suppliers is essential |
| | **Lean Paradigm** | **Green Paradigm** |
| *Benefits* | Eliminate overproduction by consuming less material and reduce the cost associated with inventory | Circular economy encourages the recycling and reuse of materials |
| | Waiting time is improved upon to reduce production downtime | The cost of energy while operating is reduced |
| | Unnecessary transportation increases the price associated with the product | Emission and carbon footprints caused by unnecessary transportation are reduced |
| | Fewer materials are used by eliminating defects | Less energy usage is attained with the use of the appropriate number of materials |
| | Excessive movement and lifting of materials are completely reduced | Less energy is consumed while eliminating unnecessary motion, lifting and transferring of materials |

*Source: Authors systematization according to Duarte & Cruz Machado, 2017.*

Some studies have suggested several lean-green implementation models used by industries in developed countries:

1. Combined tools framework. The implementation of this model allowed energy consumption reduction. Additionally, using various tools, such as Kanban, 5S, kaizen and visual management, the material usage can be improved (Siegel, Antony, Garza-Reyes, Cherrafi & Lameijer, 2019).
2. Overall greenness performance for value stream mapping (OGP-VSM) model. The main findings refer to the emission of the various processes as well as non-value-added activities were identified (Muñoz-Villamizar, Santos, Garcia-Sabater, Lleo & Grau, 2019).
3. Lean and Green House and maturity model. In order to help eliminate manufacturing waste as well as environmental waste, this process entails identifying and putting strategies into place (Verrier, Rose & Caillaud, 2016).
4. Lean and Green Model. This approach aims to lower average energy use, hazardous waste, and resource use (Pampanelli, Found & Bernardes, 2014).
5. The Sustainable Value Stream Mapping (Sus-VSM) model. This model included not just finding waste and producing value cheaply, but also evaluating the workers' ergonomic conditions (Faulkner & Badurdeen, 2014).
6. Gemba-Kaizen model. It demonstrated how the lean green implementation methodology may aid in enhancing the companies' environmental and operational performance (Cherrafi, et al., 2019).

The mentioned models provide a customer-centric application and highlights the eliminating different Lean production waste (transportation, inventory, motion, waiting time, overproduction, over processing, defects) which can provide numerous benefits such as reduced lead time, improved financial performance, reduced risk, increased customer satisfaction, quality, and efficiency (Fercoq, Lamouri & Carbone, 2016). Considering all the above, it can be stated that a universally accepted model for integration lean and green implementation is lacking to achieve balance sustainability, environmental responsibility, and operational excellence. The future research should be focused on developing a decision-making model facilitating lean tool implementation based on a company’s priorities for economic and environmental performance.

## 5. Conclusion

On the one hand, the main drivers to integration of lean and green practice are: market pressure and expectations, foreign investment, long term economic benefits and performance, management and workers commitment, positive government policies and regulations, reduced waste and lower cost of manufacture, technological transfer and innovation, research and development and workers training. On the other hand, lean barriers are lack of expertise and technical training, low technological capabilities, lack of continuous improvement culture, requires financial capital. The key green barriers are less interest in environmental issues

and resistant to change, lack of environmental awareness, recycling can be expensive and challenging.

It is evident that the integration of lean, green, and sustainable business practices is vital for achieving competitive advantage and addressing environmental concerns in industries. The synergies between lean and green paradigms can lead to enhanced operational efficiency, reduced waste, and improved sustainability performance. Various implementation models have been highlighted, such as the Combined Tools Framework, OGP-VSM Model, Lean and Green House Model, Sustainable Value Stream Mapping, and Gemba-Kaizen Model, which offer strategies for reducing energy consumption, improving material usage, and eliminating waste in both production processes and environmental practices. To sum up, the integration of lean and green practices not only fosters operational excellence but also contributes to sustainable development and resource efficiency in businesses. By adopting appropriate tools and models tailored to their specific needs, companies can achieve cost savings, environmental benefits, and competitive advantages. Encouraging the implementation of lean-green approaches among both large corporations and SMEs is essential for creating a more sustainable supply chain and promoting a circular economy that prioritizes environmental impact mitigation alongside operational effectiveness.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# SMART SOLUTIONS FOR SMART CITIES - VETSOL (Application of renewable resources in urban areas)

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***Abstract***

*This paper introduces VETSOL, an innovative energy island designed to promote self-sustainability in smart cities by generating the necessary energy for lighting, signaling, monitoring, and management. VETSOL supports the trend of sustainable urban development by generating renewable energy for various city functions. The paper will present VETSOL's capabilities in generating energy through solar panels and wind generators, enabling efficient lighting of intersections and road sections, supporting light signaling, and providing video surveillance for main highways and intersections. Additionally, VETSOL facilitates the distribution of information necessary for optimizing traffic flow in smart cities.*

***Key words:*** *smart cities, green energy, traffic, solar panels, wind generators.*

## 1. Introduction

This work includes concrete practical solutions applicable in modern urban environments. When a smart city is mentioned, most of the stories usually come down to concepts, but not specific solutions or technical improvements. The application of new technologies supports a structure that enables the collection and processing of a large amount of information. Smart solutions usually imply a more rational use of resources or their new application to improve the quality of life in smart cities. Assessment of the level of development and quality of solutions is usually obtained by comparing living conditions in individual cities.

By recognizing unused potentials, we give a new use value to structures and constructions that are present in cities, and can serve for a more rational and quality life of people in the city. The specific application of renewable energy sources with the generation and use of energy in the immediate vicinity of the source enters the spheres of smart use of energy, reduction of environmental pollution, support for other systems that give the epithet "smart" to such cities. The harmony of the use of

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wind energy, the sun and alternative energy sources (air masses triggered by the movement of vehicles in traffic) increases the utilization of hybrid resources that will be presented in the work. Here, solutions are considered and offered that use available components with a superstructure that enables the realization of energy islands. The energy generated is used for lighting, signaling, powering communication and monitoring units, and even charging electric vehicles (E-bike, E-scooter, E-taxi, E-bus, future E-aviotaxi).

Regardless of which aspect of life we touch, it has consequences in many independent areas, and the ultimate consequence is raising the quality of life of citizens. Energy islands represent new solutions that increase security in large centers in urban areas, and at the same time support the application of technologies to obtain configurations and solutions characteristic of smart cities. The rationalization of the use of existing installations increases the energy efficiency, safety, and usability of structures and facilities located in smart, urban environments.

The technical solutions offered impact all domains that give the label "smart" urban environment: successful generation and rational use of energy, work without pollution in the immediate environment (Figure 1), awareness of the state of the environment, support for traffic control, supervision, and regulation.

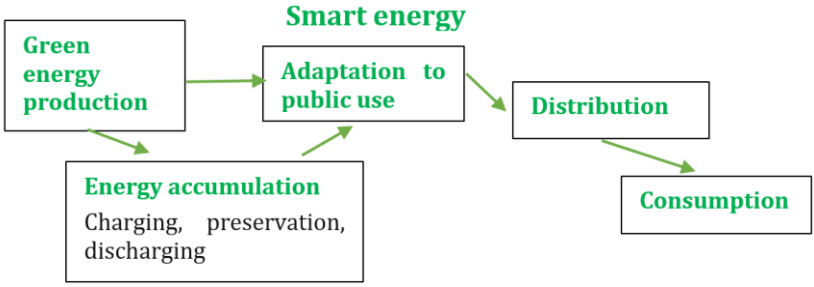


*Figure 1. Smart energy structure*

Today, when we talk about smart energy, we usually consider the production, accumulation, distribution and consumption of energy with minimal negative impact on people and their environment. Green energy implies the use of renewable sources such as: solar energy, wind energy, energy obtained from biomass. It is also known that the contribution to the final energy balance is variable and depends on which source we are looking at, so in addition to the possibility of obtaining electricity, a significant factor is related to its temporary accumulation. The increase in capacity and the reduction of losses during charging, preserving and discharging of the accumulator significantly affect the rationality of the energy system. There are several options for energy storage, but the most commonly considered are the use of chemical sources such as Li-ion and Na-ion batteries, but more and more people are pointing to the great potential that lies in the use of hydrogen in internal combustion units as well as in fuel cells. Both mechanical and thermal energy accumulators are in use. In urban areas, at least with existing solutions, chemical energy sources have proven to be the most practical.

## 2. Green energy production

Characteristic of our solution is the production of energy in the urban environment in the immediate surroundings where the consumers themselves are located. This enables rational use of energy without transmission losses. VETSOL combines several different devices that use several forms of renewable energy sources in parallel.

VETSOL 1 (Figure 2) – Vertical wind turbine with solar air deflectors, solar coating over the turbine blades and the option of direct energy conversion into a usable form or temporary storage options.

Air deflectors concentrate the movement of air masses (from the wind or driven by the movement of vehicles) towards the active part of the wind turbine, which increases the efficiency of the device. At the same time, we use the air deflectors as solar panels with two faces, so they are also used for direct conversion of solar energy into electricity. Flexible, high-efficiency, photovoltaic panels are used to cover the turbine blades so that part is also a photovoltaic panel. Using slip rings, the generated energy is fed to the charger or electrical converter. Placement of the device is planned on traffic islands.

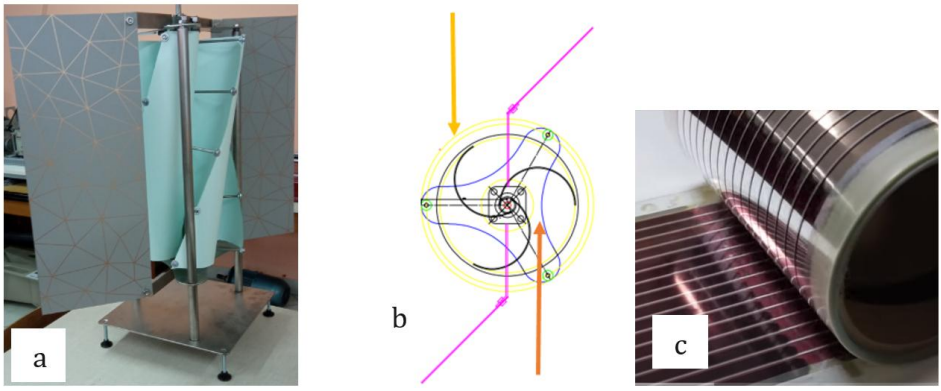


*Figure 2. VETSOL 1 a. physical layout, b. traffic-driven air routing, and c. flexible, high-efficiency photovoltaic panel.*

VETSOL 2 (Figure 3) – Horizontal, helical wind turbine mounted on a modified roadside guardrail. The protective fence is an adapted construction that carries a flexible, high-efficiency, photovoltaic foil, so it itself represents a photovoltaic panel. The segments of the fence were reconstructed in order to obtain a larger active surface for the photovoltaic system, and at the same time to obtain an air deflector for the wind turbine that uses wind energy and the energy of the masses set in motion by the movement of traffic. LED lighting segments are placed on the segments of the protective fence, but in such a way that they do not dazzle the drivers, and enable good lighting of certain sections of the road. The light is right next to the road, so it is much more effective lighting than the components placed on high candelabras.

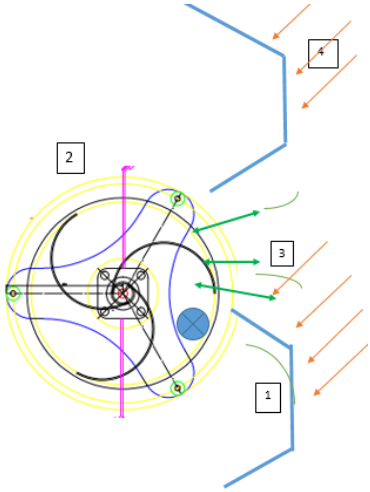


*Figure 3. VETSOL 2 - 1. Protective fence at the same time solar panel, air deflector and LED lighting support 2. Spiral wind turbine with axis in horizontal position 3. Air flow 4. Sun rays*

What is recognizable within the analyzed solution is the simultaneous use of solar energy, wind energy and energy of air masses set in motion by vehicle movement.

## 3. Energy accumulation

Today, when we talk about smart energy, we usually consider the production, accumulation, distribution and consumption of energy with minimal negative impact on people and their environment. Green energy implies the use of renewable sources such as: solar energy, wind energy, energy obtained from biomass. It is also known that the contribution to the final energy balance is variable and depends on which source we are looking at, so in addition to the possibility of obtaining electricity, a significant factor is related to its temporary accumulation. The increase in capacity and the reduction of losses during charging, preserving and discharging of the accumulator significantly affect the rationality of the energy system. There are several options for energy storage (Figure 4), but the most commonly considered are the use of chemical sources such as Li-ion and Na-ion batteries, but more and more people are pointing to the great potential that lies in the use of hydrogen in internal combustion units as well as in fuel cells. Both mechanical and thermal energy accumulators are in use. In urban areas, at least with existing solutions, chemical energy sources have proven to be the most practical.

Usually, the minimum dimensions, costs and density of the accumulated energy decide which solution we will apply. All important attributes are respected by modern chemical sources, which, in addition to large capacity, also have the possibility of fast charging as well as a large number of working cycles without reducing or impairing the working characteristics. This area is also in great

expansion and more and more rational and better solutions are constantly being found.

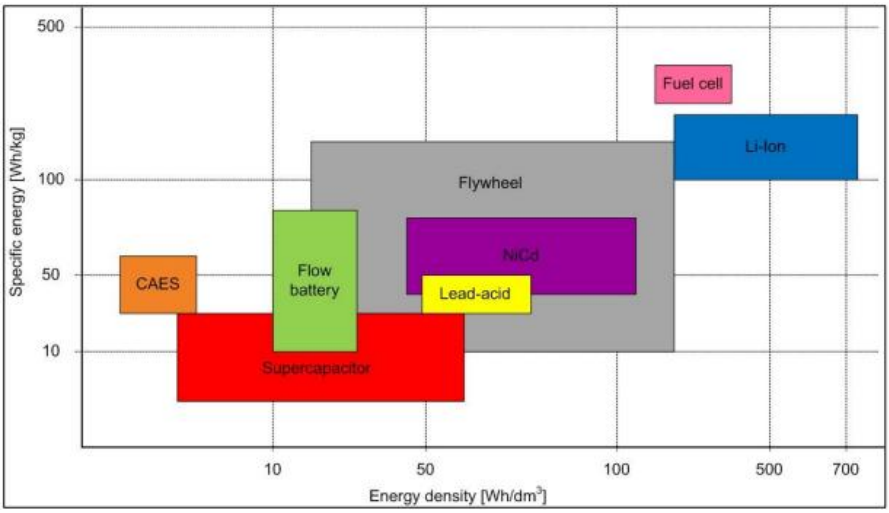


*Figure 4. Different technologies for energy storage and its density*

Usually, smart energy use means storage and rational use, and **smart charging** is also shown here on Figure 5.

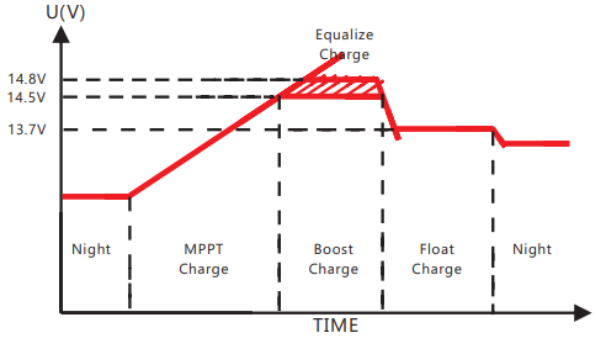


*Figure 5. Smart charging - Magic series controller has a 4-stage battery charging algorithm for rapid, efficient, and safe battery charging.*

**MPPT Charge** - In this stage, the battery voltage has not yet reached boost voltage and 100% of available solar power is used to recharge the battery.

**Boost Charge** - When the battery has recharged to the Boost voltage setpoint, constant-voltage regulation is used to prevent heating and excessive battery gassing.

**Float Charge** - After the Boost voltage stage, the controller will reduce the battery voltage to Float voltage setpoint. When the battery is fully recharged, there will be no more chemical reactions and all the charge current transmits into heat

and gas at this time. Then the controller reduces the voltage to the floating stage, charging with a smaller voltage and current

**Equalize Charge** - Certain types of batteries benefit from periodic equalizing charge, which can stir the electrolyte, balance battery voltage and complete chemical reaction. Equalizing charge increases the battery voltage, higher than the standard complement voltage, which gasifies the battery electrolyte.

## 4. Adaptation to public use

Central inverters convert DC power from solar panels or DC accumulation to AC power that can be used by homes or businesses or can be connected to the grid. To maximize efficiency and improve reliability, manufacturers are beginning to seek innovations that cut costs, create smart grid features, and standardize monitoring and control interfaces (Mamadaminov, 2014). New solutions provides designers with high-quality and reliable components that save space without sacrificing power, including off-board power connectors, terminals and splices. DER inverters are continually evolving – newer systems have advanced features that are compatible with smart grids. In addition, DER inverters are being enhanced with sensors and monitoring tools for use as energy management centers. There has been much discussion about how to implement maximum power point tracking (MPPT) to achieve high system efficiency and smart functionality from the perspective of the power generation system. Later, however, the need for grid-supporting functions to realize ancillary services such as voltage regulation in addition to general functions began to be actively discussed. So-called “smart inverters” provide such ancillary services by offering flexible control of the active/reactive power of DERs (de Carvalho et al., 2020). On the other hand, current source inverters, which have been often used in PV interconnection, cannot operate without AC voltage generated by other generators connected to the grid. These inverters themselves generally do not generate voltage and follow the voltage on the grid side, so they are called grid-following (GFL) inverters. These GFL inverters have been used not only for PV but also for BESS interconnection. In many real-world implementations, wind power interconnection is also being considered, in which the AC generated is converted to DC and sent to the grid via a GFL-type inverter. Therefore, there is a concern that a large number of grid-following-type DER inverters will lead to a relative lack of inertia contributed by conventional power generation facilities on a grid scale. Thus, DER inverters that have a voltage source called grid-forming (GFM) inverters (Ducoin et al., 2023), which create such inertial forces and enable frequency control and voltage magnitude control, are being developed to provide even smarter functionality.

## 5. Energy distribution

The use of VETSOL devices is for the time being planned for the supply of devices related to traffic control and providing power supply:

1. The system for lighting road sections, intersections, toll plazas, rest areas,

2. The system for auxiliary signaling of displaced objects in relation to the distribution network,
3. The system for distributing data on traffic conditions (fog, congestion, works,...). Powering control circuits, sensors, but also microcomputer components as well as communication equipment,
4. Video surveillance system (cameras at intersections, toll plazas, control points),
5. Information systems at bus stops.
6. Supplying roadside advertising panels,
7. Charging and supporting new traffic surveillance drones,
8. All future installations that will be used in autonomous driving.

Additional options related to island operation, connection of distributed units or direct connection to the distribution network are considered. If there is no system for energy accumulation, then the use is limited, but at the same time we get a high degree of usefulness because all the produced energy is directed directly to the network, so we do not have the typical losses that occur when charging, storing and discharging the accumulation.

Accumulation enables better balancing due to the uneven period of generation and use of the necessary energy. We adapt the configuration of the system to the requirements of the environment.

## 6. Conclusion

VETSOL units support traffic flow in smart cities. The capacity, the number of units (devices) determines the possible application in selected environments. Installation of the device does not require a large space and is easily implemented in the existing traffic infrastructure.

The construction of the device enables operation in outdoor conditions. Adequate protection of all electrical and mechanical circuits is used. Rotating brushes are used for washing and maintenance of the panels that are placed on the protective fence, which are easily adapted to vehicles that are normally used for road maintenance and usually drive mobile lawn mowers through a special arm.

The return signal from the panel can be used to identify damage to the protective fence on a certain road section.

By using VETSOL devices, smart cities receive essential support that enables increased traffic safety, as well as help in the event of an emergency situation and the need for additional signaling or data storage and distribution to both traffic participants and services in charge of traffic regulation.

The use of VETSOL devices enables the expansion of the use of intelligent intersections.

Intelligent roads are roads equipped with technological tools that interact with the environment to enable safe and efficient traffic. An intelligent road system combines physical infrastructure (such as sensors and solar panels) with software infrastructure (such as artificial intelligence and data).

*Figure 6. Intelligent road*

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# APPLICATION OF SOLAR ENERGY IN WATER TREATMENT

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***Abstract***

*In addition to the already well-known application in metal production, electroplating, electrochemical energy sources, electrochemistry is also applied in other branches of industry. Today, electrochemical technologies for the treatment of wastewater and drinking water are increasingly present. In recent years, new advanced oxidation processes based on electrochemical technology - Electrochemical advanced oxidation processes (EAOPs), have been developed for the treatment of persistent pollutants, which cannot be removed by conventional water treatments. EAOPs are based on "in situ" electrolytic formation of strong oxidants in an electrochemical reactor, able to degrade almost all organic pollutants. Despite their effectiveness in degrading different types of pollutants, the biggest challenge for EAOPs is high electricity demand to power these systems, which can have serious consequences from both an ecological and an economic point of view. The use of electricity from the distribution network to power electrochemical reactors is the biggest barrier to achieving commercial success of this technology. A possible solution to this challenge is the application of direct solar UV radiation to produce electric energy by use of a solar photovoltaic (PV) arrays for power supply of EAOPs. The aim of the research was to demonstrate the feasibility of using EAOPs directly powered by PV systems, as a sustainable system for efficient water treatment.*

***Key words:*** *green energy, EAOPs, water pollution*

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# 1. Introduction

There is an increasing demand for sustainable wastewater treatment (WWT) systems. When choosing WWT technologies, the impact of factors such as efficiency, sustainability, compliance with environmental regulatory standards and technology costs, should be considered (Gallego Schmid & Tarpani, 2019).

In the conventional WWT (coagulation, biological and chemical oxidation, etc.) many pollutants are only partially removed or even "pass" unchanged through WWT plants. Some of these pollutants can have serious consequences for human health and the environment. On the other hand, with advanced technologies it is possible to obtain high quality water.

Advanced oxidation processes (AOPs) are one of the most efficient methods for treatment of wastewater containing organic pollutants. AOPs are based on the *in situ* production of strong oxidants, mainly hydroxyl radicals (OH·), which are one of the most powerful oxidizing species, capable of unselective oxidizing any organic pollutant to complete degradation or their transformation into less toxic by-products (Khan et al., 2020). AOPs in which the initiator of the OH· formation is electricity are named electrochemical advanced oxidation processes (EAOPs). These processes are based on the electrolytic *in situ* generation of OH· in an electrochemical reactor (ECR) and include processes such as electrochemical oxidation, electro-Fenton, photoelectrochemical and sono-electrochemical technologies, and capacitive deionization (Malinović et al., 2021). Generally, these processes do not require the addition of reagents, and pollutants are degraded by direct oxidation on the anode surface or indirectly oxidized by OH·, or other active species such as chlorine compounds, $O_3$, persulfates and $H_2O_2$, air (Poyatos et al., 2010; Moreira et al., 2017). The advantages of EAOPs include high energy efficiency, possibility of automation, easy handling, simplicity of equipment and safety work. Disadvantages of the process are related to the low conductivity of many wastewaters, which requires the addition of supporting electrolytes (salts), costs of electricity supply, loss of activity and shortening life of the electrodes due to the deposition of organic matter on its surface (Sires et al., 2014).

Costs analysis of the electrochemical WWT shows that the main costs are investment and electricity costs for electrolysis. Investment costs include costs of designing and manufacturing of ECR, the addition of supporting electrolyte if the wastewaters conductivity is low, and the purchase of electrode materials. However, the biggest costs and at the same time the main disadvantage of the EAOPs are the costs of electricity for water electrolysis (Muddemann et al., 2021).

The use of renewable energy, such as solar photovoltaic cells, as an energy source for powering EAOPs is developing in recent years and is currently a interesting topic in which direct powering and the use of intermediate components for energy storage (batteries) are being investigated for obtaining efficient integrated technology. It is important to note that PV produce direct current (DC), which can be directly used by the EAOPs system. The direct use of electricity from the PV array to the ECR could provide energy autonomy for solar EAOPs as it does not require any connection to the grid (GilPavas et al., 2018; Valero et al., 2010).

Although it is still under development for optimization and further improvements, numerous results on independent, so-called "off-gird" PV modules that drive the electrochemical degradation of various organic pollutants at the laboratory/pilot level are literary available. In several studies, the electrodialysis process powered by PV cells was used for the treatment of groundwater (AlMadani, 2003), brackish water and reverse osmosis concentrate (Uche et al., 2013; Herrero-Gonzalez et al., 2018). In the largest number of studies, the electrooxidation (EO), as the most popular EAOPs, powered by PV cells (PV-EO) was used for the treatment of various wastewaters and pollutants. The PV-EO system proved to be effective in the treatment of river water (Ochiai et al., 2010), domestic wastewater (Cho et al., 2014), wastewater contaminated with phenol (Park et al., 2008), Remazol RB 133 dye (Valero et al., 2010), Methyl Red dye (Nie, et al., 2020), 2,4-dichlorophenoxyacetic acid (Souza et al., 2015), 2-nitrophenol (Nie et al., 2016). Also, the electro-Fenton process powered by PV cells has proven to be efficient for the treatment of textile industry wastewater (GilPavas et al., 2018) and the removal of Brilliant Blue FCF dye (Ganiyu et al., 2019).

### 1.1 Materials and methods

The experimental part of the research presents the application of EO process powered by PV array (PV-EO) for the removal of textile azo dye from synthetic wastewater (SWW) prepared in laboratory. The batch ECR was 500 $cm^3$ capacity, in which electrodes of the same dimensions (60x50x2 mm) are placed. ECR was powered by electricity obtained from the monocrystalline silicon PV solar panel nominal power of 170W, a maximum current of 8.33 A and a maximum voltage of 20.41 V (SolarFAM, Netherland). The panel is placed on the roof of the Faculty of Technology University of Banja Luka (angle 45°, south oriented). Solar charge controller (MPPT) (SolarFAM, Netherland) was connect between PV and the 12 V batterie (MK Powered, 12 V/74 Ah) to ensure maximum electric energy available was always drawn from solar cells. The batterie was connected directly to output DC voltage regulator to regulate the current supply to the ECR. The experimental setup for PV-EO process is shown in Figure 1.

All experiments were performed at an ambient temperature (≈20°C) with initial SWW volume of 400 $cm^3$. For the preparation of SWW, *Bemacid Red E-TL* (BR) dye (CHT GmbH, Germany) was used and sodium chloride, 99.5% NaCl (Lachner, Czech Republic) was added as supporting electrolyte to increase electrical conductivity of SWW. The initial dye concentration was approximately 100 mg/L. Exact concentration before and after treatments was determined spectrophotometrically (PerkinElmer, LAMBDA 25).

Stainless steel, EN 1.4301 (SS) and graphite felt (GF) were used as cathodes and mixed metal oxides (MMO) were used as anodes: Ru mixed oxide (Ti substrate coated with 6g $Ru/m^2$) and Ir-Ru mixed oxide (Ti substrate coated with 6g $Ru-Ir/m^2$), (Metakem, Germany). Different combinations of anode : cathode pairs were placed in the ECR, connected to the output DC regulator and the current density was adjusted to 5 $mA/cm^2$ value (which in this case corresponded to a current intensity of 0.3 A).

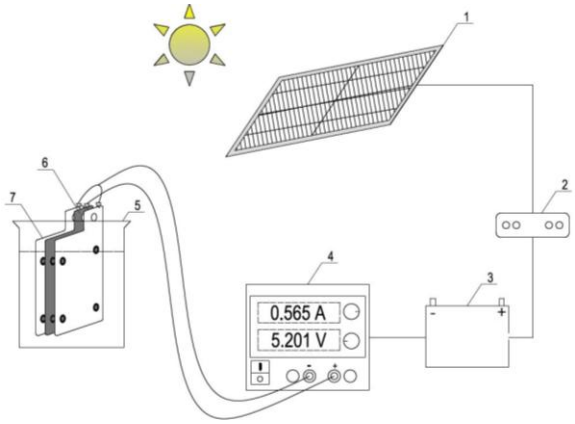


*Figure 1. Scheme of PV-EO experimental setup (1- solar panel, 2- MPPT; 3- battery, 4- voltage and current regulator, 5- electrochemical cell, 6- anode, 7-cathodes)*

## 2. Results

The results of BR removal from SWW by the PV-EO processes are expressed through the removal efficiency ($E$, %) and calculated according to the equation (1), where $c_i$ and $c_f$ are the initial and final concentration of BR expressed in mg/L.

$$E = \frac{c_i - c_f}{c_i} \cdot 100\% \quad (1)$$

The electrical energy used to remove a unit of pollutant or to treat unit of wastewater volume represents one of the most important technological indicators of the ECR operation, because it affects the overall cost of treatment. Specific energy consumption ($W_{sp}$) is calculated according to the equation (2), where $I$- is current [A], $U$- voltage on the electrochemical reactor [V], $t$- time [h], $m$- mass of the removed pollutant [kg], $V$- volume of wastewater [m$^3$].

$$W_{sp} = \frac{U \cdot I \cdot t}{m_{pollutanta}} \left[\frac{kWh}{kg_{pollutanta}}\right] \text{ or } W_{sp} = \frac{U \cdot I \cdot t}{V_{wastewater}} \left[\frac{kWh}{m^3}\right] \quad (2)$$

In this research, the impact of electrode material, electrolysis time and supporting electrolyte concentration on dye removal efficiency were examined and the energy consumption was also calculated. The results of the PV-EO process are shown in the following graphs (Figure 2, Figure 3 and Figure 4).

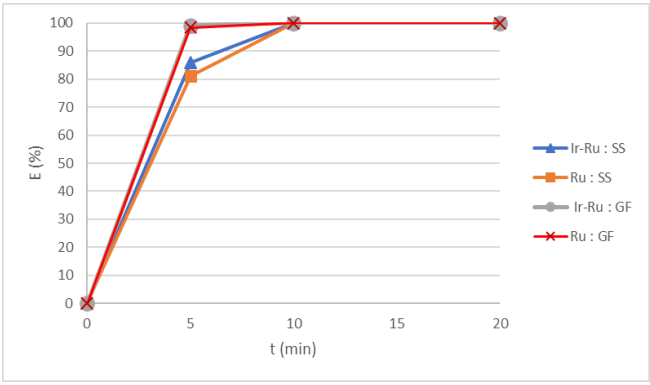


*Figure 2. The impact of electrode material on BR dye removal efficiency at different treatment time (j= 5 mA/cm²; $c_{NaCl}$= 2g/L)*

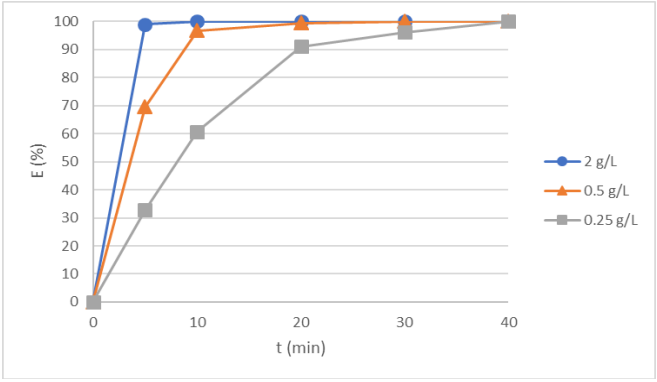


*Figure 3. The impact of supporting electrolyte concentration on BR dye removal efficiency at different treatment time (j= 5 mA/cm²; Ir-Ru : GF electrode pair)*

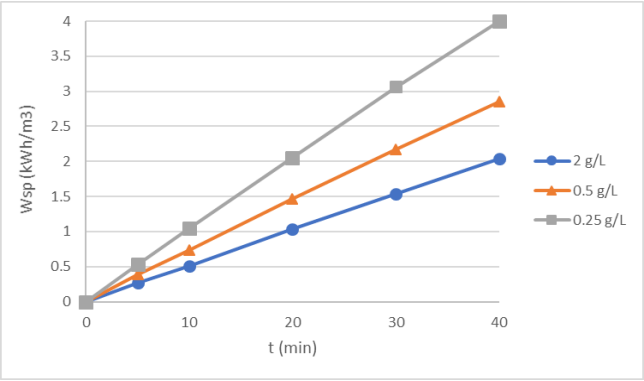


*Figure 4. Energy consumption at different supporting electrolyte concentration and different treatment time (j= 5 mA/cm²; $c_{NaCl}$= 2g/L)*

## 3. Discussion

The anodes are divided into "active" and "inactive" electrodes. "Active anodes" (low oxygen evolution overpotential) are good electrocatalysts for oxygen evolution (e.g., $IrO_2$, Pt, $RuO_2$), and "inactive anodes" (high oxygen evolution overpotential) are poor electrocatalysts for the oxygen evolution overpotential (Malinović et al., 2021). The anodes used in this research are "active" and known for their electrocatalytic activity for chlorine evolution. These anodes have good electrocatalytic properties, but also long-term mechanical and chemical stability. Thanks to these properties, chlorine evolution activity can be effectively utilized for disposal of organics through the generation of active chlorine via indirect oxidation (Jiang et al., 2021; Feng et al., 2016). Based on the obtained results shown in Figure 2, it can be observed that treatment is highly efficient and almost complete BR dye removal is achieved in 10 minutes of treatment with all tested electrode pairs. Both MMO anodes are very efficient, but Ir-Ru MMO shows a slightly higher efficiency with a shorter treatment time. As a cathode material, GF proved to be efficient than SS. Since GF is a significantly cheaper material compared to SS, only electrode pair Ir-Ru: GF was used in the further research.

As the treatment proved to be effective in a very short time and it was shown that cheap cathode materials can be used, further research focus on reducing the concentration of the supporting electrolyte. Supporting electrolyte is necessary where conductivity of the wastewater is low. Electrical conductivity is directly related to the voltage on the ECR. When the water conductivity is higher, the voltage on the ECR is lower and consequently the lower $W_{sp}$, in accordance with equation (2). In all performed experiments NaCl was chosen, as one of the commonly used supporting electrolytes (Jiang et al., 2021). In addition to increasing the conductivity of water, chlorides present in water can be easily oxidized to chlorine and other reactive chlorine species (hypochlorite, hypochlorous acid) (Sires et al., 2014). In this way, in addition to the OH· formed *in situ* in ECR by the electrolysis of water, these reactive chlorine species increase the rate of oxidation and decomposition of

organic pollutants in water. From Figure 3 it can be seen that by reducing the NaCl concentration, removal efficiency decreases and a longer time is needed for complete dye removal. Also, as the NaCl concentration decreases, energy consumption increases (Figure 4).

In the EAOPs supplied with electricity from the distribution network, extending the treatment time is not desirable, because more energy is consumed, which makes the process more expensive. In that case, supporting electrolyte concentration is increased in order to reduce the voltage on the reactor and reduce the treatment time - and thus the treatment cost. But, since in these experiments the ECR was supplied with electricity from a solar panel, it provided the possibility to use lower NaCl concentrations and longer treatment times. In this way, the cost related to the addition of supporting chemicals is reduced.

In order to use energy more efficient and further simplify the process, direct connection of PV array to the ECR can be performed and use of storage battery systems can be avoid. This clearly contributes to the efficient use of energy (no energy losses in battery charge-discharge cycles) and reduces investment and maintenance costs of the storage system. But, changes in the intensity of solar radiation during the day lead to significant energy fluctuations, so the ECR is powered by a non-constant energy source. This power profile can affect the performance and efficiency of WWT (Souza et al., 2015). For the stated reason, the experiments were performed only by using the current stored in the battery.

The price of electricity varies from country to country. For example, currently the electricity price for industrial use in Europe is between 0.023 - 0.262 € per kWh/m$^3$. Treatment of 1 m$^3$ of wastewater containing BR dye as a pollutant, under experimentally determined treatment conditions ($c_{NaCl}$= 0.25 g/L, j= 5 mA/cm$^2$) costs between 0.092 - 1.048 € for 40 minutes of treatment. Under these conditions, the electrochemical process enables the maximum BR removal (100%) to be achieved. This is one example of a very cheap treatment. However, in accordance with equation (2), energy consumption can be calculated per 1 kg of removed pollutant. In this case, the energy consumption for removing 1 kg of BR dye under the specified conditions amounts to 0.39 - 4.53 €. This can still be considered as cheap treatment, but one must keep in mind that some of the treatments would be significantly more expensive. This means for more polluted wastewater, the treatment would take longer, and therefore energy consumption would be higher.

## 4. Conclusions

Electrochemical technologies in WWT have great potential. From an environmental point of view, they have an advantage over conventional WWT, due to their high efficiency in the removal of pollutants and the fact there is no use additional chemicals, or it is used smaller quantities. The main lack in their mass application is economic profitability. It is necessary to invest additional research efforts in order to reduce price of electrode material, extend electrodes lifetime, reduce energy consumption and use renewable energy sources. This research shown that electrooxidation processs powered by renewable energy from solar

panel can be efficient, sustainable and cost-effective treatment for dyes removal from textile industry wastewaters. Finally, it can be concluded that EAOPs in combination with green renewable energy sources have great potential for their implementation and adapting the process on a commercial scale.

## Acknowledgments

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# STRATEGIES FOR MINIMIZING SICKNESS ABSENTEEISM IN INDUSTRY 5.0 MANUFACTURING SETTINGS

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***Abstract***

*This paper aims to investigate how aspects of health and job characteristics can predict sickness absenteeism in the manufacturing sector, a critical concern in the context of Industry 5.0 and advanced manufacturing. As Industry 5.0 emphasizes human-centric and sustainable approaches, understanding and managing employee well-being is paramount. The research was conducted among 175 participants of different socio-demographic characteristics. The variables were operationalized with a test battery that included - the Mental Health Inventory (MHI - 5; Berwick et al., 1991), The General Heath Questionnaire (GHQ-12, Goldberg & Hillier, 1979), Job Characteristic Inventory (JCI, Sims et al. 1976), and the rate of the sickness absenteeism was measured by the self-reported question: During the past 12 months, how many days in total were you absent from work due to illness? The results have shown that different aspects of health and specific job characteristics determined sickness absenteeism in correlation and prediction. The results underscore the importance of aligning health management strategies with the principles of Industry 5.0, ultimately contributing to enhanced operational efficiency and sustainability in the manufacturing sector. This research not only addresses current challenges but also provides a framework for future studies aimed at improving workforce well-being in advanced manufacturing settings providing preconditions for sustainable workplaces in the manufacturing sector.*

***Key words:*** *Industry 5.0, absenteeism, job characteristics, health.*

## 1. Introduction

The physical presence of employees in their workplaces is an issue that cuts across all organizations. Current reasons for absenteeism highlight the great need for solving this problem in the future. Absenteeism regarding employees is the omission or failure to show up at work at a predetermined time (Swaminathan,

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2010). Sickness absenteeism is further segmented into illness absenteeism which occurs when an employee misses work due to illness or health issues which is often common in many organizations.

Absenteeism is a common concern in every organization and influences the financial performance of the company (Nath et al., 2022). Many employees stay absent without giving any notice. It has been found in studies that less than half of the employees keep records of the absenteeism indexes or have a system put in place to try to eradicate it (Nath et al., 2022) Such complacency can further compound the concerns that are already bedeviling organizations since they do not tackle the reasons why absenteeism exists and instead focus on solving its effects.

Sickness absenteeism has been a problem for manufacturers for a long time. This problem remains an important area of concern especially now that the industry is in the age of Industry 5.0. Sickness absenteeism is inefficient amid production activities, but resorts organizations to additional costs, loss of output, hideous revenue, and excess burden on workers left in the organization (Mikalachki & Gandz, 2005). Thus, manufacturers must rethink their approaches to this problem by adopting strategic solutions based on the health of employees, and the organizational environment.

### 1.1 Research problem

Health, job characteristics, and sickness absenteeism among the employees of manufacturing companies have drawn interest in the context of Industry 5.0. With the achievement of Industry 5.0, there was less focus only on the efficiency of production systems but also on the interaction between people and machines and the application of new technologies to enhance productivity.

Within the workplace context, it has been stated that when job demands are successfully surpassed regardless of the work undertaken, mental health will deteriorate which will result in higher sickness absences. There is more around the issue of the dread of being made redundant because of automation because of the increase in absenteeism.

There is a link between general health which includes emotional, and psychological well-being with the levels of absenteeism in the manufacturing sector. Yet the progress of the progression of Industry 5.0 has eliminated some of the unpleasing job characteristics including shift work, long hours, and repetitive work, and poor work habits such as lack of work-life balance have detrimental effects on worker's overall health (Marecki, 2024). Studies indicate that people can address some of these health risks and reduce the absenteeism by changing work patterns, giving more freedom in planning schedules, and reducing physical demands (Grønstad et al., 2019).

The job characteristics have a lasting effect on both mental and physical health with an immediate impact on absenteeism in the Industry 5.0 environments. The Job Demands-Resources model recognizes that when high job demands are placed without attachment of sufficient resources, the worker is likely to experience such consequences as burnout, mental fatigue, and absenteeism (Bakker & Demerouti, 2017). Although the examination of Industry 5.0 has heightened

cognitive demands, additional resources have also been incorporated such as real-time AI systems support as well as good quality decision-making tools, which reduce the effect of job strain (García-Madurga et al., 2024). However, ambiguity in organizational roles and role overload given technological advancements, persist in exposing occupational stress and absenteeism to high levels (Ioannou, 2023). It is important to manage and mitigate the unreasonable workload by providing sufficient resources and a reasonable level of absenteeism in the workplace (Gagnon et al., 2017).

Based on the research problem identified, the research question can be stated as follows: 'In the perspective of Industry 5.0 employment, how do mental health, general health, and characteristics of the job in the organization affect sickness absenteeism in a manufacturing organizations?'

## 2. Method

### 2.1 Sample

The research was conducted on a sample of 175 respondents, employed in large companies from the manufacturing sector. In terms of socio-demographic features, the research included 74 (42.3%) female respondents and 101 (57.7%) male respondents. In terms of education, 118 (67.4%) respondents completed high school, 26 (14.9%) completed college, 16 (9.1%) completed a bachelor's degree, while 15 (8.6%) of them completed master's studies.

*Table 1: Sample structure*

| Category | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| **Male** | 74 | 42,3 | 42,3 | 42,3 |
| **Female** | 101 | 57,7 | 57,7 | 100,0 |
| **Highschool** | 118 | 67,4 | 67,4 | 67,4 |
| **Higher School** | 26 | 14,9 | 14,9 | 82,3 |
| **Bachelor** | 16 | 9,1 | 9,1 | 91,4 |
| **Master** | 15 | 8,6 | 8,6 | 100,0 |

The age of the respondents ranged from 21 to 60 years (M = 36.36; SD=9.25). The respondents' work experience ranged from 1 to 39 years (M = 11.04; SD = 8.441).

*Table 2: Descriptive statistics of the variables age and length of service*

| Variables | N | Min | Max | M | SD |
|---|---|---|---|---|---|
| **Age** | 175 | 21,00 | 60,00 | 36,36 | 9,258 |
| **Length of service** | 175 | 1,00 | 39,00 | 11,04 | 8,441 |

### 2.2 Measures

The Mental Health Inventory - MHI-5 (Berwick et al., 1991) was used to operationalize the mental health variable. The questionnaire consist of 5 questions,

with the original six-level ordered category item format. It includes questions related to both positive and negative aspects of mental health.

The General Heath Questionnaire (GHQ-12; Goldberg & Hillier, 1979) was used to measure the employee's general health. The GHQ-12 is a version of the questionnaire, derived from the original 60-item General Heath Questionnaire (The General Heath Questionnaire – GHQ, Goldberg, 1978). The questionnaire consists of 12 items on a five-point Likert-type scale

Absence from work due to health issues at the workplace was operationalized by the question: "During the past 12 months, how many days in total were you absent from work due to illness?"

The Job Characteristics Inventory (Sims et al., 1976) was used as a measure of employees' perceptions of their job characteristics. The questionnaire consists of 30 items, five-level, arranged categories, Likert type, which measure six subscales, namely: job variety, autonomy, feedback, cooperation with others, task identity and friendship.

## 3. Results

The Table 3 below shows the descriptive statistics of the variables. The table includes means and standard deviation for the variables – Absenteeism, Sickness absenteeism, Mental health, General health and six dimensions of job characteristics - Skill variety Autonomy, Mental Health, General Health, Autonomy, Feedback, Dealing with others, Task Identity and Friendship.

*Table 3: Descriptive statistics*

| Varibles | M | SD |
|---|---|---|
| **Absenteeism** | 15,84 | 11,343 |
| **Sickness absenteeism** | 5,27 | 7,954 |
| **Mental health** | 14,70 | 2,818 |
| **General health** | 35,20 | 6,321 |
| **Skill variety** | 20,46 | 3,110 |
| **Autonomy** | 21,62 | 4,472 |
| **Feedback** | 19,76 | 4,051 |
| **Dealing with others** | 12,65 | 1,828 |
| **Task Identity** | 15,90 | 3,270 |
| **Friendship** | 30,17 | 4,516 |

Based on the set regression model, in which the set of predictors consists of mental health, general health and job characteristics, and the criterion sickness absenteeism, it was determined by the coefficient of determination that the set of predictors explains 9% of the variance of the criterion. The results of the multiple regression analysis are shown in the table below the text.

*Table 4: Regression model*

| Model | R | R2 | Adjusted R2 | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ,301 | ,090 | ,042 | 10,774 |

By testing the significance of the model, it was determined that the set of predictors does not statistically significantly explain the set criterion. The results of testing the significance of the model are shown in the Table below the text.

*Table 5: Significance of the regression model*

| Model | SS | Df | MS | F | p |
|---|---|---|---|---|---|
| **Regression** | 1751,890 | 8 | 218,986 | 1,886 | ,066 |
| **Residual** | 17645,489 | 152 | 116,089 | | |
| **Total** | 19397,379 | 160 | | | |

Based on the partial contributions of the predictors, it is determined that mental health and general health are not statistically significant predictors of sickness absenteeism, while two job characteristics stood out as significant positive predictors of sickness absenteeism - Task identity (β = .293; p = .007) and Friendship (β = .183; p = .049).

*Table 6: Partial predictors*

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | p |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| **Mental health** | ,215 | ,368 | ,054 | ,584 | ,560 |
| **General Health** | ,052 | ,169 | ,029 | ,311 | ,756 |
| **Skill variety** | -,435 | ,364 | -,118 | -1,194 | ,234 |
| **Autonomy** | ,476 | ,261 | ,195 | 1,826 | ,070 |
| **Feedback** | -,058 | ,229 | -,022 | -,255 | ,799 |
| **Dealing with others** | -,962 | ,617 | -,154 | -1,559 | ,121 |
| **Task Identity** | ,986 | ,360 | ,293 | 2,744 | ,007 |
| **Friendship** | ,440 | ,228 | ,183 | 1,930 | ,049 |

## 4. Discussion

This research aimed to understand how mental health, general health, and other job related factors impact sickness absenteeism in manufacturing companies in the context of Industry 5.0. On the basis of the regression model, it was established that the predictor set of mental health, general health, and job characteristics only accounted for 9% variation of sickness absenteeism. Additionally, the test for the statistical significance of the model revealed that the set of predictors does not significantly explain the variance in absenteeism, which raises important considerations about the complexity of factors influencing absenteeism beyond those captured in this study.

Interestingly, the partial contributions of individual predictors revealed more nuanced insights. Mental health and general health, which are commonly hypothesized to have strong links to absenteeism, were found to be statistically non-significant in this model. This finding contrasts with much of the existing literature that highlights the role of poor mental and physical health in predicting absenteeism (Karanika-Murray & Biron, 2020). One possible explanation for this result could be the advancements in workplace health programs and Industry 5.0's worker-centered approach, which may mitigate some of the negative impacts of health problems on attendance. Another explanation could be the relatively low variance explained by the model, suggesting that other unexamined variables, such as organizational policies or individual coping mechanisms, may play a more significant role.

However, two job characteristics—Task Identity and Friendship—emerged as significant positive predictors of sickness absenteeism. Task identity ($\beta = .293$, $p = .007$) reflects the degree to which an employee identifies with their work and perceives it as meaningful, and this strong association with absenteeism suggests that workers who feel more responsibility toward their tasks may be more susceptible to stress or pressure, leading to higher absenteeism. Similarly, friendship ($\beta = .183$, $p = .049$), representing the social connections formed at work, was also a positive predictor. While workplace friendships are typically linked to better job satisfaction and well-being, this finding indicates that strong social bonds may encourage informal absenteeism (e.g., taking leave to support colleagues or due to social pressures). This underscores the complexity of social dynamics at work in Industry 5.0 environments, where technological collaboration is increasingly accompanied by human-centric team structures (Tóth et al., 2023). These findings suggest that job characteristics may play a more direct role in absenteeism than previously thought, and interventions targeting work identity and social dynamics may be important in managing absenteeism in manufacturing companies.

## 5. Conclusion

This study explored the relationship between mental health, general health, and job characteristics in predicting sickness absenteeism within manufacturing companies adapting to Industry 5.0 technologies. The findings challenge traditional assumptions, as mental and general health were not found to significantly influence absenteeism. Despite widespread recognition of health as a key factor in absenteeism, this suggests that technological advancements and changes in workplace dynamics under Industry 5.0 may reduce the direct impact of health issues on attendance. Job characteristics, however, emerged as critical factors influencing absenteeism. Specifically, the sense of responsibility towards tasks and social relationships in the workplace were significant predictors. These findings demonstrate the necessity of understanding the specific factors that will shape absenteeism in a humanized, technologically oriented-work setting. Pertaining to Industry 5.0, the results indicate that organizations need to manage the job and organizational culture so as to reduce absentees and increase engagement. Given the current structural composition of the industry, the study highlights the importance of expanding the boundaries of absenteeism management to include factors outside health, to include critical job characteristics.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# COMPREHENSIVE APPROACHES TO LITHIUM BATTERY RECYCLING IN THE ERA OF CIRCULAR ECONOMY

*Jelena Mitrović[1], Aleksandra Stevanović[2]*

***Abstract***

*This paper aims to provide a comprehensive overview of lithium battery recycling approaches, highlighting its ecological and socio-economic importance. Lithium batteries have become indispensable energy storage devices and have a wide range of applications. The increasing consumption and disposal of lithium batteries have caused significant responses to concerns about environmental sustainability. To solve these challenges, lithium battery recycling has emerged as an adequate solution for efficient use and sustainability. The proliferation of lithium batteries in various industries has led to the need for efficient recycling strategies that minimize environmental impact, conserve resources, and promote circular economy. The recycling approaches include mechanical separation, hydrometallurgical techniques, and pyrometallurgy. Establishing a strong recycling industry encourages the creation of new jobs, promotes technological innovation, and facilitates the transition to a more sustainable energy mechanism. Around that, recycling reduces reliance on limited sources of raw materials, increases energy efficiency, and contributes to a more self-sufficient and resilient economy. Reviewing current trends, challenges, and best practices in battery recycling, this paper contributes to the body of knowledge in this area and encourages further research and development efforts. Successful implementation of efficient and environmentally friendly of acceptable lithium battery recycling practices plays a vital role in achieving a sustainable and circular approach to energy storage and resource management.*

***Key words****: lithium battery, recycling, circular economy.*

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## 1. Introduction

Lithium batteries became thus reliable and handy sources of energy, which can be used in a great variety of applications, for example, portable electronics, electric vehicles, renewal energy systems etc. However, an increasing apathy towards the catastrophic overconsumption and the disposal of lithium batteries has sparked unease over environmental sustainability, resource limitations, and hazardous waste management. Lithium batteries have become pervasive in many sectors, thereby raising problems of their efficient recycling, avoiding damage to the environment, saving resources, and contributing to the circular economy requirements. Battery recycling processes include the recovery of several metal materials from batteries through a series of disassembly, sorting, and battery materials processing which consists of lithium, cobalt, nickel, copper etc. The recycling of lithium batteries is a term that encapsulates several areas of science and technology. It includes development and optimization of processes, mechanical separation, hydrometallurgical, pyrometallurgical processes and other direct processes.

This paper aims to provide an overview of lithium battery recycling, highlighting its scientific, environmental and socio-economic importance. By reviewing the current trends, challenges and best practices in battery recycling, this paper contributes to the body of knowledge in the field and encourage further research and development efforts. The successful implementation of efficient and environmentally friendly lithium battery recycling practices plays a significant role in achieving a sustainable and circular approach to energy storage and resource management.

## 2. Recycling of used lithium batteries

Pyrometallurgy, hydrometallurgy and direct recycling are the three main mechanisms among recycling spent lithium batteries. Pyrometallurgy refers to the treatment of batteries at elevated temperatures with a separation process. Hydrometallurgy involves the use of aqueous solutions to dissolve significant metals from spent lithium batteries and extract the metals through a purification step. Direct recycling means that the structure of the battery's active materials is directly renewed. Currently, pyrometallurgical and hydrometallurgical processes are widely applied in industry, while the direct recycling technique is mostly at the laboratory level. Zhou and collegues (2020) compared the advantages, disadvantages and challenges of mentioned lithium battery recycling processes. When it comes to the hydrometallurgical process, the main advantages are – a high recovery rate, a product of high purity, low energy consumption, less waste gases and high selectivity, the main disadvantages include – more waste water and a long process, while the main challenges include the treatment of waste water and process optimization. The main advantages of the pyrometallurgical process are simple operation, short flow, no requirements for input categories and sizes, high efficiency, disadvantages include the facts that Li and Mn are not recovered, high energy

consumption, low recovery efficiency, more waste gases and waste gas treatment costs, while the main challenges include reducing energy consumption and emission pollution, reducing the negative impact on the environment. The advantages of the direct recycling process refer to a short recovery path, low energy consumption, environmental friendliness, high recovery rate, the disadvantages include high operational requirements of the equipment, incomplete recovery, while the main challenges include reducing recovery costs, reducing requirements and additional performance optimization products.

## 3. Pyrometallurgy

Pyrometallurgy uses high temperatures to recover (Lv, 2018) and purify valuable metals through physical and chemical transformations (Liu et al., 2019). Structural changes and phase transitions occur at lower temperatures, and chemical reactions occur at higher temperatures. One of the effective pyrometallurgical options for recovering valuable elements from end-of-life lithium batteries is melting. Due to its high productivity and simplicity, the application of melting prevails in the industry. During this processing, lithium battery substances are heated above their melting points, facilitating the segregation of metal elements in the liquid phase through reductions and preventing the resulting formations from mixing layers (Makuza et al., 2021). Melting takes place in two stages. At the very beginning, the battery materials are heated at low temperatures in order to evaporate the electrolyte and prevent the battery from exploding due to pressure. This is followed by heating at higher temperatures where the battery materials melt.

Another pyrometallurgical process used to recycle used lithium batteries is thermal reduction (baking/calcination). Pretreatments of lithium batteries are usually done in advance to obtain the cathode material for extractive processing (An, 2019). During thermal reduction, active cathode substances are heated with reducing coke, charcoal or C, leaving a C residue and a mixture of intermediate compounds for further processes. A carbonaceous material, waste graphite from reducers is particularly attractive - a low-cost process with high effects (Zhang et al., 2020). Compared to the high-temperature melting process, thermal reduction shows the superiority of high metal recovery rates and low energy requirements. Huang and colleagues (2019) developed a thermal reduction process using spent graphite as a reductant to recover nickel and cobalt from electrode powders of used lithium batteries. Salt roasting aims to convert metal compounds into water- soluble salts by salt roasting. This technique has been shown to be effective for the separation of metals in Li transition metal oxides (Shi et al., 2019). A chlorination roasting approach combined with aqueous leaching has been proposed to recover manganese, cobalt, nickel and lithium from NCM cathode substances (Jian et al., 2021).

## 4. Hydrometallurgy

After pretreatment, hydrometallurgy is used to regenerate high-value elements from spent lithium batteries such as manganese, lithium, nickel and cobalt. The technology of hydrometallurgical recycling consists of two stages, namely the leaching of lithium batteries and the recovery of high-value elements from the leachate (Chagnes & Pospiech, 2013). The leaching agent commonly used in the rinsing step includes a bacterial solution or an alkaline and acidic (including organic and inorganic acid) solution. High value elements are separated and recovered by various technologies such as solvent extraction, electrolysis, precipitation, ion exchange and so on.

Leaching is most important in the entire hydrometallurgy process to extract high value elements from used lithium batteries. The purpose of the leaching process is to dissolve and convert the valuable elements in the batteries into metal ions in the leaching solutions. The metal ions in the leachate are further separated and recovered by subsequent processes. Acid leaching includes inorganic and organic acid leaching, which is mainly used to dissolve metals in spent lithium batteries. Inorganic acid used for lithium battery leaching includes HCl (Xuan et al., 2019), H2SO4 (Fan et al., 2021), HNO3 (Cognet et al., 2020), and H3PO4 (Chen et al., 2019). Reducing agents such as Na2SO3 or H2O2 can be used to improve the efficiency of the leaching process. Organic acid leaching is a new treatment method used for lithium batteries. The organic acids used include tricarboxylic acid (e.g. citric acid (Refly et al., 2021), dicarboxylic acid (Li et al., 2017), ascorbic acid (Refly et al., 2020), oxalic acid (Zeng et al., 2015) and monocarboxylic acid (Li et al., 2017), acetic acid (Li., 2018) and formic acid (Gao et al., 2017).Organic acids used for battery leaching have many advantages compared to inorganic acids, such as recyclability, easy degradation, sufficient acidity for leaching, and less secondary emissions.

Alkaline leaching uses interactions between metallic elements and hydroxide ions in an alkaline environment. This method has attracted attention because it selectively dissolves metals and potentially avoids further expensive purification or separation steps. NaOH is commonly used to leach material from batteries for selective removal (Chen et al., 2011).

Bioleaching is another leaching method that uses acids produced by metabolizing microorganisms to leach end-of-life lithium batteries. Bioleaching is an attractive alternative to traditional acid leaching due to lower cost, environmental acceptability, and less demand in industrial implementations. However, this method takes a long time and is subject to pollution, these disadvantages limit its application. Horeh and colleagues (2016) proposed a process for leaching used lithium batteries using a fungus called Aspergillus niger.

The fungi used secrete citric acid, oxalic acid, gluconic acid and malic acid during the bioleaching process.

## 5. Direct recycling

Another way to recycle used lithium batteries is direct recycling. In this processing, the structures of the lithium battery are retained, while the active substances of the battery are directly recovered and collected (Shi et al., 2018). Direct recycling shows many advantages over pyrometallurgy and hydrometallurgy in terms of simplicity of operation, less amount of secondary waste and less hazardous emissions (Ciez & Whitacre, 2019). In addition, after regeneration, the electrodes can be reused directly, which is another advantage of direct recycling. Solid-phase sintering uses solid-phase Li agents as a Li resource for the regeneration of cathode materials. In this process, Li-I is integrated into available sites at elevated temperatures, and is used to replenish the loss of Li. Solid phase sintering is considered the most direct route for lithium recovery (Bai et al., 2020). LiOH (lithium hydroxide), LiNO3 (lithium nitrate), or Li2CO3 (lithium carbonate) can be used as a Li resource in the solid state sintering process.

Hydrothermal relitation is another potential method of direct recycling of spent lithium-ion batteries. Initially, the excess Li source solution is used to treat spent battery materials, and the added lithium is incorporated into spent cathode structures. It is usually followed by a short annealing treatment, with the aim of reconstructing the crystallinity of the material and improving the restoration of the structure. In the further process, technologies are incorporated to accelerate Li ion transfer including water pulsed plasma discharge (Zhu, 2016) and ultrasound (Zhang et al., 2014).

Stoichiometric additions of lithium are not required because the hydrothermal approach can limit lithium restorations, in contrast to solid-phase rhelithium (Bai et al., 2020). Degraded cathodes with any level of defects could be compensated by the hydrothermal technique. Hydrothermal relithia can work effectively with many cathode chemistries such as NMC 111, NMC 523, NMC 622 and LCO (Sloop et al., 2020).

## 6. Conclusion

The recycling of lithium batteries is of utmost importance due to the significant growth of their use in various industries. With the ever-increasing demand for lithium batteries and their limited resources, it is crucial to implement efficient recycling techniques to recover valuable materials and reduce environmental impact. The recycling of lithium batteries is in accordance with the principles of the circular economy and contributes to a more sustainable and responsible approach to resource management. It helps to minimize waste generation and associated environmental hazards from improper disposal. The EU Battery Directive sets specific requirements for the collection, treatment and recycling of batteries, including lithium batteries. The directive aims to increase the recycling rate of batteries and reduce the impact of their disposal on the environment. It also places the responsibility on battery manufacturers to take over and properly manage end-of-life batteries. Compliance with EU regulations ensures

that lithium battery recycling is done in a safe and environmentally friendly way. It encourages the development of infrastructure and technologies for efficient battery recycling, promotes the use of recycled materials and encourages a circular economy approach in the battery industry.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EXAMINING THE RELATIONSHIP BETWEEN CHATGPT, GEMINI, AND BING USE AND LIFE SATISFACTION: A CASE STUDY OF SLOVENIA

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***Abstract***

*This study uniquely investigates the use of AI tools, specifically OpenAI ChatGPT, Google Bard-Gemini, and Bing, in Slovenia, focusing on their perceived impact on life satisfaction and educational policies. A survey of 757 respondents revealed that OpenAI ChatGPT is the most commonly used AI tool (57.7%), followed by Bing (19.4%) and Google Bard-Gemini (11.8%). Despite the high usage rates, the correlation between AI tool use and overall life satisfaction was weak, challenging the hypothesis that the frequent use of AI tools leads to greater life satisfaction. Additionally, while 19.4% of respondents reported improved life satisfaction due to AI tools, the majority (60.3%) experienced no change, and some (8.0%) reported a decline. The study partially supports the hypothesis that Slovenians are generally favorable toward AI in education, with 51.9% opposing a ban on AI tools, 25.0% supporting a ban, and 23.1% remaining undecided. These findings suggest a widespread but cautious acceptance of AI tools, emphasizing the need for further research into their effects on well-being and educational policies.*

***Key words:*** *Life satisfaction, Artificial intelligence, ChatGPT, Gemini, Bing, school.*

## 1. Introduction

In recent years, artificial intelligence (AI) has increasingly influenced various facets of daily life, from work and communication to personal well-being. This paper explores the intersection of AI usage and life satisfaction in Slovenia, focusing on

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three prominent AI tools: ChatGPT, Gemini, and Bing. Through a comprehensive case study involving 757 participants with an average age of 35.95 years, the research aims to understand whether the use of these AI tools correlates with higher life satisfaction among Slovenians. The study investigates the extent to which users perceive improvements in their well-being as a result of AI tool usage and gauges public support for integrating AI into the educational system. We hypothesize:

Hypothesis 1: There is a positive correlation between the frequency of AI tool use and overall life satisfaction among Slovenians.

Hypothesis 2: A significant proportion of Slovenians perceive an improvement in their well-being as a direct result of using AI tools.

Hypothesis 3: Slovenians are generally supportive of the implementation of AI tools within the country's educational system.

We focused on studies that measured satisfaction with life using the SWL questionnaire, the most widely used scale for this purpose. Additionally, our literature review was limited to publications from 2020 to 2024.

By examining these relationships, the study provides valuable insights into the potential of AI to enhance personal and societal well-being.

## 2. Literature review

The relationship between life satisfaction and perceptions of artificial intelligence (AI) across 39 European countries is explored by Hinks (2024). The study reveals that individuals harboring negative perceptions of AI tend to report lower life satisfaction. This suggests that fear and uncertainty about AI's societal impacts may adversely affect overall well-being. Transparent discussions about AI's role are emphasized as a crucial measure to alleviate these concerns.

Kim et al. (2023) investigate the use of explainable AI to analyze the connections between life satisfaction, diabetes mellitus, and its comorbid conditions. AI can identify key factors influencing life satisfaction among diabetes patients, thus aiding personalized health interventions. The study underscores AI's potential to enhance both healthcare outcomes and life satisfaction.

Abubakar (2020) employs a hybrid structural equation modeling (SEM) and AI approach to examine the effects of boreout on career, life, and job satisfaction among different generations. Significant generational differences are highlighted, with boreout negatively impacting satisfaction. The study calls for tailored organizational strategies to address generational disparities.

A U-shaped trend is found in the relationship between age and life satisfaction, with life satisfaction peaking in early adulthood, declining in midlife, and rising again in older age. This analysis, conducted by Kaiser, Otterbach, and Sousa-Poza (2022) using machine learning, illustrates the complexity of life satisfaction across the lifespan.

Metzger (2024) presents a dissertation examining AI's impact on life satisfaction across demographic groups. While AI enhances well-being through improved services and convenience, it also raises concerns about privacy and job

security, which can detract from life satisfaction. These findings highlight the dual nature of AI's influence.

Employees' perceptions of robotics, AI, and automation (RAIA) on job satisfaction, job security, and employability are examined by Bhargava, Bester, and Bolton (2020). The study finds that while RAIA technologies improve efficiency and satisfaction, they simultaneously provoke concerns about job security. Organizations are encouraged to address these apprehensions.

Çiftci and Yıldız (2023) analyze the relationships between social media addiction, happiness, and life satisfaction using machine learning. Their findings reveal that social media addiction adversely affects happiness and life satisfaction, particularly among specific demographic groups, necessitating interventions to reduce these negative impacts.

The study by Vorina et al. (2024) explored the use of AI tools, such as OpenAI ChatGPT, Google Bard-Gemini, and Bing, and their impact on life satisfaction among students across various countries. The findings indicated that 21% of respondents experienced an improvement in their well-being after using these AI tools.

## 3. Methodology

### 3.1 Questionnaire

This study used the Satisfaction with Life Scale (SWLS) to assess subjective well-being. A separate 16-item questionnaire was used to collect data on life satisfaction, AI tool usage, and demographics. Participants rated their life satisfaction, AI tool usage frequency, and provided opinions on AI policies. The data were collected from March to April 2024 and analyzed using IBM SPSS22.

### 3.2 Sample

The dataset comprises 757 valid responses, representing participants aged 18 to 76. The mean age is 36.47 years, with a standard deviation of 13.838, indicating a relatively wide age distribution. The sample is heavily skewed towards females, who constitute 72.1% of participants, while males account for only 27.9%. In terms of education, the majority (59.3%) have completed elementary school or less. Only 39.9% have completed secondary school, and just 0.8% have a high school education or higher.

## 4. Discussion-confirm the hypothesis

At the start of our research, we were interested in determining the proportion of respondents who had experience using various language models, including OpenAI ChatGPT, Google Bard-Gemini, and Bing.

*Table 1: Have you ever used OpenAI ChatGPT?*

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 437 | 57,7 | 57,7 | 57,7 |
| | no | 320 | 42,3 | 42,3 | 100,0 |
| | Total | 757 | 100,0 | 100,0 | |

*Source: Author's research*

OpenAI ChatGPT: 57.7% of respondents had used OpenAI ChatGPT, while 42.3% had not (see Table 1). This suggests that OpenAI ChatGPT is the most widely used of the three AI language models in the survey.

*Table 2: Have you ever used Google Bard-Gemini?*

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 89 | 11,8 | 11,8 | 11,8 |
| | no | 668 | 88,2 | 88,2 | 100,0 |
| | Total | 757 | 100,0 | 100,0 | |

*Source: Author's research*

Google Bard-Gemini: Only 11.8% of respondents had used Google Bard-Gemini, and 88.2% had not (see Table 2). This indicates that it is significantly less used compared to OpenAI ChatGPT.

Bing: 19.4% of respondents had used Bing, and 80.6% had not (see Table 3). This places Bing in the middle in terms of usage compared to the other two AI language models.

*Table 3: Have you ever used Bing?*

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes | 147 | 19,4 | 19,4 | 19,4 |
| | no | 610 | 80,6 | 80,6 | 100,0 |
| | Total | 757 | 100,0 | 100,0 | |

*Source: Author's research*

We assume:

**Hypothesis 1**: There is a positive correlation between the frequency of AI tool use and overall life satisfaction among Slovenians.

The dependent variable (SumSWL) is the sum of all 5 statements, with a minimum SumSWL score of 0 and a maximum of 35. We conducted a Spearman rank correlation analysis (Table 4):

*Table 4: Corelation matrix usage OpenAI ChatGPT Google Bard-Gemini Bingf and SWLS?*

| | How many hours per week do you typically use OpenAI ChatGPT? Please enter the number of hours: | SumSWL | How many hours per week do you typically use Google Bard-Gemini? Please enter the number of hours: | How many hours per week do you typically use Bing? Please enter the number of hours: |
|---|---|---|---|---|
| How many hours per week do you typically use OpenAI ChatGPT? Please enter the number of hours: | 1,000 | ,002 | ,532** | ,541** |
| | | ,962 | ,000 | ,000 |
| | 437 | 437 | 81 | 126 |
| SumSWL | ,002 | 1,000 | ,056 | -,016 |
| | ,962 | | ,601 | ,849 |
| | 437 | 757 | 89 | 147 |
| How many hours per week do you typically use Google Bard-Gemini? Please enter the number of hours: | ,532** | ,056 | 1,000 | ,642** |
| | ,000 | ,601 | | ,000 |
| | 81 | 89 | 89 | 40 |
| How many hours per week do you typically use Bing? Please enter the number of hours: | ,541** | -,016 | ,642** | 1,000 |
| | ,000 | ,849 | ,000 | |
| | 126 | 147 | 40 | 147 |

*Source: Author's research*

Based on the provided correlation matrix (see Table 4), we can observe the following relationships between the variables:

OpenAI ChatGPT and Google Bard-Gemini: There is a weak positive correlation of 0.056 between these two variables. This suggests that individuals who use OpenAI ChatGPT more frequently are also slightly more likely to use Google Bard-Gemini, but the relationship is not very strong.

OpenAI ChatGPT and Bing: A moderate positive correlation of 0.601 exists between these two variables. This indicates a stronger relationship, suggesting that individuals who use OpenAI ChatGPT are more likely to also use Bing.

Google Bard-Gemini and Bing: The correlation between these two variables is the strongest, with a value of 0.642. This suggests a moderately strong positive relationship, indicating that individuals who use Google Bard-Gemini are more likely to also use Bing.

SumSWL (overall well-being) and AI language models: The correlations between SumSWL and the three AI language models are relatively weak, ranging from -0.16 to 0.056. This suggests that there is no strong relationship between the overall well-being of individuals and their usage of these AI tools, so hypothesis 1 is not confirmed.

**Hypothesis 2:** A significant proportion of Slovenians perceive an improvement in their well-being as a direct result of using AI tools.

*Table 5: Do you believe your overall life satisfaction has changed since you started using artificial intelligence tools (OpenAI ChatGPT, Google Bard-Gemini, Bing)?*

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | yes, for the better | 147 | 19,4 | 31,7 | 31,7 |
| | yes, for the worse | 37 | 4,9 | 8,0 | 39,7 |
| | no, it hasnt changed | 280 | 37,0 | 60,3 | 100,0 |
| | Total | 464 | 61,3 | 100,0 | |
| Missing | System | 293 | 38,7 | | |
| Total | | 757 | 100,0 | | |

*Source: Author's research*

We can see (Table 5) that: 147 respondents (19.4%) reported that their overall life satisfaction had improved since using AI tools; 37 respondents (4.9%) reported that their overall life satisfaction had worsened since using AI tools; 280 respondents (37.0%) reported that their overall life satisfaction had not changed since using AI tools. While a portion of respondents did report an improvement in their well-being, a significant number also reported no change or even a decline. Therefore, the data do not strongly support Hypothesis 2.

**Hypothesis 3:** Slovenians are generally supportive of the implementation of AI tools within the country's educational system.

Based on the provided data, we can see (Table 6) that: 189 respondents (25.0%) would ban the use of AI tools in schools. 393 respondents (51.9%) would not ban the use of AI tools in schools; 175 respondents (23.1%) were unsure about banning AI tools in schools. While a majority of respondents (51.9%) do not support a ban on AI tools in schools, a significant portion (25.0%) would still ban their use. Based on the data provided in Table 6, hypothesis 3 can be partially confirmed.

*Table 6: Would you ban the use of the mentioned artificial intelligence tools in schools??*

| | | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|---|
| Valid | yes | | 189 | 25,0 | 25,0 | 25,0 |
| | no | | 393 | 51,9 | 51,9 | 76,9 |
| | I dont know | | 175 | 23,1 | 23,1 | 100,0 |
| | Total | | 757 | 100,0 | 100,0 | |

*Source: Author's research*

## 5. Conclusion

This study aimed to investigate the use of AI tools such as OpenAI ChatGPT, Google Bard-Gemini, and Bing in Slovenia, and their perceived impact on life satisfaction and educational policies. Through a survey of 757 respondents, we examined AI tool usage, subjective well-being, and public attitudes toward AI in schools.

The findings reveal that 57.7% of respondents had used OpenAI ChatGPT, making it the most popular AI tool in the study, compared to 19.4% for Bing and 11.8% for Google Bard-Gemini. Despite the high usage of OpenAI ChatGPT, the correlation between AI tool use and overall life satisfaction (SumSWL) was weak, failing to support Hypothesis 1, which posited that frequent AI tool usage correlates with higher life satisfaction. This suggests that while a significant portion of the population is using AI tools, their impact on well-being is minimal.

Hypothesis 2, which proposed that a significant proportion of Slovenians perceive an improvement in their well-being due to AI tools, was also not strongly supported. While 19.4% of respondents reported improvements in life satisfaction, 60.3% noted no change, and 8.0% felt their well-being had worsened.

Hypothesis 3—that Slovenians are generally supportive of AI implementation in schools—was partially confirmed. The data show that 51.9% of respondents did not support a ban on AI tools in schools, indicating general acceptance of AI in education. However, 25.0% of respondents support banning AI tools, while 23.1% remain undecided, suggesting that public opinion is still divided and requires further discussion.

While AI tools are widely used, their perceived impact on life satisfaction is minimal, and attitudes toward their use in education are cautiously positive but tempered by some reservations. This highlights the need for more focused research and discourse on AI's role in personal well-being and educational systems.

Future research should explore how specific factors and contexts influence the perceived impact of AI tools on life satisfaction and well-being. Additionally, investigating public attitudes toward AI in education, including reasons for opposition or uncertainty, will help inform more effective integration strategies.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# FROM RISK TO SUSTAINABILITY: IMPROVING LITHIUM-ION BATTERY SAFETY FOR SUSTAINABLE ENERGY APPLICATIONS

*Aleksandra Stevanović[1], Jelena Mitrović[2]*

***Abstract***

*This paper addresses the critical safety issues associated with the use of lithium-ion batteries, which are indispensable in modern energy storage and various applications. Vehicles that operate on the principle of internal combustion engines produce harmful exhaust gases and are mostly responsible for pollution and global warming. An alternative to vehicles powered by internal combustion engines is electric ones. The battery of an electric vehicle is a very important component that stores energy for its propulsion. Among the familiar, batteries, lithium-ion batteries are the most popular and the most commonly used batteries. Although lithium-ion batteries make up the majority of the rechargeable battery market, there are serious concerns about their safety. Accidents, fires, and explosions of electric vehicles have been reported frequently in recent years. These adverse conditions that impair the safety of lithium-ion batteries include mechanical damage, electrochemical conditions, and thermal conditions. To ensure the overall safety of lithium-ion batteries, safety techniques must be such that they protect against all of the mentioned conditions. The battery must be protected from internal as well as external influences in order to achieve the general safety of lithium-ion batteries. There are various techniques to improve the safety of lithium-ion batteries, but improvement in the context of materials is the basic and most important technique to improve battery safety. By contributing to the development of safer lithium-ion batteries, this paper is significant in advancing sustainable energy technologies and promoting a resilient, self-sufficient economy.*

***Key words:*** *lithium-ion battery, sustainability, energy..*

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# 1. Introduction

For the last few decades, the entire world population has been fighting pollution and global warming permanently. Vehicles powered by internal combustion engines emit harmful exhaust gases, contributing to pollution and global warming because they use carbon-based fuels. An alternative to vehicles powered by internal combustion engines is electric vehicles, because these types of vehicles use electricity as their energy source, instead of fossil fuels. Electric vehicles produce no exhaust gases, and their operation is very quiet and significantly cheaper compared to vehicles with internal combustion engines. The battery of an electric vehicle is a very important component that stores energy for its propulsion. The lithium-ion batteries are the most popular and most commonly used batteries, due to their advantages in the form of high specific energy, long working life, high efficiency, lightweight, and absence of memory effect. However, the increased interest in lithium-ion batteries arises by certain an unfortunate event associated with these batteries, which has often contributed to lower public confidence. There are various techniques to improve the safety of lithium-ion batteries, but improvement in the context of materials is considered as basic and most important technique. By contributing to the development of safer lithium-ion batteries, this paper is significant in advancing sustainable energy technologies and promoting a resilient, self- sufficient economy.

# 2. Mechanism of a thermal runaway in lithium-ion batteries

A thermal runaway occurs when the battery overheats or reaches a critical temperature (Yuan et al., 2019). The main causes of thermal runaway in lithium-ion batteries are critical situations at the mechanical, electrochemical, and thermal levels (Chombo & Laoonual, 2020). Mechanical accident conditions include crushing, penetration, dropping, impact, overturning, and vibration (Sahraei et al., 2012). In the conditions of mechanical accidents, lithium-ion batteries are first deformed under the mechanical action of the load, and the deformation results in the development of internal stress. Electrochemical accidents in lithium-ion batteries include forced overcharging, over-discharging, external short- circuiting (ESC), etc. Overcharging is a condition in which power is forced to flow through a lithium-ion battery cell even after the state of charge (SOC) has reached its maximum limit. Overcharging is very dangerous because overcharging adds additional energy, under current conditions (Leising et al., 2001). Heat generation due to a side reaction during electrolyte decomposition leads to a sudden rise in temperature and even thermal runaway (Kriston et al., 2017). Thermal disasters such as fire, heat stroke, and overheating are the direct causes of battery thermal runaway (Feng et al., 2018). Overheating due to conditions such as high ambient temperature, high heat transfer to adjacent cells, and inefficient heat dissipation continues to increase battery temperature. Because lithium-ion batteries are very sensitive to temperature and must operate within a limited temperature range, thermal shocks are very detrimental to their safety. The ideal operating temperature

for lithium-ion batteries is between 15 ◦C and 35 ◦C, and the maximum cell temperature difference ($\Delta T_{max}$) must be <5 ◦C (Thakur et al., 2020). When lithium-ion batteries operate outside this temperature range, they experience adverse effects that lead to thermal runaway.

## 3. Internal Material Advancements for Safer Lithium-Ion Batteries

Materials enhancement is a technique to improve the safety of a lithium-ion battery, and recent advances in internal battery materials to improve its safety include improvements in cathode and anode materials, the use of non-flammable electrolytes, flame retardant additives, overcharge protection additives, and advances in external materials such as advances in battery thermal management and battery case material.

The internal material of the lithium-ion battery should be such that it has a high tolerance in situations of different types of disasters because each component directly affects the safe functioning of the lithium-ion battery. Advances in internal battery materials are effective techniques for improving battery safety that include improvements in cathode and anode materials, using non-flammable electrolytes, flame retardant additives, overcharge protection additives, etc. help to improve battery safety from electrochemical and thermal hazards such as overcharge, over-discharge, short circuit, overheating, thermal shock, etc. These internal material improvements include material modification, the use of new materials, and the use of additives to improve the safety of the lithium-ion battery.

Overcharging is a type of damage that lithium-ion batteries experience by passing current through it in a situation where the battery is already fully charged (Wen et al., 2012). To prevent overcharging the battery, an external battery management system device is also used to maintain the optimal charge and discharge voltage and current for each cell. But the battery management system increases the cost, weight and volume of the battery, also, in some cases, the failure of the battery management system risks overcharging. Electrochemically reversible additives should be added to protect the battery internally from overcharging. These additives based on their functions are categorized as redox shuttle additives and shut-off additives.

Further, various techniques have been considered to improve the thermal stability of the cathode material and two main safety techniques are proposed - element replacement and surface protective coating. The replacement of elements led to improved thermal stability of layered oxide cathodes because it stabilizes the crystal structures. Replacing elements such as Ni and Mn with other metal cations such as Mg, Ti, Zr, Ga, F and Al can improve the thermal stability of layered oxide cathodes (Luo, 2010).

The coating material can be inorganic compounds such as Al2O3, AlF3, AlPO4, ZnO, MgO, TiO2, ZrO2, FeF3, and SnO2, which are capable of conducting Li-ions after being lithiated or organic films such as poly (diallyl dimethylammonium chloride), or protective films formed with additives g - butyrolactone and multicomponent

additives consisting of vinylene carbonate, 1,3-propylene sulfite and dimethyl-acetamide.

Graphite is a commercially used material for the anode of a lithium-ion battery due to its advantages such as: low cost, high insertion capacity, layered structure, high electrical conductivity, relatively small volume change during cycling, and high reversibility. Li4Ti5O12 (LTO) is used in commercial lithium-ion batteries for its ability to operate at high charge/discharge rates, improved thermal stability, and long lifetime. Unfortunately, the use of LTO anodes does not eliminate the risk of surface reactions (Duan et al., 2020).

The separator of lithium-ion batteries is a very important component for their operation and from the point of view of their safety. A separator is a thin porous membrane placed between electrodes to retain, separate and prevent internal short circuit (Schadeck et al., 2018). To maintain the safety of the battery and its smooth operation, the mechanical integrity of the separator must remain intact, otherwise at higher temperatures the separator can shrink and cause an internal short circuit that releases a huge amount of energy and causes the battery to explode. Therefore, researchers are working to minimize shrinkage and destruction of the separator at higher temperatures.

When thermal runaway is triggered, reactions are set in motion that increase the rate of heat release, causing gases to form and increase the internal pressure of the battery. The low flash point or thermal stability of organic solvents poses a serious threat to battery safety, for example, the flash point of ethyl methyl carbonate, diethyl carbonate, dimethyl carbonate and propylene carbonate is 33 ◦C, 15 ◦C and 22 ◦C, respectively. Flammable organic electrolytes have the lowest thermal stability and during the process of thermal runaway release large amounts of flammable gases, which can cause the battery to catch fire. To solve this problem to increase the safety of lithium-ion batteries, a method has been developed that adds flame retardant (FR) additives to the electrolyte to reduce its flammability.

Flame retardant additives include organic phosphorus compounds are: triethyl phosphate (TEP), bis(2-methoxyethoxy) methylallylphosphonate, trimethyl phosphate (TMP), triphenyl phosphate (TPP), tris(2,2,2- trifluoroethyl) phosphite (TTFP), (ethoxy)pentafluoro cyclotriphosphazene (PFPN) and ethylene ethyl phosphate (EEP).

Changing the properties of conventional electrolytes with electrolyte additives has a limited effect on improving battery safety. Therefore, researchers have proposed replacing the current flammable electrolyte with nonflammable electrolytes such as: ionic liquids, low molecular weight hydrofluoroethers, and solid state electrolytes to improve battery safety (Wang et al., 2016). It was concluded that by increasing the ionic liquid content to 40%, the mixed electrolyte becomes hardly flammable and has very good electrochemical stability.

Current collectors (CC) are a key component of lithium-ion batteries as they work as a link to support active components, such as binders, conductive additives, cathode and anode materials, and as such electrochemically connect the entire anode and cathode structure to the external circuit. The thickness of the current collector has been reduced in the last two decades to improve the energy density of

the battery in the range of 16 to 26% (Mahmud et al., 2022). Al is widely used as a current collector material due to its excellent resistance to. Although the current collector does not participate in the electrochemical reactions, it has a significant effect on the performance of the electrodes. However, rapid self- extinction under extreme circumstances such as overheating and short- circuiting poses a serious threat to the safety of lithium-ion batteries (Kong et al., 2020).

### 3.1 External Material Advancements for Safer Lithium-Ion Batteries

External material improvements to improve battery safety include improvements to the battery thermal management system (BTMS) and battery case protection materials. The battery thermal management system improves the safety of Li-ion batteries from thermal accidents such as: overheating, thermal shock, etc., by keeping the battery temperature within limits, while the protective battery case helps to protect Li-ion batteries from mechanical accidents such as : crushing, vibrations, penetrations, and thermal disasters such as: fire, thermal shocks, etc.

The main factors for thermal runaway conditions in Li-ion batteries are - overcharging, internal short circuits, high charge/discharge rates, and sudden increase in internal battery temperature leading to battery burnout or explosion (Luo et al., 2010). Therefore, it is very important to maintain the internal temperatures of lithium-ion batteries within optimal limits. The optimal operating temperature of lithium-ion batteries is 15–35 ◦C, and the maximum power limit is also achieved in this temperature range. In a situation where lithium-ion batteries operate outside this temperature limit, the battery has a negative impact on its electrochemical performance. When the battery's temperature rises above 35 ◦C, it experiences degradation during discharge, and high power shuts down during charging.

Further, along with battery cooling, the battery thermal management system also helps maintain a uniform temperature inside the battery and maintains ΔTmax below 5 ◦C inside the battery (Liang et al., 2018). If the internal battery ΔTmax exceeds 5 ◦C, then a thermal runaway condition occurs, leading to a fire and ultimately endangering the safety of the battery. The battery's heat generation can be reduced by reducing the battery's internal resistance, but the heat produced by the electrochemical reaction occurring inside the battery cannot be avoided. Therefore, the battery thermal management system is very important from the point of view of battery safety.

An air cooling based battery thermal management system uses either natural air cooling for heat management or forced air cooling using a fan/blower. Due to various attributes such as simple design, no leakage, low cost and light weight, this battery thermal management system technique was the first to be used by various electric vehicle manufacturers such as: Honda Insight, Nissan Leaf, Toyota Prius, Renault Zoe, etc (Liang et al., 2018).

Initially, the researchers discovered that the phase change material (PCM) has a significant amount of latent heat, which can allow the battery's operating temperature to remain relatively constant. Therefore, the phase change material is considered in the context of battery thermal management systems.

As the technology develops, the rate of charging and discharging also increases and the pure phase change material does not remain as efficient due to excessive heat generation and localized temperature rise caused by its poor thermal conductivity. Therefore, researchers have focused on increasing the thermal conductivity of phase change materials so that good thermal management can be achieved (Mitra et al., 2022).

The protective case or battery housing plays a key role in ensuring the safety of electric vehicles by providing protection to the batteries. With the rapid increase in battery energy density, the needs of long-range electric vehicles are met. With higher energy density, more energy stored in the battery helps electric vehicles to cover long distances, but the negative effect of this is explosions and fires in the event of a crash or accident.

The protective casing of the battery must include characteristics such as electromagnetic compatibility, anti-corrosion properties, rigidity, integrity, thermal management and fire safety. It is important to use a battery case with a lightweight design to increase and decrease the range of the negative effect of the electric vehicle battery on the dynamics and acceleration of the performance vehicle (Chen et al., 2021).

## 4. Conclusions

The paper provides an overview of the safety challenges in the context of lithium-ion batteries, including mechanical, electrochemical and thermal. To date, significant progress has been made in developing materials development strategies to address these challenges and improve battery safety. Advanced materials and additives have shown improvements in terms of stability and reducing the risk of thermal runaway. The design and engineering of advanced electrode materials, separation materials and protective coatings contribute to better thermal management and overall safety of lithium-ion batteries. Looking ahead, future research should focus on advanced characterization techniques, modeling and integration of safety features into battery management systems. Interdisciplinary collaboration and knowledge sharing is critical to solving complex challenges and accelerating progress toward safer lithium-ion batteries. In conclusion, the field of materials to improve the overall safety of lithium-ion batteries is rapidly evolving to meet the demand for safer and more reliable energy storage solutions.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# FROM FRAGILE TO AGILE: BUILDING ORGANISATIONAL RESILIENCE THROUGH AGILE TRANSFORMATION

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***Abstract***

*Considering that agility fosters change readiness, ambidexterity, and adaptability—attributes that typically augment organisational resilience—this paper investigates agile transformation to identify its core elements that underpin organisational resilience and promote its development across the organisation. We begin by examining the fundamentals of both agile transformation and organisational resilience, followed by an in-depth analysis of their interdependencies. We conclude by discussing the implications of agile transformation as a pivotal strategy for organisations to cultivate resilience, either independently or alongside other approaches. The paper aims to elucidate organisational resilience within the context of agile transformation, recognising that resilience is not solely derived from agility but is complementary to it and can be a key objective of agilization efforts. Additionally, we propose guidelines for conducting agile transformation in a way that is most conducive to building organisational resilience.*

***Key words:*** *agile transformation, organisational resilience, business agility, agile change management..*

## 1. Introduction

Agility and resilience have become closely intertwined in today's volatile business landscapes, making the ability to quickly adapt and recover from unexpected events even more critical for navigating uncertainty and thriving in turbulent times. While some organizations are inherently agile or resilient, or both, others develop these qualities through the process of business transformation

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(Grego et al., 2024). Consequently, achieving organisational resilience through agile transformation has been identified as a promising solution for becoming both agile and resilient, which will be further explained and structured into guidelines for succeeding in such endeavors.

### 1.1 Organisational resilience

Organisational resilience, or simply resilience, is commonly referred to as the ability or capacity of an organisation to prepare for and effectively respond to challenges, thereby ensuring business continuity and competitive standing and increasing preparedness for future disruptions (Barasa et al., 2018; Burnard & Bhamra, 2019; Kadenic & Tambo, 2023). Miceli et al. (2021) identify two main dimensions of resilience – it is seen as a means of both protecting an organisation's current state from challenges and adapting the organisation to overcome them. Therefore, resilience manifests both absorptive and adaptive qualities, allowing for practices that differentiate between threats and opportunities and create appropriate responses (Burnard & Bhamra, 2019; Miceli et al., 2021).

While organisations may benefit from quick wins, resilience is more often viewed as a long-term commitment stemming from the ambidexterity of responding to challenges and adapting to changing circumstances. As such, resilience can be established at strategic, operational, and individual levels, enabling organisations, their components, and individuals to thrive during periods of adversity (Hillmann & Guenther, 2018; Burnard & Bhamra, 2019; Nkomo & Kalisz, 2023). This is where resilience and agility meet, creating enough room for agile transformation to be considered as a strategy for achieving organisational resilience while also becoming agile.

### 1.2 Agile transformation

Agile transformation can be defined as "a continuous process that organisations undertake to develop or enhance their agility capabilities and, while often viewed simply as the adoption of agile frameworks, it signifies much more – it represents a shift in how value is created, how change is managed, and how people interact" (Grebić et al., 2024). Therefore, the primary goal of agile transformation is to improve organizational agility, while also providing a range of benefits that boost performance and support sustainable growth. Consequently, organisations undergoing agile transformation typically experience enhanced flexibility, adaptability, and innovation, which, if sustained throughout and beyond the transformation process, lead to increased agility and resilience (Hutter et al., 2023; Carroll et al., 2023).

Agile transformation, especially on a large scale, permeates an organization entirely, influencing its people, processes, and practices to adopt proactive approaches to managing change and risk (Carroll et al., 2023). Given this context, dimensions of resilience can be seamlessly integrated into the scope of agile transformations, thereby enabling organizations to maintain stability while embracing change. Thus, the interconnectedness of organisational resilience and

agile transformation calls for further examination and more detailed insights into their relationship, which this research is aimed at providing.

## 2. Research methodology

Considering that the development of organizational resilience through agile transformation has not been extensively explored in contemporary research, we have conducted a comprehensive systematic literature review to identify relevant findings and subsequently analysed them to establish foundational definitions and the necessary steps for successfully navigating these initiatives.

### 2.1 Data collection

The initial search, employing key words such as “agility”, “resilience”, and “agile resilient transformation”, returned hundreds of papers across a wide range of topics; however, the systematic literature review was narrowed to focus solely on those relevant to one or more aspects of this research. Consequently, our review consists of nearly thirty papers that discuss agile transformation and the potential for achieving organisational resilience through these initiatives. The papers included in this review were published in the past eight years and appeared mostly in recognized international scientific journals, as well as in conference proceedings, book editions, and other reputable sources. It is noteworthy that we excluded from the review papers that did not mention the interplay between organisational resilience and agile transformation, except for those providing basic definitions for these phenomena.

### 2.2 Data analysis

The data analysis process encompassed four steps: grouping papers by their primary focus, segregating attributes of agility and resilience, performing an in-depth comparative analysis of their interdependencies, and outlining guidelines for building resilience through agile transformation. By employing this approach, we ensured that each paper underwent a structured analysis, thereby reinforcing the research goal and contributing to a better understanding of how agile transformation influences organisational resilience, and vice versa. Furthermore, this analysis maps out critical points of both concepts, establishing a perspective on the minimum requirements that should be met to facilitate the development of organisational resilience while conducting agile transformation, irrespective of transformation scale and complexity.

## 3. Results

Recent research by Grego et al. (2024) confirmed that organisations practicing an adaptive approach to resilience typically leverage business transformation during disruptions to adapt to new circumstances and shape appropriate responses. On the other hand, organisations that practice an absorptive

approach to resilience are usually inherently agile, flexible, and innovative, and thus tend to rely on established processes and incremental improvements rather than ad hoc solutions to respond to disruptions (Grego et al., 2024). Given this insights, adaptive resilience is more inclined to adopt agile methods in response to changing conditions, whereas absorptive resilience originates from built-in agility that has been cultivated through earlier efforts (Stachowiak & Pawłyszyn, 2021; Kadenic & Tambo, 2023). Therefore, agile transformation complements both the adaptive and absorptive dimensions of resilience, emerging as a strategy for navigating current disruptions and building capacities to handle future disruptions effectively.

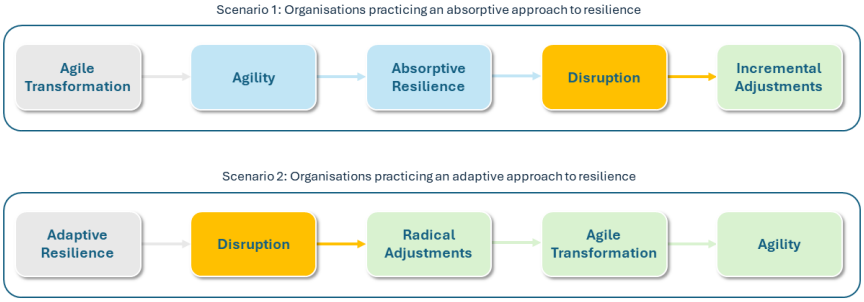


*Figure 1: Resilience scenarios*

As depicted in Figure 1, agile transformation fosters agility, which in turn leads to absorptive resilience and the implementation of incremental adjustments during disruptions. Accordingly, should organisations that practice adaptive resilience opt for agile transformation in response to a disruption, it could potentially lead to agility and, subsequently, absorptive resilience. Hence, if we set aside the unique circumstances of each disruption, agile transformation and agility are common elements in both scenarios, thus bringing us back to the essential need for agility to thrive in volatile and unpredictable environments (Holbeche, 2019). Furthermore, to build sustainably resilient organisations through agile transformation, regardless of its sequence in the resilience scenario, organisational learning must be integrated at all levels of the organisation (Koh et al., 2023).

The coexistence of agility and resilience has been confirmed to enhance performance by reducing costs, time-to-market, and recovery period, thereby playing a critical role in overcoming challenges and outperforming competitors (Lotfi & Saghiri, 2018; Lotfi, 2019; Cho et al., 2023). This can be partially attributed to the balance between reactive and proactive strategies inherent in agility and resilience, respectively, thus creating patterns that enable both quick responses and incremental improvements (Rahi et al., 2021; Hussain & Malik, 2022). Moreover, the convergence of agility and resilience has also been demonstrated to be effective for digital transformation (Nkomo & Kalisz, 2023), green solutions and sustainability (Sharma et al., 2020; Miceli et al., 2021), supply chain management (Calvo et al., 2020), and similar areas, as well as across various industries such as manufacturing, chemicals, tourism, healthcare, and others.

It is noteworthy that recent research indicates agile leadership has a positive impact on resilience, with direct communication, continuous collaboration, team autonomy, and shared responsibility fostering trust and empowering employees to actively engage in responding to the constantly emerging challenges (Mendrofa et al., 2024). This also introduces new challenges, particularly for established organizations burdened by high inertia and strict hierarchical structures, making the development of agile leaders a critical focus of any potential agile transformations they might pursue in the future. In addition, holistic approach to achieving resilience through agile transformation should be further developed, such as done in the field of project management (Kadenic & Tambo, 2023; Savkovic et al., 2023; Savkovic et al., 2024).

## 4. Discussion

Drawing from the existing body of knowledge on resilience and agile transformation, along with evidence of their coexistence and complementarity, we propose a three-step guide – *"Sensing, Reasoning, Transforming"* – to achieve resilience through agile transformation. This model is derived from the guidelines for achieving organizational agility provided by Hutter et al. (2023) and the resilient response framework by Burnard and Bhamra (2019); therefore, it is aimed at establishing practices that complement both agility and resilience.

The first step of the guide, "Sensing", involves exploring potential threats and opportunities that could impact the organization, that is, anticipating and preparing for disruptive events that may occur in the future. The second step, "Reasoning", entails a detailed analysis of the characteristics of disruptive events, either before or at the time of their occurrence, to develop appropriate responses that tackle challenges and propose improvements, whether incremental or radical, depending on the practice of absorptive or adaptive resilience. The third step, "Transforming", involves the implementation of these formulated responses and the alignment of an organization with the changed circumstances, thereby enabling business continuity, reducing tension, and establishing a new normal. As such, the three-step guide – *"Sensing, Reasoning, Transforming"* – can be seamlessly integrated with agile transformation process, especially in terms of planning, risk assessment, and continuous value delivery.

## 5. Conclusions

Given the array of global crises that pose environmental, economic, social, health, security, and other threats, the need for resilience is more pressing than ever. Achieving resilience through agile transformation presents a challenging yet promising solution to overcome obstacles and prosper in times of disruption. Therefore, it is vital to establish practices that foster both agility and resilience within organizations. Accordingly, this research has consolidated the existing knowledge on the concepts of resilience and agile transformations, developing a model that outlines potential scenarios and delineates proactive or reactive responses in line with commonly practiced dimensions of resilience. Additionally, we have proposed a three-step guide – *"Sensing, Reasoning, Transforming"* – to

facilitate resilience through agile transformation, thereby enriching both theoretical and practical discourse on these subjects. Moreover, this research underscores the importance of understanding the interplay between resilience and agile transformation and calls for empirical studies to validate or refute the insights presented herein.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CURRENT TRENDS IN UPSKILLING AND RESKILLING: ANALYZING MODERN LEARNING AND DEVELOPMENT PROGRAMS

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***Abstract***

*Over the past 5 years, upskilling and reskilling have emerged as critical strategies for organizations aiming to navigate the rapidly evolving technological and economic landscape. This paper analyzes contemporary trends in learning and development programs, focusing on how organizations are equipping their workforce with the necessary skills to stay competitive. Our study highlights how companies are leveraging advanced technologies to identify skill gaps, tailor training programs, and track employee progress. Additionally, we examine the shift towards continuous learning cultures and the role of remote and hybrid learning models, accelerated by the COVID-19 pandemic. Key case studies and industry examples illustrate successful upskilling and reskilling initiatives, providing a comprehensive overview of effective L&D strategies. We also discuss some of the challenges organizations face in implementing these programs. In conclusion, the dynamic nature of today's workforce requires innovative and adaptable L&D programs. This paper underscores the importance of strategic investment in upskilling and reskilling to foster organizational resilience and sustained growth.*

***Key words****: upskilling, digital learning platforms, learning and development*

## 1. Introduction

The current disruptive work environment is pushing organizations to significantly restructure their operations, greatly impacting the skills business leaders expect from their workforce. Many leaders recognize the growing need for upskilling and reskilling, acknowledging that learning has evolved from merely a retention tool to a critical component in executing business strategy. Learning and Development (L&D) focuses on creating a culture of continuous learning across the

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organization, highlighting the importance of coaching, feedback, leadership, and personal accountability (ey.com, 2022).

According to Ruona (2016) and Hamlin and Stewart (2011), the primary goal of L&D is individual development, particularly in relation to work-based or work-related contexts. L&D involves not only specific learning activities but also fostering a culture that encourages continuous professional growth (Harrison, 2011).

Learning in the workplace is complex and often less directly observable compared to educational contexts like schools, where learning is typically assessed through assignments. Measuring this learning is also challenging, as it often involves tacit, skill-based knowledge rather than explicit facts (Kopp et al. 2020). However, L&D practices, along with the role of L&D practitioners, are now well-established in both organizational practice and academic research (Garavan, 2023).

Workplace training is a structured approach to learning aimed at enhancing the effectiveness of individuals, teams, and organizations. I-O psychologists have contributed significantly to improving training quality through research on learning and knowledge transfer, developing training evaluation tools, refining training design and delivery methods, and strategically positioning the training function within organizations (Kraiger & Ford, 2021).

The need for continuous skill adaptation to meet new demands poses a challenge for organizations, given the often informal and social nature of workplace learning. Many organizations are responding by increasing their investment in training and development (Kodwani, 2017).

## 2. Current trends in L&D

The COVID-19 pandemic has disrupted the education and training market, shifting development from in-person settings to online platforms. This shift has prompted organizations to reassess their priorities, with a growing need for new skills. Experts believe this marks the start of a long-term transformation, not only in technology but also in the mindset of employers and employees. The demand for upskilling and reskilling has intensified, accelerated by the pandemic and the resulting economic crisis (Mikołajczyk, 2021).

The training market has quickly adapted to the widespread use of video formats, such as webinars and virtual meetings, as alternatives to face-to-face interactions. It's likely that remote communication will remain a dominant part of business operations moving forward (Mikołajczyk, 2021).

A case study from Lizier and Reich (2021), suggests moving away from strictly structured learning approaches towards a blend of formal and informal learning methods, emphasizing learning through work and complex social networks. To improve L&D systems, organizations should design initiatives that are more embedded in everyday practices, encouraging professionals to see themselves as continuous learners beyond formal training (Lizier & Reich, 2021).

Maheshwari and Vohra (2018) argued that training and development practices can be effectively described through strategy, design, implementation, and effectiveness. These practices are primarily used for skill enhancement and

fostering a positive mindset. Effective training and development align with change objectives and benefit from strong leadership support (Maheshwari & Vohra, 2018). In their study, various types of training were observed, including technical, product, process, behavioral, and attitude training. Notably, during change initiatives, behavioral and attitude training—such as yoga and meditation—were incorporated to foster a positive environment and mindset. Secondly, factors such as active leadership, identifying influencers, on-the-job learning, and a positive environment were crucial for successful change implementation. Finally, training and development practices are effective in achieving change objectives like increased productivity and efficiency through new technologies (e.g., MOST, ERP). They also help in establishing new norms and behaviors (Maheshwari & Vohra, 2018).

Csillag et al. (2019) identified two contrasting patterns regarding informal learning dominance in small firms. First pattern is integrated learning approach, or blending formal and informal learning methods. For instance, they may fund formal training or conferences and then encourage employees to share their newly acquired knowledge through internal workshops. Secondly, there is combination of knowledge sources, or a strategic use of both external and internal knowledge sources. Some small firms actively seek external knowledge and employ individuals with diverse backgrounds to foster a learning environment within the company (Csillag et al., 2019). The study also confirms that small business owners and managers play a crucial role in shaping learning processes (Csillag et al., 2019).

According to Fullwood and Rowley (2021), the culture of knowledge sharing is crucial for the development of volunteers as well. Unlike paid employees, volunteers are not motivated by concerns over performance evaluations or career advancement, which often leads to more open and effective knowledge sharing. Volunteers are driven by different motivations, and providing ample learning and social opportunities is vital for their well-being and engagement, which in turn benefits the organization (Fullwood & Rowley, 2021).

Thunnissen & Sanders, (2021) concluded that there are some differences between L&D practices in the public and the private sector. Their research was conducted in the Netherlands, and it shows that compared to the private sector, the public sector is often considered a better employer regarding the range and frequency of L&D opportunities offered. Public sector employees generally engage in training more frequently than those in other sectors. However, there are concerns about the actual value and relevance of these opportunities, as the L&D approach in the public sector may be outdated. L&D activities in the public sector are mainly focused on helping employees remain effective in their current roles rather than preparing for future job changes or new skills (Thunnissen & Sanders, 2021).

Garavan et al. (2020) have predicted in 2020 that several key external factors will be shaping learning and development in organizations. Based on surveys and interviews, four major trends have emerged as critical for the future of L&D over the next five years:

1. Globalization will remain a key driver influencing L&D.
2. Demographic shifts are becoming increasingly significant.

3. Technology and flexible work practices are reshaping how employees engage with organizations, with cloud-based and collaborative technologies playing a crucial role.
4. Changes in the nature of work, such as the rise in knowledge work and the need to work across cultures and diverse teams, will continue to evolve.

## 3. L&D and The Fourth Industrial Revolution

The Fourth Industrial Revolution has driven creativity and innovation across politics, society, and the economy, transforming knowledge management globally. This digital shift challenges traditional practices in work, meetings, and learning, leading to new and innovative L&D approaches. Globalization and technological advancements are pushing organizations to radically change their L&D strategies. Employees now seek more autonomy in managing their development, skills, and career transitions. L&D programs must adapt to the pressures of rapid technological change, with specialists supporting sustainable employee engagement, focusing on environmental, economic, and social responsibilities. (Govender, 2022).

Today, L&D work is predominantly conducted online, leveraging 4IR technology to guide learners through abundant information and data. Since the global COVID-19 pandemic, the role of L&D has become crucial in ensuring that employees develop skills for lifelong learning and adaptability, which are essential for businesses to thrive in the virtual world of today (Llandis et al., 2020).

In their research, Garavan et al. (2020) conclude that although L&D professionals recognize the importance of technology, they are generally dissatisfied with current learning technologies. These technologies, while offering better user interfaces, integration, and flexibility, are still primarily used for delivering learning rather than creating knowledge, curating content, or evaluating L&D effectiveness. Additionally, L&D professionals tend to rely on informal and social sources of evidence rather than leveraging data analytics, highlighting a gap in data-driven decision-making (Garavan et al. 2020).

Traditional knowledge management tools like trainings and workshops are widely used in enterprises, with 64% of companies in the artificial intelligence (AI) sector employing them to improve employee skills. Additionally, 46% of surveyed companies use e-learning platforms for knowledge sharing. These tools offer benefits such as easy access and customization for organizational needs. However, employees directly involved in AI development rate more innovative learning tools like knowledge bases, knowledge pills, gamification, and simulations as more useful for driving innovation. In contrast, office and administrative staff, who are not involved in product creation, place greater value on traditional methods like workshops, trainings, and e-learning (Drewniak & Posadzińska, 2020).

A growing body of literature is exploring the power and potential of generative AI tools like ChatGPT (Passmore & Tee, 2023).

The first version, launched in November 2022, was designed for a wide range of user requests, offering an interactive, conversation-like experience. In March

2023, GPT-4 was introduced, boasting the ability to perform in the top decile on standardized tests such as SATs and law exams (CNN, 2023).

In their research, Passmore & Tee (2023) tested six propositions about GPT-4's capabilities, with three being supported. GPT-4 was found to generate acceptable content on topics related to coaching ethics, mindset, and research, as assessed by an expert. However, it failed to meet standards for defining coaching, producing scientific-quality content for publication, or coaching to an international coaching body's standards. This suggests GPT-4 is effective at generating plausible content that can convince experts, but it falls short in replicating human-level performance for more complex tasks, such as full coaching conversations or scientific outputs. In terms of coaching conversations, GPT-4 was able to generate open questions and summaries in a coaching style, but its performance was rated below the ICF ACC coaching standard by a professional assessor. While AI is not yet capable of meeting professional coaching standards, the ongoing development of generative technologies raises the possibility of AI tools achieving accreditation in the future (Passmore & Tee, 2023).

## 4. Popular practices in L&D

Faraz Naim (2021) highlights some of the most popular L&D practices today, focusing on a consulting firm in India, such as:

1. **Mentoring program** where new employees are paired with senior leaders for guidance. Each new recruit is assigned a buddy from a different team on their first day to provide feedback, clarify roles, and discuss career development.
2. **Cross Training** involves teaching employees to perform the duties of other positions, providing backup for absences.
3. **eLearning** is used for delivering consistent content across the organization. Employees can access materials at their own pace via laptops or mobile devices, with participation being informal and self-directed.
4. **Job Rotation** helps employees develop skills by working in different teams and departments, which provides broader experience and helps employees understand various challenges and skills needed across the business.
5. **Job Shadowing** is a practice in which employees interested in acquiring new skills or taking on additional roles can observe and follow the operations of their colleagues and seniors through job shadowing.
6. **Knowledge Sharing** is useful for sharing insights and expertise by delivery managers. The company utilizes tools and technology for this purpose.
7. **Social media-Based Learning** is commonly used for induction and client interaction training. ABC has introduced an internal social networking tool integrated with Twitter and Facebook, to foster communication and discussion among employees (Faraz Naim, 2021).

## 5. Coaching culture

According to Alabdali (2019), implementing a coaching culture is crucial for ensuring the success of learning and development programs, as it boosts information retention. Organizations must foster this culture to drive progress, activate learning, and align with their overall goals (Alabdali, 2019).

Coaching offers several individual benefits, such as skills development, stronger employee-manager relationships, and personal goal achievement. The benefits extend to the organization as well, and some of them are: reduced turnover, succession planning, and increased motivation and engagement. Coaching can help meet organizational goals in two key ways:

1. Talent development - prepares employees for future roles, facilitates knowledge transfer, and builds coaching capabilities in the next generation.
2. Organizational development, which enhances individual skills, which contributes to overall organizational growth and competitiveness (Alabdali, 2019).

## 6. Conclusion

The pandemic has reshaped employee development, not just in format but in content. Employees seek new topics for growth, though engagement has declined due to the fatigue from numerous online initiatives (Mikołajczyk, 2021). Workplace learning analytics can be effectively integrated with traditional performance management approaches to showcase its impact across the organization. A holistic and streamlined framework is advantageous for demonstrating this broader impact (Kopp et al., 2020). In the 4IR era, L&D specialists must shift from traditional training to fostering collaborative, innovative learning cultures. Their role now involves creating learning strategies, facilitating change, managing networks, and promoting lifelong learning to align with organizational goals and employee growth. (Govender, 2022). Innovative learning tools may play a key role in fostering innovation within AI-focused companies (Drewniak & Posadzińska, 2020). Coaches and trainers are encouraged to engage with AI to explore how it can enhance their practice, as AI tools hold potential to support and improve coaching and training efforts (Passmore & Tee, 2023). Despite organizational rhetoric that emphasizes the importance of learning through work, both the daily experiences of professionals and organizational documentation suggest that this is not fully realized. Adopting a complex adaptive systems approach highlights the need to integrate work and learning more effectively and reveals the ongoing need to transform L&D systems and practices within organizations (Lizier & Reich, 2021). While L&D practitioners have been encouraged to adopt more strategic roles over the past two decades, progress in this area has been modest. There is still a need for L&D professionals to more fully embrace strategic responsibilities to enhance their impact (Garavan et al., 2020).

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DIGITAL TRANSFORMATION AND HR TECHNOLOGY – INTEGRATING AI INTO TALENT ACQUISITION AND RETENTION OF EMPLOYEES

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***Abstract***

*The integration of artificial intelligence into human resources has driven significant advancements in talent acquisition and employee retention. This paper examines how AI-powered technologies have transformed recruitment processes by enhancing candidate sourcing, streamlining applicant tracking, and leveraging data analytics for better hiring decisions. These innovations have enabled organizations to attract top talent more efficiently and improve the overall candidate experience. In addition to recruitment, AI has been pivotal in developing effective retention strategies. This study includes key case studies and industry examples that showcase successful AI implementations in HR, but also some challenges and ethical considerations. By exploring these issues, we provide recommendations for HR professionals to harness AI's potential responsibly and ethically. In conclusion, AI's integration into HR functions represents a transformative shift, enhancing both efficiency and employee-centric approaches. This paper highlights the critical role of strategic AI implementation in modernizing HR practices and driving organizational success.*

***Key words:*** *Digital Transformation, Artificial Intelligence, Talent Acquisition*

## Introduction

Among various HR practices, talent acquisition has been most impacted by AI and technological advancements. Technology has transformed how organizations attract, acquire, and hire talent. Advances in HRIS (Human Resource Information Systems) have streamlined the administrative aspects of talent acquisition, reducing time, effort, and costs across various tasks. Tools like chatbots, applicant tracking systems, intelligent search engines, and candidate relationship management (CRM) systems have significantly improved the efficiency and effectiveness of this function. While HRIS has enhanced overall HR efficiency, the application of AI in talent

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acquisition has led to a radical transformation, elevating the role of technology in this domain (Tiwari et al., 2022).

The integration of AI in TA has transformed traditional recruitment, offering opportunities and challenges for building diverse, inclusive workforces. Organizations are increasingly leveraging AI technologies like machine learning and predictive analytics to enhance recruitment efficiency. AI optimizes workflows, reduces time-to-hire, and improves the quality of candidate matches, ushering in a new era of innovation in identifying and selecting talent (Fatema & Ahmad Khan, 2024). McKinsey's Global Institute predicts that by 2030, around 70% of companies will adopt some form of AI. AI offers the potential to balance accuracy and fairness in hiring by using dynamic, personalized scoring algorithms (Mishra et al., 2020).

Additionally, AI is commonly used in other HR practices, such as Onboarding, Performance Management, Learning & Development and administrative tasks. AI can also play a crucial role in enhancing employee engagement and retention. By examining employee data, AI algorithms can detect patterns and trends that signal low engagement or elevated turnover rates (Murugesan et al., 2023).

## 2. AI and retention of employees

AI can assist with internal promotions and employee retention by identifying those at risk of leaving the company. For example, Veriato, a tech company, has developed AI platforms that monitor employee computer activity, such as emails, keystrokes, and browsing behavior, to flag potential "escape risks." The software analyzes changes in communication tone and activity patterns to predict when employees might be considering leaving, providing employers with early warning signs (Rathi, 2018).

According to Hughes et al. (2019), workplace relationships and social interactions are crucial for job satisfaction, meaning, and retention. Informal conversations with colleagues and feedback from supervisors provide social support that enhances employee well-being. However, AI-managed work environments may reduce these interactions. To counter this, organizations can create online communities where employees can connect with each other and the company, fostering a sense of community. While privacy must be respected, these platforms can help replace traditional social interactions in AI-driven workplaces (Hughes et al., 2019).

The research from Bhardwaj et al. (2020), also showed that AI plays important in employee retention, analyzing performance, collecting data regarding employees, providing accurate and real time information (Bhardwaj et al., 2020).

## 3. Artificial Intelligence in Talent Acquisition

AI plays a transformative role in talent acquisition by automating and enhancing recruitment processes at various stages. From resume screening to onboarding, AI improves efficiency and effectiveness. It matches keywords in resumes to job descriptions, interprets the context of skills, and automates

candidate sourcing using predictive analytics to identify potential talent. Chatbots engage with candidates, answering questions and conducting initial screenings, while AI systems analyze video responses during interviews and handle scheduling tasks. AI-driven assessments provide adaptive and accurate evaluations of candidates' skills, and predictive analytics help forecast time-to-hire and candidate fit. Additionally, AI promotes diversity by minimizing unconscious bias and tracking inclusivity metrics. Despite these advantages, research shows that Talent Acquisition and People (TAP) professionals are more comfortable using AI for sourcing and pre-selection, hesitating to implement AI in interviews due to concerns about maintaining human interaction and skepticism regarding AI's effectiveness in this phase. AI also optimizes the recruitment experience through advanced technologies like natural language processing, which assesses speech for fluency and grammar, and video interview tools with facial recognition that evaluate body language and minimize bias. Furthermore, programmatic advertising, data management platforms, and chatbots enhance the process by targeting job ads and providing personalized candidate interactions. AI tools such as job description optimization, candidate rediscovery from existing databases, and social media candidate discovery streamline recruitment, improve productivity, and lower costs. Machine learning, predictive analytics, and robotic process automation also enable AI to continuously refine its processes, making it increasingly vital for modern recruitment. These technologies help HR departments by automating repetitive tasks and providing data-driven insights, ultimately boosting recruitment efficiency and enhancing the candidate experience while ensuring organizations meet their talent acquisition needs effectively (Fatema & Ahmad Khan, 2024; Gupta & Srivastava, 2023; Gethe, 2022; Takhi et al., 2020).

### 3.1. Advantages of AI in Talent Acquisition

Utilizing AI in talent acquisition enhances efficiency, objectivity, and alignment with organizational goals. However, ongoing monitoring and refinement of AI systems are crucial to maintain fairness, transparency, and ethical practices in recruitment (Fatema & Ahmad Khan, 2024).

AI offers multiple benefits for recruiters, including faster recruitment processes, improved quality of hires through standardized skill matching, and seamless workflow continuity. It reduces recruitment costs by lowering turnover rates and increasing revenue per employee. Additionally, AI enhances recruitment effectiveness, simplifies onboarding, and personalizes communication to foster trust between candidates and employers, allowing recruiters to focus on core responsibilities. Beyond recruitment, AI integration provides businesses with a competitive edge, creates new jobs, and drives investment growth by transforming industries and augmenting human capabilities. AI increases productivity by automating routine tasks and improving decision-making through data-driven insights. It fosters collaboration between humans and AI, optimizes resource allocation, and enhances employee experiences by freeing them for higher-value tasks. AI also enhances recruitment by leveraging big data to improve diversity, predict performance, and identify talent gaps. While AI is particularly embraced for

white-collar roles, such as software engineers, it is less favored for specialized roles. Moreover, AI can improve work-life balance by reducing workloads through task automation (Gethe, 2022; Sheshadri & Palivela, 2023; Gupta & Srivastava, 2023).

Overall, AI adoption in organizations is high, and HR leaders positively associate it with improved efficiency, quality, and cost in talent acquisition, with innovation playing a key role in driving AI adoption (Tiwari et al, 2022).

### 3.2. Disadvantages and challenges

AI in talent acquisition has notable disadvantages that can impact its effectiveness and raise ethical concerns. One major issue is the potential for perpetuating biases in algorithms, leading to discriminatory hiring practices. Since AI systems often rely on historical data, they may not accurately reflect emerging skills or future talent needs, and their lack of transparency can make it difficult to understand or justify decisions. This reliance on past data can also result in AI overlooking contextual details or unique experiences that differentiate candidates. Privacy is another critical concern, as AI handles vast amounts of sensitive personal data, increasing the risk of breaches or misuse. Furthermore, AI struggles to assess qualities like emotional intelligence and creativity, which are essential for many roles, and there is a risk of unintended discrimination in the hiring process. The high implementation costs of AI can be a barrier, especially for smaller organizations, and its adoption may create job insecurity for recruiters, who fear being replaced by technology. AI also faces challenges with complex decision-making, where human judgment is still crucial. Additionally, adopting AI requires HR professionals to acquire new skills and knowledge in technology, which can be a significant hurdle, alongside the need to maintain data security and adapt to frequent AI updates. These factors, including privacy concerns and the risk of bias, present significant challenges for organizations looking to integrate AI into their recruiting processes (Fatema & Ahmad Khan, 2024; Gethe, 2022).

## 4. Conclusion

Artificial intelligence significantly enhances and optimizes the talent acquisition process. (Khan, 2022). AI holds promise for transforming talent acquisition, ensuring fair, transparent, and effective hiring practices. HR managers should collaborate with AI developers and data scientists to ensure ethical and responsible AI use. Embracing AI responsibly can provide organizations with a competitive edge by enhancing their ability to attract a diverse and talented workforce (Sattu et al., 2024). However, enthusiasm for AI wanes during the interview stage due to concerns that it might harm the candidate experience and come across as impersonal. HR leaders should thoughtfully implement AI in recruitment processes and address these concerns to ensure effective use (Gupta & Srivastava, 2023). AI and data analytics boost talent acquisition by offering deeper candidate insights and automating routine tasks. While not replacing recruiters, AI enhances efficiency, allowing them to focus on building relationships and strengthening the employer brand, ultimately improving both candidate experience

and recruitment outcomes. (Takhi et al., 2020). It also shifts recruiters' roles from administrative tasks to strategic functions. Rather than replacing HR, AI enhances it, becoming a fundamental aspect of business operations (George & Thomas, 2021).

AI can aid internal promotions and employee retention by identifying those at risk of leaving, as demonstrated by Veriato's platform that monitors employee activity to detect potential departure risks (Rathi, 2018). While AI-managed environments might reduce social interactions crucial for job satisfaction and retention, organizations can create online communities to maintain employee connections (Hughes et al., 2019). Additionally, AI's role in analyzing performance and providing real-time data supports effective retention strategies (Bhardwaj et al., 2020).

Organizations must adopt AI to leverage its benefits and stay competitive (George & Thomas, 2021), as well as gain a significant edge in the market (Vedapradha et al., 2023). Organizations that don't adopt AI may struggle with talent acquisition and retention. HR leaders and policymakers should stay updated on AI developments and market trends to maintain a competitive edge. (Bilal & Várallyai, 2021).

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# INTEGRATING SUSTAINABILITY AND CIRCULAR ECONOMY PRINCIPLES IN LEADERSHIP AMIDST UNCERTAINTY

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***Abstract***

*After the recovery process of the world economy from the consequences of the Coronavirus, the crisis in Ukraine and the problem of the increase in living costs, a new business scene and a leadership role have been established. Inevitably, online businesses have replaced a part of the communication and way of motivating employees, and increased the importance of flexibility of thinking. They also increased the need for metacognitive knowledge and the ability to learn quickly as a means of survival in a dynamic environment, and the necessity for decision-making in a world where the only certainty is that nothing is certain. One of the key parameters for adapting to the new situation is the mentor's influence on the development of competencies in human resources, and establishing the foundation of sustainable leadership as an increasingly important concept, with a focus on environmental protection. The paper investigates the aforementioned influence of leaders who, in addition to their traditional role, are steadily moving into the role of Coach who provides support to employees, encourages new ways of thinking, and nurtures curiosity and faith in the value of continuous learning. On the other hand, a Coach sets an example of ethical behaviour and brings decisions under the principles of nature preservation. A mentor behaves as a leader who takes care of the circular economy, such as the productivity of resources, the elimination of waste and pollution, and the restoration of natural systems for the organisation to be successful and sustainable over time, as well as the pioneer and promoter of this important topic. The goal is to look at the key elements and characteristics that make a leader successful and efficient, and a leader who acts in accordance with the circular economy.*

***Key words:*** *Leadership, sustainable leadership, circular economy.*

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# 1. Introduction

The paradigm of circular economy was created as a result of linear economy, in order to protect the environment and reduce the negative effects i.e. the emission of greenhouse gases which leads to permanent damage to the atmosphere and the climate changes we are all witnesses to. Circular economy is based on the efficient use of resources and achieving sustainable development. (Reis et al., 2023) This is done by reintroducing renewable materials or waste into the production process and supplying the energy needs of communities. In this way, bioeconomy is improved, renewable bioenegry is produced, and organic waste is valorized. (Andrić et al., 2023) Since the emergence of the 4.0 concept, the research in the field of industrial engineering evolved towards increasing economic, ecological, and social values. An integration of digital technologies and intelligent techniques with the paradigm of sustainable production has occurred. (Milošević & Ćosić 2023) Digitalization can therefore make an essential contribution to the transition to a circular economy. Products can contain tags that can be scanned during exploitation or recycling and thus enable the access to relevant product data (Ćosić et al., 2006) enabling the circular flow of materials throughout the product life cycle by using the 6R concept based on innovation (Reduce, Reuse, Recycle, Refuse, Rethink, and Repair) (Gholami et al., 2022)

On the other hand, the way of introducing circular economy must be supported and monitored by a leader. In relation to major business transformations such as CE, the role of leadership in ensuring an effective paradigm shift is essential. (Moktadir et al., 2018) Inevitably, online businesses have replaced a part of the communication and way of motivating employees, and increased the importance of flexibility of thinking. They also increased the need for metacognitive knowledge and the ability to learn quickly as a means of survival in a dynamic environment, and the necessity for decision-making in a world where the only certainty is that nothing is certain. One of the key parameters for adapting to the new situation is the mentor's influence on the development of competencies in human resources, and establishing the foundation of sustainable leadership as an increasingly important concept, with a focus on environmental protection. Several studies have highlighted that management control systems support ethical leadership by setting moral standards and monitoring organizational practices and employee behaviors (Kleine & Weiβenberger, 2014; Ko et al., 2018) The leader sets an example of ethical behaviors, through which he provides support to employees, encourages new ways of thinking, fosters curiosity and belief in the value of lifelong learning. Lead by their own example, the leader promotes the company's ethics, culture and values, as well as moral behavior in the company. Because of all the above, it is reasonable to assume that ethical leadership resonates most with circular economy.

Geissdoerfer et al. (2017) argue that the circular economy represents a sustainable development strategy, positioning it as a crucial approach for addressing global environmental challenges by promoting resource efficiency and minimizing waste. This aligns CE with the core objectives of the sustainable

development goals (SDGs), particularly those that focus on environmental sustainability, economic resilience, and social well-being.

## 2. Literature review

### 2.1 Drivers and barriers to the adoption of CE practices

Circular economy practices consist of a couple of principles ranging from the 3R (e.g., Reduce, Reuse and Recycle) to the 6R framework (e.g., Repair, Reduce, Reuse, Recycle, Redesign, and Remanufacture) (Jia et al., 2020). Literature has gained significance in the last decade due to the benefits it can offer when applied in industry. It has the capacity to provide sustainable production, a tendency to reduce the use of natural resources, or rather to promote a more rational use of resources, as well as benefits in the form of waste reduction at the end of a product's lifecycle, due to reuse. In the domain of personality psychology, the trait concept has carried the burden of dispositional explanation. A multitude of personality traits has been identified and new trait dimensions continue to join the growing list. In a similar fashion, the concept of attitude has been the focus of attention in the explanations of human behavior offered by social psychologists. (Ajzen, 1987). Attitude refers to an individual's positive or negative evaluation of performing a particular behavior, subjective norm refers to what others do or what behavior they consider appropriate and perceived behavioral control refers to an individual's ability to exert control over himself/herself in performing a specific behavior (Ajzen, 1991). Concerning ethical leadership, we propose that a leader's attitude toward ethical behavior, subjectivenorm about ethical behavior and perceived behavioral control influence his/her ethical intention, which in turn, translates into followers' perceptions of ethical leadership (Guo, L., 2019). The literature points to a limitation in the research on the impact of ethical leadership on the introduction of circular economy when it comes to the subjective views of the respondents.

### 2.2 Ethical leadership

Some of the most common accepted definitions: Ethical leadership is considered a key driver of sustainable development, employee well-being, and environmental care (Amisano, 2017). Ethical leadership focuses more on integrity, trustworthiness, fairness, and ethical conduct in personal and professional life. (Cheffi et al. 2023). Ethical leaders engage in acts and behaviors that benefit others, and at the same time, they refrain from behaviors that can cause any harm to others (Yukl et al., 2013).

### 2.3 The 6 Main Principles of Ethical Leadership

1. *Respect* – Respect includes valuing others' skills and contributions. Mutual respect leads to healthier workplace relationships where both sides appreciate and support what the other is doing and feel secure in talking through issues and

challenges. Healthy relationships create positive work environments, which drives increased productivity.

2*. Accountability* – Ethical leaders hold themselves accountable for their actions. They make decisions based on integrity and stand behind their work.

3. *Service* – Leaders make ethical decisions based on doing what is right for employees, customers, and the community.

4. *Honesty* – Leaders who are transparent build trust amongst their organizations and amongst customers*.*

5. *Justice* – Ethical leaders approach situations with a focus on treating everyone fairly, and they expect their teams to treat each other and customers the same way. Through their actions, they build equitable work environments where everyone feels respected.

6. *Community* – Ethical leaders view their companies as communities and consider everyone involved when evaluating situations and making decisions (Professional & Executive Development, Harvard Division of continuing education).

Construct of ethical leadership: ethical leaders think about long-term consequences, drawbacks and benefits of the decisions they make in the organization. They are humble, concerned for the greater good, strive for fairness, take responsibility and show respect for each individual. Ethical leaders set high ethical standards and act in accordance with them. They influence ethical values of the organization through their behaviour. Leaders serve as role models for their followers and show them the behavioural boundaries set within an organization. They are perceived as honest, trustworthy, courageous and demonstrating integrity. The more the leader "walks the talk", by translating internalized values into action, the higher level of trust and respect he generates from followers. (Mihalič et al., 2010). Remains problematic that there continues to be a conflation between ethical leader behaviors and followers' evaluations of the leader's values, traits, and behaviors (Alvesson & Einola, 2019; Fischer et al., 2020).

### 2.4 Circular economy practices

The implementation of at least one of CE principles is considered an adoption of CE practices (Garrido-Prada et al., 2021). It may also be beneficial for national governments worldwide as they expect to reach decarbonisation objectives and aim for efficient use of natural resources. (Vivek, S., et al., 2023) In study involving industry and academic experts, concluded that leadership is a key factor in the successful deployment of CE practices. (Moktadir et al., 2018) Thus, the potential economic benefits of CE drive businesses to adopt CE practices. (Franco, 2017) argued that the current business climates that favour CE practices threaten firms engaged in linear economic systems. Also, managerial support drives CE adoption, where the top management is committed to collaboratively working with employees. (Lahti et al., 2018)

A takeaway from study is that ethical leadership in has an indirect impact on the extent of CE practices rather than a direct one, as highlighted in sustainability literature (Choi et al., 2015; Pasricha et al., 2018).

# 3. Methodology

## 3.1 The survey

The study was based on a survey, which was given to 63 leaders from companies in both manufacturing and service sectors. It consists of two parts, where the first part examines the respondents' opinion on ethical leadership, while the second part refers to the examination of the degree of implementation of circular economy in companies. This study expands the scope of existing circular economy studies and aims to confirm or refute the mutual influence of ethics on it. This study used the following recommended surveys, corrected and adapted them according to the opinion of the authors. The target sample are the leaders of large companies (more than 1000 employees) purposefully chosen because large companies are pioneers in the application of the circular economy in the Republic of Serbia, with top management often based in developed European countries. The introductory part of the questionnaire covers the demographic characteristics of the respondents, followed by the aforementioned section on ethical leadership and circular economy. The ethical leadership part consists of 10 statements that need to be confirmed, denied or partially agreed with on a Likert scale, chosen due to its popularity among leadership experts. The leaders who were given the survey are partly from manufacturing and partly from service companies. The sample size is adequate for hypothesis testing in accordance with the proposed norms.

## 3.2 Data analysis and results

Table 1 presents survey results regarding the perceptions of leaders' ethical behaviors and practices among respondents. Each question corresponds to a specific statement about leadership ethics, with respondents asked to rate their agreement on a scale from 1 to 5, where 1 typically indicates strong disagreement sand 5 indicates strong agreement.

*Table 1: Etichal leadership*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Leader listens to what employees have to say. | 4,1 | 12,2 | 38,8 | 22,4 | 22,4 |
| 2. Leader disciplines employees who violate ethical standards. | 4,1 | 6,1 | 30,6 | 38,8 | 20,4 |
| 3. Leader conducts personal life in an ethical manner. | 4,1 | 8,2 | 26,5 | 38,8 | 22,4 |
| 4. Leader has the best interests of employees in mind. | 10,2 | 8,2 | 32,7 | 28,6 | 20,4 |
| 5. Leader makes fair and balanced decisions. | 6,1 | 6,1 | 30,6 | 26,5 | 30,6 |
| 6. Leader can be trusted. | 4,2 | 14,6 | 18,8 | 27,1 | 35,4 |
| 7. Leader discusses business ethics or values with employees. | 6,1 | 8,2 | 30,6 | 20,4 | 34,7 |
| 8. Leader sets an example of how to do things the right way in terms of ethics. | 4,2 | 8,2 | 32,7 | 18,4 | 36,7 |
| 9. Leader defines success not just by results but also the way it is obtained. | 8,2 | 16,3 | 30,6 | 24,5 | 20,4 |
| 10. When making decisions, leader asks, "what is the right thing to do?" | 6,1 | 24,5 | 42,9 | 16,3 | 10,2 |

The survey was completed by 63 leaders, of which 57.4% were female and 42.6% were male. The largest number of respondents (72.1%), belong to the age group between 30 and 40 years, while 14.8% of leaders are between 40 and 50 years old, 11.5% belong to the younger category between 20 and 30 years, and 1.6% of respondents are over 50 years old. In terms of work experience, the largest group

consists of those with 10 to 15 years of experience, representing 39.3% of respondents. This is followed by individuals with 5 to 10 years of experience, accounting for 32.8%. Additionally, 9.8% of respondents have 15 to 20 years of experience, and another 9.8% have more than 20 years. The smallest group, 8.2%, includes those with less than 5 years of work experience.

It is encouraging to note, based on the responses of the majority of participants, that a leader can be trusted (62.2%). Additionally, 55.1% of respondents believe that leaders set a positive example of ethical behavior. An area for improvement is vertical communication, where employees feel that leaders listen to what they have to say, particularly considering the professional knowledge they bring to their roles and the expertise they could contribute with innovative suggestions for process improvement.

Table 2 presents survey results regarding the adoption of sustainable practices by a company, focusing on environmental responsibility and resource management. Each question corresponds to a specific statement related to the company's sustainability efforts, with respondents rating their agreement on a scale from 1 to 5, where 1 typically indicates strong disagreement and 5 indicates strong agreement.

*Table 2: Circular economy*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Cares about reducing the use of products and resources. | 1,6 | 12,9 | 32,3 | 32,3 | 21 |
| 2. The company uses biodegradable materials instead of conventional ones. | 19,4 | 22,6 | 37,1 | 14,5 | 6,5 |
| 3. Equipment/cars/machines are intensively used by being shared among employees and branches. | 11,3 | 19,4 | 25,8 | 27,4 | 16,1 |
| 4. Renewable energy is used to reduce the environmental impact. | 22,6 | 22,6 | 30,6 | 14,5 | 9,7 |
| 5. You recycle products and materials. | 8,1 | 17,7 | 24,2 | 25,8 | 24,2 |
| 6. You consider and use regenerative/biodegradable materials instead of conventional ones. | 16,1 | 25,8 | 29 | 21 | 8,1 |
| 7. You regularly maintain products to extend their lifespan. | 1,6 | 8,1 | 24,2 | 35,5 | 30,6 |
| 8. You recycle waste. | 6,5 | 16,1 | 21 | 27,4 | 29 |
| 9. The company implements a process for recovering products that customers no longer use. | 25,8 | 22,6 | 24,2 | 19,4 | 8,1 |
| 10. You repair and maintain defective products and materials in order for them to be reused with their original function in mind. | 6,5 | 17,7 | 19,4 | 41,9 | 14,5 |

It is inevitable that when discussing the circular economy, the first step implemented in companies is often the most commonly recognized one, waste recycling. The majority of respondents, 66.1%, believe that their company regularly maintains products to extend their lifespan. Additionally, the responses indicate that companies are making efforts to reduce the use of products and resources. However, a significant area for improvement is the use of renewable energy sources to reduce environmental impact, with 45.2% of respondents indicating that this aspect is at an unsatisfactory level in their companies.

## 4. Findings

Ethical leadership was measured using 10 items adopted from Brown and cooperates (2005). This instrument was chosen because of its popularity among leadership scholars (Avolio et al., 2009) and relevance to the study of sustainability practices (Choi et al., 2015). The survey results confirm the connection between the principles of ethical leadership and the process of implementing a circular economy.

This conclusion is supported by responses indicating that 62.3% of respondents believe that leaders can be trusted. Approximately 67% of employees agree with the statement that leaders listen to what employees have to say. Furthermore, 55.7% of employees trust that their leader sets an example of working in an ethical manner. Opportunities for enhancement exist in the relationship between leaders and employees concerning ethical behavior, especially regarding the inclusion of employees' perspectives in decision-making processes. It is imperative to establish clear standards that promote zero tolerance for unethical conduct and to implement appropriate disciplinary measures in the event of violations. Leaders play a crucial role in establishing the organizational culture and must consistently model ethical behavior, setting a standard that is expected of all employees. This commitment is essential for fostering a business environment built on strong ethical foundations. When cross-referencing the results of leadership with the implementation of circular economy practices in the observed companies, it is evident that products and materials are being recycled, regular maintenance is conducted to extend product lifespans, and waste is recycled. However, the responses from participants revealed areas for improvement in the adoption of circular economy principles, specifically: the implementation of processes for the recovery of products no longer used by customers, the use of regenerative or biodegradable materials instead of conventional ones, and the adoption of renewable energy sources to mitigate environmental impact. Ethical leadership fosters unity among employees, promotes a sense of community, and encourages the sharing of equipment, vehicles, and machinery both among employees and across different branches of the organization. These insights provide a clear direction for decision-making aimed at accelerating the transition to a circular economy.The study simultaneously examined the role of ethical leadership alongside ten dimensions of circular economy practices. Conducted in Serbia with a sample of 63 leaders, the research identified key areas for developing circular economy initiatives within both service and manufacturing sectors. The findings suggest that ethical leadership can play a crucial role in facilitating the transition to a circular economy. This study contributes to the emerging body of literature on the micro-foundations of sustainability, focusing on the individual actions and interactions that underpin this movement (Aguinis & Glavas, 2012).

Future research directions could include replicating this study in other countries to enhance the generalizability of the findings. Additionally, prioritizing the principles of ethical leadership according to their impact on promoting and implementing circular economy practices could help identify which principles exert the strongest influence on the transition process. Researchers might also consider incorporating other relevant constructs, such as ethical effectiveness or ecological dynamics, into the investigation. This broader approach would facilitate a more comprehensive understanding of the principles that affect the adoption of circular economy practices in organizations, ultimately aiming for a more rational use of natural resources and greater environmental sustainability.

**Appendix 1. Questionnaire**

*Ethical leadership* (Source: Brown et al., 2005).
Please indicate the extent to which the following statements describe effective leadership (1-Not at all; 5-frequently if not always):

1. Leader listens to what employees have to say.
2. Leader disciplines employees who violate ethical standards.
3. Leader conducts personal life in an ethical manner.
4. Leader has the best interests of employees in mind.
5. Leader makes fair and balanced decisions.
6. Leader can be trusted.
7. Leader discusses business ethics or values with employees.
8. Leader sets an example of how to do things the right way in terms of ethics.
9. Leader defines success not just by results but also the way it is obtained.
10. When making decisions, leader asks, "what is the right thing to do?"

*Circular economy activities* (adapted by the authors from PBL's Potting et al., 2016):

1. Cares about reducing the use of products and resources.
2. The company uses biodegradable materials instead of conventional ones.
3. Equipment/cars/machines are intensively used by being shared among employees and branches.
4. Renewable energy is used to reduce the environmental impact.
5. You recycle products and materials.
6. You consider and use regenerative/biodegradable materials instead of conventional ones.
7. You regularly maintain products to extend their lifespan.
8. You recycle waste.
9. The company implements a process for recovering products that customers no longer use.
10. You repair and maintain defective products and materials in order for them to be reused with their original function in mind.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DIGITAL TECHNOLOGIES AS SUSTAINABILITY ENABLERS

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***Abstract***

*Although sustainable practices have been addressed in Industry 4.0, sustainability as a concept started to attract attention when established as one of the critical pillars of Industry 5.0. Beyond environmental impact, its scope includes social, economic, and ecological aspects. To investigate how the use of specific digital technologies contributes to sustainable practices in manufacturing processes, the authors of this paper show a correlation between digital technologies and sustainability. The dataset used in the research represents the Serbian manufacturing sector, and the data was obtained in 2023 through the Digital Servitization Survey.*

***Keywords:*** *Industry 5.0, sustainability, digital technologies, Digital Servitization Survey.*

## 1. Introduction

Digital technologies and sustainability awareness have been developing parallelly during the last decade (Bressanelli et al., 2018). When compared to each other, both digital technologies and sustainable practices require investments. However, even though digitalization can positively impact the company's profit, sustainability positively impacts other business aspects, such as customer loyalty, brand reputation, and ESG scores, emphasized through the Industry 5.0 concept (Trstenjak et al., 2023).

When implemented, digital technologies contribute to sustainability by digitalizing specific processes and reducing waste (Mustapić et al., 2023). Additionally, the impact digital technologies have on society, in terms of upskilling and reskilling, as well as the possibilities for humans to do more cognitive than physical work, is perceived as good (Rannertshauser et al., 2022). However, the

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intensity of the impact certain digital technologies have on people, the planet, and profit is unknown.

To examine the impact that digital technologies have on sustainability in the Republic of Serbia's manufacturing sector, the authors of this paper propose the following research question:

**RQ:** *Is there any association between digital technologies and sustainability in the manufacturing sector in the Republic of Serbia?*

The authors conducted Fisher's exact test on 38 manufacturing firms from the Republic of Serbia to answer the research question. The rest of the manuscript consists of the following sections: Section 2 provides a literature review of sustainability and digital technologies; Section 3 covers the methodology used in the research; results and discussion are presented in Section 4, and Section 5 shows the main conclusions of the paper.

## 2. Literature review

### 2.1 Sustainability

Sustainability addresses people, the planet, and profit – three P's, also known as the triple bottom line (TBL) (Dhayal et al., 2023). This TBL represents a sustainability framework which supports the development and implementation of business strategies (Dhayal et al., 2023). In the context of sustainability, firms have developed corporate social responsibility (CSR), which represents the impact firms make on environmental, economic, and societal aspects (Potočan et al., 2021). Except through the three P's, sustainability is also addressed through the United Nation's *Sustainable Development Goals (SDGs)* (Wu et al., 2018)

Sustainability parameters used in this research are: (1) the company has metrics to assess the economic performance of the services, (2) the company has metrics to evaluate the environmental impact of services, (3) digital servitization is seen as a way to be sustainable, and (4) reconfigurability or upgradability is seen as a critical strategy to achieve sustainable solutions.

### 2.2 Digital technologies

Digital technologies are being developed and implemented since 2011 (Lasi et al., 2014). Due to the use of digital technologies, business models are being transformed (Martynov et al., 2019). This transformation includes digital services, which are being offered alongside physical products – a phenomenon called *digital servitization* – which has appeared together with *product-service systems* (Rakic et al., 2023). Furthermore, sustainable manufacturing practices are addressed through the Industry 4.0 concept, which emphasizes how digital technologies can contribute to sustainability (Branger & Pang, 2015). When transitioning from Industry 4.0 towards Industry 5.0, digital technologies go beyond digitalization and aim at designing a human-centric, sustainable, and resilient solutions (Golovianko et al., 2023; Slavic et al., 2024).

Digital technologies that were assessed in this research are (1) Additive Manufacturing/3D Printing, (2) Advanced Manufacturing Solutions (Cyber-physical systems, Collaborative robots), (3) Artificial Intelligence/Machine Learning, (4) Big Data Analytics, (5) Cloud Computing, (6) Cybersecurity, (7) (Industrial) Internet of Things, (8) Mixed Reality (Virtual and Augmented Reality), and (9) Simulation of Connected Machines.

## 3. Methodology

This research collected data from January 2022 until January 2023 through the "Digital Servitization Survey." Although this survey gathered answers worldwide, the data used in this research represents answers collected from firms in the Republic of Serbia. The "Digital Servitization Survey" was structured by 15 international experts and is based on a literature review of Industry 4.0 and product service systems. The experts mentioned come from fields of *servitization*, *product-service systems*, *manufacturing engineering and operations*, and *Industry 4.0*.

The survey was distributed by e-mail and social media from January 2022 until January 2023, and 314 firms responded. Out of these 314 firms, 119 are from the Republic of Serbia. The response rate in the Republic of Serbia was 15%. When manufacturing firms were extracted, only 38 firms were left. These companies are grouped by size, manufacturing sector, and annual turnover.

Descriptive statistics and Fisher's exact test present the relationship between digital technologies and sustainability. The authors used Fisher's exact test instead of Chi-square due to the sample size of 38 firms and the expected cell value of five or fewer. Furthermore, codes used in this research are from DT1 to DT9 for digital technologies and from S1 to S4 for sustainability parameters.

Table 1 presents the sample distribution by company size. Most firms—16 (42%)—have 11 to 50 employees. Next, 17 firms (45%) have 51 to 250 employees, and 5 firms (13%) have more than 251 employees.

*Table 1: Sample distribution by company size*

| **Firm size** | ***n*** | **%** |
|---|---|---|
| 11 to 50 employees | 16 | 42 |
| 51 to 250 employees | 17 | 45 |
| More than 251 employees | 5 | 13 |

The data presented in Table 1 show that this research is mainly based on small and medium enterprises since only 5 large enterprises have participated.

Table 2 presents the sample distribution by manufacturing sector according to the NACE classification. Most companies are beverage manufacturers (NACE 11) – 7 firms (19%). Next, 5 firms (13%) come from the following sectors: the manufacture of food products (NACE 10), rubber and plastic products (NACE 22), and electrical equipment (NACE 27). Four firms (10%) are manufacturers of machinery and equipment, nowhere else classified (NACE 28), and 3 firms (8%) are manufacturers of textiles (NACE 13). Finally, all other firms that participated in the research (9 firms; 24%) come from other NACE sectors.

*Table 2: Sample distribution by manufacturing sector*

| **Manufacturing sector** | ***n*** | **%** |
|---|---|---|
| Manufacture of beverages | 7 | 19 |
| Manufacture of food products | 5 | 13 |
| Manufacture of rubber and plastic products | 5 | 13 |
| Manufacture of electrical equipment | 5 | 13 |
| Manufacture of machinery and equipment n.e.c. | 4 | 10 |
| Manufacture of textiles | 3 | 8 |
| Others | 9 | 24 |

Furthermore, this research mainly is based on data from manufacturers of beverages, food products, rubber and plastic products, and electrical equipment.

Table 3 shows the sample distribution by annual turnover, measured in millions of euros. Additionally, 14 firms (37%) earn less than 2 million annually, 18 firms (47%) earn between 2 and 10 million annually, 4 firms (10%) earn between 11 and 25 million annually, 1 firm (3%) earns between 26 and 50 million annually, and 1 firm (3%) earns more than 50 million annually.

*Table 3: Sample distribution by annual turnover*

| **Annual turnover (euros)** | ***n*** | **%** |
|---|---|---|
| Less than 2 million | 14 | 37 |
| 2 to 10 million | 18 | 47 |
| 11 to 25 million | 4 | 10 |
| 26 to 50 million | 1 | 3 |
| More than 50 million | 1 | 3 |

Analysing the annual turnover of the firms that participated in this research, it is concluded that most firms earn up to 10 million euros annually.

## 4. Results and discussion

The use of *digital technologies* and *sustainability* according to the gathered data is presented in Figure 1. When addressing digital technologies, 3% of firms use Additive Manufacturing/3D Printing (DT1), 8% use Advanced Manufacturing Solutions (DT2), 5% use Artificial Intelligence/Machine Learning (DT3), 8% use Big Data Analytics (DT4), 11% use Cloud Computing (DT5), 8% use Cybersecurity (DT6), 11% use (Industrial) Internet of Things (DT7), 8% use Mixed Reality (DT8), and 8% use Simulation of Connected Machines (DT9). Regarding the sustainability parameters, 16% of firms have metrics to assess the economic performance of the services (S1), 11% of firms have metrics to evaluate the environmental impact of services (S2), 16% of firms see digital servitization as a way to be sustainable (S3), and 13% of firms see reconfigurability or upgradability as a critical strategy to achieve sustainable solutions (S4).

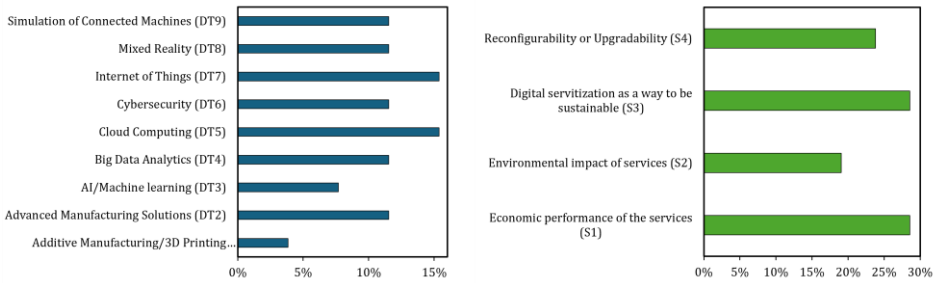


*Figure 1: The use of digital technologies and sustainability*

According to data presented in Figure 1, firms tend to focus more on sustainability than digital technologies. Table 4 presents Fisher's exact test between *digital technologies* and *sustainability parameters* expressed through log odds ratios. When intertwining DT1 and S1-S4, no association is identified. Nonetheless, a significant association is identified between S1 and DT5, S1 and DT7, S3 and DT5, and S3 and DT7.

*Table 4: Fisher's exact test between digital technologies and sustainability*

| | DT1 | DT2 | DT3 | DT4 | DT5 | DT6 | DT7 | DT8 | DT9 |
|---|---|---|---|---|---|---|---|---|---|
| **S1** | 2.875 | 4.174** | 3.587* | 4.174** | 4.762*** | 4.174** | 4.762*** | 4.174** | 4.174** |
| **S2** | 3.387 | 3.497* | 4.234** | 3.497* | 4.595** | 3.497* | 4.595** | 3.497* | 3.497* |
| **S3** | 2.875 | 4.174** | 3.587* | 4.174** | 4.762*** | 4.174** | 4.762*** | 4.174** | 4.174** |
| **S4** | 3.106 | 4.541** | 3.868* | 4.541** | 3.871** | 3.060* | 3.871** | 3.060* | 4.541** |

*Note: Values are presented of log-odds ratio; *p < 0.05; **p < 0.01; ***p < 0.001.*

Table 4 suggests a lack of association between Additive Manufacturing/3D Printing and sustainability parameters. However, metrics which assess the economic performance of the services and Cloud Computing, metrics which assess the economic performance of the services and (Industrial) Internet of Things, seeing digital servitization as a way to be sustainable and Cloud Computing, and seeing digital servitization as a way to be sustainable and (Industrial) Internet of Things significantly influence each other. There is a strong association between these digital technologies and sustainability parameters.

Figure 2 presents a Multiple Correspondence Analysis (MCA) for digital technologies and sustainability. MCA has a satisfactory variance of at least 70% (Orošnjak & Šević, 2023). Three clusters are identified in Figure 2. The blue cluster gathers only digital technologies, while the red and green clusters contain digital technologies and sustainability parameters.

Additive Manufacturing/3D Printing, Artificial Intelligence/Machine Learning, Advanced Manufacturing Solutions, Big Data Analytics, and Simulation of Connected Machines, which comprise the blue cluster, represent digital technologies usually implemented by the same company. All sustainability parameters gathered in the red cluster are used in manufacturing firms implementing Cloud Computing, Cybersecurity, (Industrial) Internet of Things, and

Mixed Reality. Finally, the green cluster gathers a negation of data used in the research.

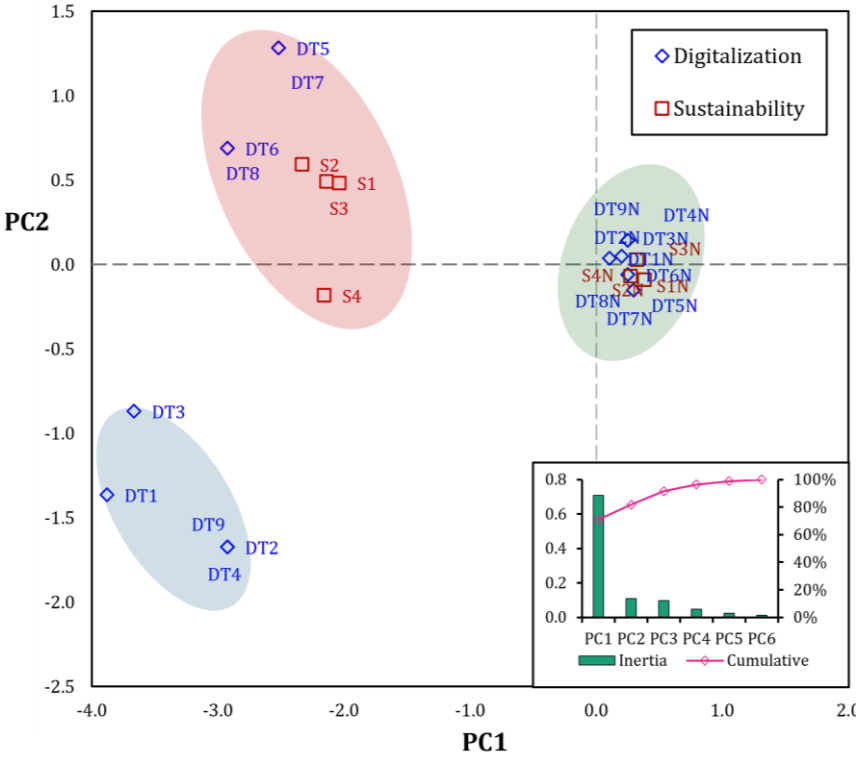


*Figure 2: MCA for digital technologies and sustainability*

## 5. Conclusions

This research has investigated the association between *digital technologies* and *sustainability* using a dataset representing the Republic of Serbia's manufacturing sector. The data used in this research was obtained through the "Digital Servitization Survey." The obtained findings suggest that digitalization has a significant association with sustainability metrics.

The high significance was identified when associating metrics which assess the economic performance of the services (S1) with Cloud Computing (DT5) and (Industrial) Internet of Things (DT7), as well as when associating seeing digital servitization as a way to be sustainable (S3) with Cloud Computing (DT5) and (Industrial) Internet of Things (DT7). Additionally, research has shown that firms likely implement the same group of digital technologies – Additive Manufacturing/3D Printing, Artificial Intelligence/Machine Learning, Advanced Manufacturing Solutions, Big Data Analytics, and Simulation of Connected. Also, the research has shown that firms that have implemented Cloud Computing,

Cybersecurity, (Industrial) Internet of Things, and Mixed Reality use selected sustainability parameters.

Nonetheless, manufacturing firms in the Republic of Serbia must implement the sustainability framework according to their needs to fulfil rules and regulations and enter new markets that require certain sustainable practices. When faced with this challenge, firms already implementing digital technologies will develop sustainable strategies more efficiently.

Further research should include more sustainability parameters grouped by people, planet, and profit or environmental, economic, and societal aspects. Additionally, manufacturing and service sectors of other countries should be investigated and compared to each other to identify best practices that companies in transitioning economies apply.

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# STATE TERRORISM – POLITICAL-SECURITY AND CRIMINAL ASPECT

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***Abstract***

*The goal of this paper is to provide an answer to the question of what state terrorism is, what are its criminal law and security-political specificities, causes, and what is the role of the state as an actor in its origin, implementation and development. It is very difficult to give an objective and scientifically reasoned answer to these questions, because in the case of state terrorism, the state, with its activities, concrete actions and procedures, leaves the generally accepted framework of the principle of legality and becomes a direct or indirect actor, the subject of terrorism that aims to achieve its state-political, military, economic and other goals and interests, plans, organizes, finances and implements various forms of political violence in the form of spreading fear, pressure, threats, assassinations, political murders, diversions, subversions, causing riots, riots, rebellions and uprisings and wars. For these purposes, the state, as an actor of this form of terrorism, uses the legal state apparatus and available resources.*

***Key words:*** *terrorism, state, security, political violence.*

## 1. Terrorism: An Introduction - origin of terrorism, historical aspect, concept, basic features

In order to determine the definition of state terrorism and its concrete analysis, it is necessary to start from the basic, initial analytical category, which is terrorism, which requires the determination of its essential meaning/concept, content, motives, causes, basic characteristics, elements, geographical aspect, modality and forms of individual and organized action, etc. If we look at the answer to these questions through the prism of scientific and contemporary and social reality, then it can be easily concluded that we are on a very "slippery ground", because terrorism, in addition to social, is also a distinctly political-security phenomenon whose scientific research description has relatively little qualified scientific-theoretical explanations and empirical evidence, and more and more interpretations based on daily-political interests, ideological-political and religious

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bias, emotions, etc. This approach is the breeding ground for numerous mistakes and misconceptions about the global phenomenon of terrorism, which are increasing every day, because science to a greater or lesser extent is more and more subservient to politics, i.e. it becomes a "school assignment of the government", which is paradoxical.

The problem of scientific objectivity in social and especially political sciences has come to the fore precisely in terms of the understanding and essential definition of terrorism. The emergence of subjectivism in taking positions in favor and in the interest of one's group, community or state was best characterized by Ludwig Fleck, who stated - "we all look at the world with our own eyes, but we see it through the eyes of our collectivities" (Simeunović, 2009, p.15).

Regarding terrorism, as one of the most frequent political words, there are a large number of definitions in the world today, which abound in content and concept with numerous contradictions, inaccuracies, vagueness, opposite theoretical approaches, which is also reflected in the definition of state terrorism.

"Terrorism is like a plague from the Middle Ages that scares both leaders and citizens with equal intensity. It is a rapidly spreading infection with no known cure. Controlling terrorism requires new cooperation mechanisms - both national and international - that range between intelligence and police agencies. Effective action must be simultaneously offensive and defensive and inevitably require compromise with some of the civil liberties" (United Nations Security Council Resolutions, 2001).

As a special political phenomenon, terrorism is a modern phenomenon that, in its current form, has existed only since the end of the 18th and the beginning of the 19th century. However, some historical examples of political violence in pre-modern times give grounds for some authors to claim that terrorism originated in ancient times and that it is a companion of the entire human civilization, i.e. that it is older than ancient Greece and Rome. Numerous political murders of statesmen and assassinations of political office holders are cited as examples. For example, the murder of Julius Caesar by Brutus, which took place in 44 B.C., was defined as terrorism, without giving a substantive answer to the question of whether this particular murder was carried out by a terrorist organization, or whether this murder was just a classic conspiracy by people. who were in power, and who at that time used that usual method to replace a government through murder, or in this particular case it was a coup d'etat. These theses were also confirmed by Sinclair, a British theoretician, who stated that even in ancient times, a violent change of power was much more common than a non-violent one (Sinclair, 2003).

Walter Laquer, an American theoretician of political violence, also spoke about the ancient roots of terrorism, who believes that terrorism has always been a justified and legitimate means of opposing tyranny and despotism (Laquer, 1987, p. 12), and that is why in ancient Greece and Rome the killers of tyrants proclaimed as heroes.

Other theoreticians link the origin of terrorism to class society and the emergence of the state as an institution that protects the interests of the ruling class. Some believe that terrorism originated in ancient Jerusalem when religio-political sects and Islamic-armed "assassins" groups emerged.

Terrorism as a modern form of collective, "rarely individual", organized and institutional political violence (criminality) is primarily related to the French bourgeois, civil revolution, i.e. to the period of the Jacobin dictatorship (reign of terror), when the two most powerful factions clashed politically - the moderate Girondins and the radical Jacobins. At the time of the then arbitrary rule, the French revolutionaries committed mass and brutal executions of opponents and enemies of the revolution when tens of thousands of citizens, French aristocracy, among them the leaders of the Jacobins, Maximilien Robespierre and Louis Saint-Giuste were executed by guillotine and other terrorist tactics.

In addition to the French, terrorism was also a feature of the American revolution because it was used in the fight against the British and their sympathizers from the ranks of the colonists, and at one time it was used in imperial Russia as well.

The term terrorism basically comes from the Latin word "terror, terroris" (Oxford Latin Dictionary, p. 1929) which means terror, great fear, reign of terror, political intimidation. It is a way of governing through instilling fear, violence, and intimidation, that is, terrorism is a doctrine and a method of struggle to achieve certain political, ideological and religious goals, planned, organized, continuous and systematic use of violence.

Regardless of the semantic problems and differences, terrorism today is not easy to define because of its characteristics and manifestations.

It is not a single term, but on the contrary, it is a multidimensional, global social and political-security phenomenon, a planetary evil that follows almost all contemporary international trends. Defining its term requires a multidisciplinary approach, because as a socially dangerous phenomenon, it requires an analysis from multiple aspects - sociological, philosophical, historical, political, criminological, criminal, criminal law, etc.

Despite numerous, so far unsuccessful attempts, today the research and definition of the term terrorism has become an insurmountable scientific and political problem around which no consensus has yet been reached, even regarding its basic elements. The opinions and attitudes of scientific circles about the concept of terrorism range from the fact that it is not possible to define terrorism at all, that is, that a definition is not needed (Schmid, 1983, p. 7), to the point that it is a futile work, i.e. there is no definition that can cover all the varieties of terrorism that have emerged throughout history (Laquer, 1977, pp. 5,79). The situation is completely identical in the numerous attempts of international organizations, universal and regional, where state representatives are exclusively guided by their political interests in defining terrorism, so those definitions are therefore provisional, imprecise and have become the prey of an aggressive political struggle. Simply, social consciousness has not yet developed to the extent that terrorism is unequivocally understood as a completely unacceptable, immoral, illegal crime, as a pathological phenomenon, regardless of which social group its perpetrators belong to. This scientific confusion and wide-open problem is very easy to prove in situations where one individual as the perpetrator of a terrorist act is treated as a

terrorist by one part of society, and another part of society perceives him as an idol and a symbol of the struggle for national and social liberation.

Long gone are the times when we talked about the beneficial and non-beneficial effects of terrorism, i.e. about terrorism as a method of struggle of the working class, as a means of defending the revolution, or as Carlos Mariguela, a Brazilian politician and communist and ideologue of the "urban guerrilla", said in his "Manual for the Urban Guerrilla" in the late 60s - "terrorism is a tool the revolutionary can never give up" (Marighella, 1969, p. 46). In opposite ideological and political positions, there was the long-term leader of the Palestine Liberation Organization (PLO), Yasser Arafat, who believed that the one who justifiably fights politically, morally and decisively for the liberation of his country from colonialism, imperialism, invasion, exploitation, cannot be considered a terrorist.

The lack of a single, generally accepted definition of terrorism was also significantly contributed to by the national criminal legislation of certain countries, which did not prescribe all terrorist activities as a criminal offense, but only those that have the state as a terrorist target, or more precisely, the criminal law definitions did not qualify as terrorism those activities that were carried out in abroad and that endanger and injure foreign interests. The paradox was that in these attempts to define in any context, state terrorism was not mentioned at all, which was symptomatic and indicative, because terrorism in the social sciences and terrorist discussions was essentially only related to the activity of non-state subjects/actors. All this made it even more difficult scientifically, politically and legislatively to reach a consensus on a single definition of terrorism. The efforts made in defining terrorism were useful because over time terrorism increasingly gained an international, global dimension, the need for international cooperation in its suppression also matured, but in today's world all this was not enough, as confirmed by everyday terrorist practice.

In order to fight against something, we must first know who we are fighting against, because a global preventive and repressive anti-terrorist strategy is not possible without joint research into the causes of terrorism and the circumstances that favor it - and this is only possible with a unique, universal definition. The reasons why there is no globally accepted definition of terrorism are numerous and varied, and three key ones dominate, namely - the relationship between science and politics, in which politics dominates, i.e. science, to a greater or lesser extent, has always been a function of daily politics. The second reason is the failure to distinguish terrorism from other basic and complex, apparently related forms of political violence (terror, terrorizing, guerrillas, etc.), which conceptually and content coincide to a greater or lesser extent, but are fundamentally different (Simeunović, 2009, p.p. 13-33).

It is precisely for these reasons that W. Laker rightly warned that "terrorism is a dangerous ground for simplifiers and generalizers" (Laquer, 1987, p. 9), that is, it is an abstract phenomenon that has no real essence that can be discovered and described (Thackrah, 2004, p. 9).

The third reason is the absence of objectivism in the essential and substantive definition of the term terrorism, i.e. the pronounced subjectivism based on daily political interests.

Regardless of these obstacles that stand in the way of a unique definition, ie. to the absence of political motives, to cultural, historical and other differences, certain consensual elements/characteristics of terrorism can still be identified that constantly appear in almost all terrorist activities, which any partial, political-ideological or religious interest cannot marginalize or make them disputed - these are:

- violence as a method, (application of various forms of violence or the threat of using violence)
- political, ideological or religious character/goal of violence;
- citizens, political, military, security, institutional and other administrative structures as targets - direct and indirect victims (Dimitrijević, 1988, p. 529);
- intimidation, inducing fear, horror and other psychological reactions
- threat, coercion directed towards political structures or society as a whole in order to achieve set terrorist goals (political, ideological, religious);
- a large number of victims targeted by terrorists;
- the spectacularity, brutality, shockingness of terrorism;
- illegality and social unacceptability of terrorism;
- systematic, planned and organized nature of terrorism.

Starting from the mentioned elements, today in scientific, political and legislative theory and practice there are around 300 or more definitions of terrorism, of which around 100 are in official use, and all of them are mostly based on the same or similar facts. There are almost as many of them as there are authors who try to get to it, because "the problem is in defining the problem" (White, 2004, p. 4) because the definition of the concept of terrorism depends dominantly on the foreign policy of the state.

Although the definition of terrorism is the most controversial and ambiguous component around which there is no international legal relevant consensus, nevertheless, among the numerous definitions in the scientific and professional literature and administration, the following definitions can be singled out as important.

In 1999, the UN General Assembly adopted a Resolution according to which terrorism consists of "terrorist acts and activities aimed at the annulment of human rights, basic freedoms and democracy, threats to the territorial integrity and security of states, destabilization of a legitimately constituted government, endangering a pluralistic civil society and a negative impact on the economic or social development of countries" (UN Resolution 54/164, 1999).

One of the most comprehensive and precise definitions of terrorism was given by the European Union in 2002, according to which terrorism is defined as "an intentional act that can cause serious damage to a country or an international organization, starting with the aim of seriously intimidating the population,

unjustifiably forcing a government or an international organization to do something do or refrain from doing any act seriously destabilizing or destroying basic political, economic or social structures by means of an attack on the life or physical integrity of a person, kidnapping, taking hostages, seizing aircraft or ships or manufacturing, possessing or transporting weapons or explosives" (Marques, 2002).

In 2000, the US Department of Defense defined terrorism as "the calculated use of violence or the threat of violence to instill fear with the intent to intimidate or coerce governments or societies, to achieve goals that are primarily political, religious, or ideological."

In 1999, the US Federal Bureau of Investigation defined terrorism as "the unlawful use of force or violence against persons or property to intimidate or coerce the government, the civilian population, or any segment thereof in furtherance of political or social objectives."

Among the better-known definitions from scientific and academic research are the following:

According to Brian Jenkins and Walter Laquer, terrorism is "the use or threat of use of force designed to bring about political change" and for Laquer, terrorism is "contributing to the achievement of political goals through the illegitimate use of force, when the targets are innocent people."

Boaz Ganor, an Israeli theorist, defines terrorism "as the deliberate use, or threat of use, of violence against civilians or civilian targets to achieve political, ideological, and religious goals" (Ganor, 2001). This definition is significant and has a high utility value for the Israeli security forces operating in the field.

Definitions that reduce terrorism exclusively to activity aimed at causing extreme fear and terror include Wilkinson's definition according to which terrorism is "the systematic use of intimidation for the purpose of coercion, usually in the service of political goals" (Wilkinson, 2002, p. 29) and Vogel's definition which defines terrorism as "the spread of terror through unpredictable and surprising, but systematically executed acts of violence to achieve political goals" (Vogel, 1979).

Among the national definitions, as one of the most compact, based on the appropriate time reality, was given by Dragan Simeunović, professor of the Faculty of Political Sciences - it reads:

"Contemporary terrorism is a multidimensional political phenomenon, a complex form of organized group, less often individual or institutional political violence marked not only by terrifying brachial-physical and psychological, but also sophisticated-technological methods of political struggle that are usually used in times of political and economic crises, and rarely in under the conditions of achieved economic and political stability of a society, they systematically try to achieve "big goals" in a morbid-spectacular way, and inappropriately given the conditions, above all the social situation and historical possibilities of those who exercise it as a political strategy".

The socially threatening opus of terrorism includes the threat of force within the framework of intensive psychological-propaganda activity, abuse of the Internet for terrorist purposes, kidnapping, blackmail, psychophysical abuse, assassinations, sabotage, diversions, suicide attacks, individual and mass political murders, and the

intention of manifesting less often than actual and potential political opponents, and more often on representatives of the system and innocent victims.

As a form of individual, illegitimate, illegal and non-institutional violence, terrorism is always directed against certain institutions of a society, that is, in concreteum against a state" (Simeunović, 2009, p. 80).

Although the United Nations has made a significant effort in defining terrorism, there are two "perpetual issues" that make it difficult for the United Nations and block consensus around a universal definition - they are state terrorism, i.e. the question of whether the definition can include not only the terrorist activity of organizations and groups, but and the state - and another issue is the "struggle for national liberation", that is, whether it is necessary to distinguish between terrorism and the right of the people to self-determination and the fight against foreign occupation (Simeunović, 2009, p. 59).

Most generally, terrorism can be defined as "the deliberate use of illegal violence or the threat of illegal violence to instill fear, with the intention of coercing or intimidating a government or society in order to achieve goals that are generally political, religious, or ideological" (Fortna, 2015, p. 519 —556.)

Therefore, "terrorism is a dangerous and deadly game in which the main actors are terrorists, victims, the main target (usually some government) and the media" (De Benoit, 2013, p. 79), that is, it is a special method of armed struggle (Wilkinson, 2002, p. 17), or a weapon system that can be used independently or, historically more often, as part of a wider repertoire of armed combat (Wilkinson, 2002, p. 17).

## 2. The main causes, motives and objectives of terrorism

The etiological dimension of political violence, and therefore of terrorism, shows that violence in society is essentially a two-way process where the state, on the one hand, ensures the functioning of the state order as a whole and the protection of the interests, freedoms and rights of citizens, on the other hand, using violence (protests, coups, coup d'états, revolutions, etc.), when the state-political structures are not capable of effectively and independently solving internal crises, conflicts and problems, when the regime massively and uncontrollably violates human rights and freedoms or when the state is in serious danger. The complexity of the terrorism phenomenon is therefore reflected in the research and understanding of the causes, dynamics and escalation of terrorism.

The answer to the question of the causes of terrorism inevitably requires a scientific and objective knowledge of the social relations that cause terrorism, because it is a social-historical category of human behavior conditioned by concrete, contextual and structural circumstances - sociopolitical, economic, industrial on the one hand and the targeted intentions of actors, more precisely, wider the socio-political context dictates the motives and causes of terrorism (Lečić, 2014, p. 102).

The identification of the causes and motives of terrorism, regardless of whether the state or non-state collectivities are behind it, has not yet been sufficiently researched, so the etiology of terrorism cannot be generalized, that is, a

cautious scientific approach is required. The reason for this is that information, knowledge and statistics about terrorism are often biased due to the subjective connotations, motives and perceptions of researchers and public opinion in general.

Although the previous explanations of terrorism are inconsistent and partly disputed, it is necessary "therefore to search for the general conditions that make terrorism probable" (Dimitrijević, 1982, p. 182).

However, a general analysis can identify four groups of causes that determine modern terrorism (Tomaševski, 1980, pp. 3-4):

The first are the political-ideological causes that arose with the emergence of left-wing political parties and strategies. They are inspired by social problems, insecurity, political and economic crisis, unemployment, poverty, mass dismissal of workers, inflation, anarchy of the educational system, injustice, etc.

Others are ethno-separatist, ie. ethnic-nationalist causes by which ethnic groups or emancipatory movements express dissatisfaction with their status position and the level of their national-status rights in multinational states where they are a minority. According to UN data, there are more than 3,600 ethnic groups in the world today that are fighting for either a greater degree of independence (autonomy) equivalent to state-legal status, or for the formation of a separate state or for joining the country of origin. The exercise of the right to ethnic distinctiveness and the recognition of the right to grow into a nation and form a national state rapidly became a real danger of the 21st century, which was predicted by Carl Friedrich in his thesis "on nationalism as the strongest force on the planet" (Friedrich, 1968, p. 30).

The third group of causes refers to marginalized social groups and strata that, due to dissatisfaction with the general state of society, and especially due to their ephemeral and peripheral socio-economic and political status in society (e.g. migrants, students, unemployed workers), have extremist and terrorist aspirations and strive for radical changes.

The fourth group of causes consists of those that are specifically related to the personality structure of the subjects of terrorism, i.e. they have a pathological, psychopathological and criminal dimension - eg. unrealized political ambitions, the intention of revenge, adventurism, religious fascination, etc. This is the absence of rational motives.

In addition to the aforementioned classification, the causes of terrorism can be divided into objective and subjective, external and internal. Objective ones refer to political, economic, religious, ethnic, class and social contradictions, injustices and imperfections in one society (state) - eg. undemocratic constitutional order, destruction of state institutions, socio-economic differences, unresolved national question, nationalism, chauvinism, extremism, colonial dependence, national, territorial, economic, social, religious and cultural hegemony and others. Due to these causes, certain political and religious social groups have lost confidence in the system and authority of the state government and in traditional social values, which is why they decide on political violence (terrorism) in such a social climate.

Subjective causes refer to the firm, extremist-radical beliefs of the subjects of terrorism that the unsustainable social situation in the country (objective causes)

can only be changed by political violence (terrorism), which is the only possible variant of action in the given environment.

The analysis of practice shows that the causes of terrorism are multifactorial, i.e. terrorism is a combination of several factors with different effects and strength - eg. in the case of religious terrorism, individual characteristics of the personality have a predominant influence, and in the case of ethno-separatism, external, socio-political factors dominate, and in some third forms, both factors work with approximately the same intensity.

It is believed that terrorism is initially caused by only one basic factor, and that in its further development it is determined by other, additional conditions and reasons (Bjorgo, 2005). Of course, the socio-political vision is one of the basic patterns of terrorism, within which the issue of political, ideological, religious, ethnic and other identity occupies a special place, which, if not consistently achieved, inspires individuals and social groups to violent intentions, including terrorism. Among these identities, religious identity certainly has the strongest strength, because it is linked to "righteousness and God's justice", which is confirmed by the terrorist practice in the last 30 years or so, in which religious terrorism has taken a central place, gradually suppressing ideological and political ones. More precisely, the spread of faith at any cost has become the basic mobilizing and motivating factor (religious fundamentalism).

However, the causes of terrorism must also be sought in the unilateral, short-sighted, and violent actions of major powers, which are carried out under the guise of alleged multilateralism, without any real international cooperation behind it. It is indicative of the practice of great powers that at a certain moment they provide support to a side that they judge to represent the "lesser evil of two" and then over time the "unprincipled ally" chosen in this way turns against them and soon becomes "the state's number one enemy" (Lečić, 2014, p. 108).

## 3. State terrorism – concept, theoretical approaches, basic features

Just as today there is no universal definition of terrorism, there is also no generally accepted definition of state terrorism, because in theory and practice a distinction is generally made between political violence that is carried out under the auspices of the state and those forms of political violence that are carried out by terrorists as non-state entities. The essence is that state terrorism is carried out under the control, financing, planning or support of the state and thus becomes an instrument for achieving political goals in those situations when it is neither rational nor profitable to wage an official armed conflict (war) against someone else, regardless of whether it is waged within or outside the borders of a state.

Therefore, state terrorism is carried out by the state when the legal state apparatus (army, police, intelligence and security services) undertakes threats, violence, and spreads fear towards other internal and external subjects - adversaries. This form of terrorism is in terms of its goal, its forms, characteristics, consequences, in the sense of criminal law, similar to classic and any other form of

terrorism, because the state here, as an actor of terrorism, violates the principle and the defined limit of legality, i.e. goes beyond the framework of legal, legitimate, ethnic or moral behavior, assuming the role of a terrorist.

Therefore, state terrorism implies any violent action initiated by the existing government to achieve a specific goal. This goal most often includes a conflict with another state (Crime Museum Types of Terrorism).

The concept of state terrorism is today consciously and systematically avoided and denied by states and international organizations, even though it is present and directed by the state institutions of certain countries. Today, it is considered an instrument of foreign policy or secret terrorism, which differs according to whether the state as an actor is directly involved in it or whether it supports and sponsors it as the orderer of a certain action that is implemented in practice by some private organization. In situations where the state as an actor has contact with terrorist activities, the number of victims and the material damage caused are usually higher, and the losses have longer-term negative effects on the population and resources (Primorac, 2002, p. 63.)

This terrorism is also called regime or state-sponsored terrorism, by which the state, with the help of specialized and special entities, influences the activities of individuals or groups that operate in the country or abroad. It is often directed against various guerilla and liberation movements. In recent times, the term "terrorism as a surrogate war" has also appeared, which is reflected in the fact that a country enters a war, but due to some reasons (mostly financial) it is not worthwhile for it to enter a traditional, open conventional war (Mijalković, 2015, p. 189).

Generally speaking, the state can be involved in state terrorism in several ways, and two are basic:

1. When the state is an organizer, leader and supervisor of terrorism. This method is a hallmark of totalitarian and authoritarian regimes when regular security forces are used to achieve political goals
2. When the state provides support to individuals, terrorist groups and organizations in the implementation of certain terrorist actions. Here, the state leaves the entire process of planning and executing a terrorist act to some other non-state entity. Support can be financial, operational, military, ideological (Perešin 2010, pp. 60-61).

In the contemporary political-legal security literature, there are three completely different theoretical approaches in defining and understanding the essence and role of the state terrorism phenomenon. In the multitude of definitions and forms of terrorism, the concept of state terrorism has been unjustifiably lost, and the appearance of the state in the role of a terrorist has been mostly neglected. However, in defining the concept of state terrorism, three approaches have been differentiated that essentially have a neutral form, that is, they do not mention the state as a possible perpetrator of terrorism. In only 15% of the definitions, the state is mentioned as a possible perpetrator of the criminal act of terrorism, because it is considered that terrorism is reserved only for non-state entities.

The first approach starts from the thesis that states as subjects of international law, that is, as legal entities, cannot be the perpetrators of a criminal act, and implicitly not even the criminal act of terrorism. This position is justified by Weber's arguments, which imply that terrorism as a form of political violence can only be carried out by non-state subjects and not by the state as an apparatus of public authority (Sporat, 1997, p. 133).

The second approach starts from opposite theoretical positions, that is, it believes that it is necessary to distinguish between the state as the subject (actor) of terrorism and other non-state perpetrators of terrorist activities. One of the advocates of this position is Andrew Silke, a British professor of criminology who believes that there are similarities and points of contact between state and non-state terrorism, but essentially in practice they are two completely different phenomena. A similar position is taken by Martha Crenshaw, professor of political science at the American Stanford University, who believes that state and non-state terrorism should be strictly distinguished because, on the one hand, the state has a quantitatively greater scope of influence, power and authority, i.e. has an assumed legitimate authority, which, on the other hand, non-state subjects of terrorism do not have. Due to this element or advantage of the state, it is impossible to equate state terrorism with non-state terrorism, because according to it, the state has much more opportunities (capacity, ways) to expand its political influence and direct and control the behavior of others compared to non-state subjects of terrorism who do not have this opportunity. Nevertheless, she believes that the state can be the subject of terrorism in order to achieve its legitimate political interests and in practice can use certain methods of terrorist organizations - for example planting explosives at airports (Libya, Lockerbie, 1988), forming paramilitary "death squads" in opposition to political opponents (Argentina, the so-called "dirty war", 1983-84, when between 20 and 30 thousand people were liquidated), hiring professional killers for liquidation of political dissidents abroad - South Africa during Apartheid (Crenshaw, 2011, p. 4).

The third approach starts from the unequivocally clear position that states can be a typical actor of terrorism and that there is no essential difference between state and non-state terrorism, that is, any attempt to distinguish between these phenomena would be politically, analytically and morally problematic and absurd (Jarivs & Lister, 2014 p. 52).

Respecting these different theoretical approaches, state terrorism can still be defined in the most general sense as an intentional act of political violence, i.e. planned and organized undertaking of certain activities that are equivalent to terrorist methodology, for the undertaking of which the order or consent is always given by the official state structure, while the responsibility for its execution can almost never be assigned to the state, i.e. this kind of terrorist activity by the state is difficult to prove in a court of law practice.

Therefore, one of the most significant characteristics of state terrorism is precisely the fact that it is the result of the official support or consent of government structures that plan the organized execution of political violence, repression and intimidation, most often in other countries and much less often on their own

territory. This means that state terrorism is of an instrumental character because it deliberately, in advance targets certain innocent victims as targets, in order to achieve future political, ideological, religious and other goals (Blakeley, 2009, p. 15).

## 4. Types and objectives of state terrorism

In contemporary literature, the forms of manifestation of state terrorism in practice are determined and interpreted differently. It mainly manifests itself through open diplomatic pressure, threats, coercive measures applied by one state towards another, then through the open participation of states in assassinations, coups, coups and bombings, as well as through "surrogate activities" in which one state provides open political and logistical assistance and support to other states or rebel organizations that directly execute acts of terrorism.

In addition to these forms of manifestation, some authors also talk about secret state terrorism, then state-sponsored terrorism, where an individual state tacitly agrees to the preparation of terrorist activities that non-state subjects plan to carry out on the territory of other states. It is interesting to distinguish between "limited" state terrorism, which is aimed at a specific, specific terrorist target, and "general" state terrorism, where the target is the entire population of a particular state. Relatedly, Noam Chomsky, an American philosopher, classifies state terrorism into "limited" and "wholesale" terrorism. The first is aimed at specific, individual goals, and the second refers to continuous intimidation of wider social layers, by successive repetition of terrorist acts over a longer period of time.

Those who support and justify state terrorism believe that it is an effective "tool" with which economic interests are realized in practice, first of all, it provides access to foreign markets, natural resources and resources of other countries or suppresses the activities of social-progressive movements and organizations.

For the sake of illustration, one can cite the subversive and psychological-propaganda activities of the American intelligence service CIA, in the early 1950s in Guatemala, when a coup was organized against the legal and legitimate political structures that implemented agrarian reform through the nationalization of several hundred thousand hectares of arable land that was owned by American transnational companies. The outcome of the engagement of this American secret service was the complete destruction of the labor movement in Guatemala and the destabilization of the overall political situation in this country through the activation of a wave of right-wing terrorism that claimed thousands of victims.

In addition to economic goals, state terrorism is also aimed at realizing the political-strategic interests of a state, more precisely, it focuses on the destabilization of the ruling political regimes of enemy states. An example is Iraq, which during the reign of Saddam Hussein politically, materially and financially helped the anti-Iranian organization "People's Mujahideen of Iran" who fought against the then pro-American president of Iran, Shah Mohammad Reza Pahlavi, at the end of the seventies.

Some countries use state terrorism on the internal level as well, by using terrorist methods to suppress the activities of the political opposition in an

organized, planned and systematic manner. An example is the political regimes in certain Latin American countries during the Cold War period that practiced assassinations, kidnappings, paramilitary action and the formation of "death squads" against opposition structures that were a threat to the ruling dictators (Argentina, Chile, Guatemala).

State terrorism was also used by certain states in the 90s, when they strategically supported certain terrorist organizations and movements in other states in the hope that they would overthrow the existing political regime and later establish vassal political structures that would then be instrumentalized in the function of states that sponsored them through terrorist activities.

## 5. Historical aspect of state terrorism and examples from practice

State terrorism is not a phenomenon of the new and modern age because the ruling regimes of many countries throughout history have resorted to various forms of violence as one of the basic mechanisms of governance and establishing their influence and power. Those former regime (government) forms of violence (liquidation of rulers, dissidents), today, according to their basic characteristics (elements), would fully correspond to state terrorism and would coincide with it.

The period of the 18th and 19th centuries can be marked as a source of state terrorism, and it was reflected in the constant struggle against state opponents and dissenters. An example is the French bourgeois revolution and the Jacobin dictatorship when, at the end of the 18th century, the government of that time carried out terror against its political opponents. It was then that the term "terror" appeared for the first time, which originally denoted legal and legitimate political activities that qualify today as terrorist acts under the auspices of the government or the so-called legal terrorism or state terrorism.

State terrorism is not limited by time and geography and is spread to a greater or lesser extent in almost all parts of the world. Its manifestation forms are different and ranged from the formation of certain squadrons and "death squads" in Brazil, Turkey, then in counter-insurgency operations in Peru, all the way to the use of military-police and intelligence structures in dictatorial and totalitarian regimes and an atmosphere of total fear and terror was created in which numerous criminal acts were committed by the state.

Examples of state terrorism are numerous.

One of the first countries to be accused of state terrorism was Libya. Through her secret service, she organized a terrorist attack in 1988, when an explosive device was activated over the Scottish city of Lockerbie in the plane of the American airline "Pan American", on the London-New York route. In this act of terrorism, which was directly aimed at the USA, 270 passengers died. The then president of Libya Muammar el Gaddafi, ten years after this attack, under the pressure of political and economic sanctions, recognized this terrorist act and extradited the suspects to Great Britain in exchange for the lifting of sanctions, publicly renouncing terrorism

forever. According to intelligence from the investigation, Gaddafi personally issued an order to the secret service to shoot down the American plane.

Libya was also accused of the downing of a French plane over the African state of Niger in 1989, when it refused any kind of cooperation in this regard, which led to the introduction of diplomatic and economic sanctions in the form of an air traffic ban, an embargo on arms and military equipment.

This country again became the center of terrorist activities when, after the death of Gaddafi and the civil war, in 2011 and 2014, two government regimes were formed in Libya, which had their own separate army and police. One state government practiced and supported terrorist actions, considering them liberating, while the other side claimed the opposite, that it was suppressing terrorism. In the environment of bombings, assassinations and sabotage, Libya then became a stronghold of the terrorist organization known as Islamic State.

Typical examples of state terrorism include Iran, which, in the organization of its secret services, sent hired assassins abroad to carry out assassinations and to liquidate political dissidents and leaders who actively acted against Iranian state structures. It was done for internal political reasons to intimidate and destroy the Iranian opposition.

Strong accusations have been made against Iran for years, supported by concrete evidence, that it sponsors Islamist terrorism, that is, it financially and logistically helps the two largest Arab terrorist organizations in the Middle East - Lebanese Hezbollah and Palestinian Hamas, supplying them with weapons and encouraging them to commit acts of terrorism against their common enemy, Israel. For these purposes, Iran allocates several hundred million US dollars supporting extreme and radical Islamist groups in the world - Lebanon, Palestine, Iraq, Afghanistan and others. Proving these accusations, the US intelligence structures registered the existence of 11 terrorist training centers (camps) on the territory of Iran by means of satellite and audio-video recordings. The largest among them is the Imam Ali camp in eastern Tehran, where the largest terrorist actions were prepared and where the most militant Islamists were trained. In other Iranian camps, which were built in a camouflaged infrastructure like tourist villages with shops, specialized training was organized for suicide terrorists and terrorists for carrying out complex liquidations in the interior. It is estimated that more than 5000 men and women went through these Iranian training centers, and about 500 people went through suicide courses (Simeunović, 2009, pp. 25-206).

Examples of state terrorism include the communist regime of North Korea, which once organized and sent its "secret agents" to Rangoon, Burma, to carry out a secret terrorist bombing attack on a South Korean government political delegation that was on an official visit to Burma. The goal was to undermine the promotion and affirmation of the foreign policy of "hostile" South Korea.

Practice has shown that state terrorism is an instrument of the foreign security policy of the USA. An example is the assassination of Iranian General Qassem Soleimani, the commander of the special military formation of the Quds Unit, an elite detachment of the Iranian Revolutionary Guard, directly subordinate to the Iranian religious leader (President) Ali Khamenei. Suleimani had enormous

power in Iran, he was the second most influential military-political figure, right after Ayatollah Khamenei, and he was individually the most powerful operative in the Middle East. He was the ideologist and creator of Iran's foreign policy and was directly responsible for expanding its influence in the region of the Near and Middle East, he was the de facto minister of foreign affairs of this country. The US considered that General Suleimani was a terrorist, that he was responsible for planning and organizing a series of terrorist acts and plans that killed dozens of American citizens. The killing of Soleimani took place at the Baghdad airport in Iraq in 2020, and it was directly ordered by then US President Donald Trump because Soleimani was a threat to the national security of the US. This secret operation was carried out by the US military intelligence unit, using an expensive silent drone, worth 64 million dollars, which was launched from the US military base in Qatar with four laser-guided missiles. Regarding the planning and execution of this action, the President of the USA did not previously consult or seek the consent of the US Congress, and he did not inform his Western allies about this plan either.

Examples of state terrorism from the recent past include the murder of the famous journalist, "Washington Post" columnist Jamal Khashoggi, a citizen of Saudi Arabia and the USA, who was a harsh critic of the political regime of Saudi Arabia, primarily Prince Muhammad bin Salman. The murder was organized by the secret service of Saudi Arabia, which liquidated Khashoggi in the consulate of this country in Istanbul, Turkey in 2018, who had previously made an appointment at the consulate to collect the personal documents required for marriage. According to credible information for the investigation, Khashoggi was awaited at the consulate by a team of several secret agents of the Saudi intelligence service, who forcibly detained him, injected him with large amounts of drugs, and then tied him up and tortured him, so that the dismembered remains of his body were later handed over to a local "accomplice" outside the consulate. According to the data of the American intelligence service CIA, this assassination was directly ordered by the Saudi Prime Minister, Prince Mohammed bin Salman and other high-ranking political officials and intelligence officers of this country.

From the above, it can be reasonably concluded that the state-sponsors or state-organizers of terrorist activities very skillfully, planned and organized use (abuse) their own state resources, parts of the state apparatus or other directly trained, hired and controlled groups as an instrument of internal and external policy in order to achieve strategic and tactical political and other goals.

## 6. Concluding remarks

Although terrorism and state terrorism are not easy topics at all, it is evident that the phenomenon of state terrorism is shrouded in secrecy and open hypocrisy, because there is almost no mention or discussion about it in the scientific literature, especially not about Western state terrorism. Its mention, in part its existence, critical examination and academic study are ignored. The reasons for this are exclusively political in nature, which prevent the creation of a political and criminal law definition.

Although the state owns a monopoly on the use of force in accordance with the law, in practice it does not always act in accordance with the principles of legality and legitimacy and moral value standards. It very often goes beyond these prescribed limits and behaves as a subject of terrorism, which is systematically neglected in the social sciences.

Regardless of how involved it is in acts of state terrorism, the state in advance, through well-planned and coordinated action of the powerful media machinery, either denies any connection with terrorist activities, or in the last resort, justifies its actions as a necessity to protect its vital interests and the interests of citizens.

The political interest of the beneficiaries of state terrorism, especially Western governments, is that much more attention is paid in theory and practice to the so-called insurgent terrorism (ideological-political, religious, ethno-separatist), i.e. those activities that are not related to the state, i.e. that terrorism where the state appears as an object of attack and not as a subject of terrorism. That is why it is necessary to overcome these limitations, political confrontations and biases and scientifically and legislatively recognize and verify state sponsorship and complicity in terrorism and objectively overcome the strong and notable silence and barriers about state terrorism, because it is, from a moral point of view, a much more difficult form of terrorism than non-state terrorism.

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# ENVIRONMENTAL MANAGEMENT SYSTEMS CERTIFICATION IN SERBIA: THE INFLUENCE OF TRADE AND ENVIRONMENT

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***Abstract***

*Nowadays, emerging economies tend to open their markets to foreign investors, because they see the key to accelerated economic growth in foreign capital. It is true that foreign investments are an instrument of accelerated economic growth, however, the ecological side of sustainable development should also be considered, and not only economic and possibly social pillar. Thus, the aim of this paper is to review and examine the impact of trade, economic growth and environmental degradation on ISO 14001 certification in Serbia. For research purposes, secondary data from the World Bank were used, for the period from 2006 to 2023, using Pearson product-moment correlation. The results revealed very strong, positive and statistically significant correlations – between the number of ISO 14001 certificates and trade, the number of ISO 14001 certificates and gross domestic product and the number of ISO 14001 certificates and regulatory quality. The results of the research could be useful to policymakers, especially those in the field of environmental protection.*

***Key words****: EMS, Environment, ISO 14001, Trade, Pearson product-moment correlation.*

## 1. Introduction

Domestic and foreign economic activities that are necessary for economic growth and development participate in environmental pollution due to the

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production of greenhouse gas emissions (GHGs) (Mladenović, Sokolov-Mladenović, Milovančević, Marković & Simeunović, 2016) which are harmful because they affect global warming. The best-known GHGs are: carbon dioxide ($CO_2$) – the result of burning fossil fuels; methane ($CH_4$) – mostly comes from agriculture, namely animal husbandry; nitrogen dioxide ($NO_2$) – most often the result of certain industrial processes, the use of nitrogen fertilizers, but also the burning of fossil fuels; hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride ($SF_6$) and nitrogen trifluoride ($NF_3$) – synthetic gases. Considering the causal influence of $CO_2$ on environmental degradation (UNCTAD, 2020; Taub, Miller & Allen, 2008; Government of the Republic of Serbia and United Nations Country Team in Serbia, 2017), it is an unwritten rule among scientists in the field of ecological economics that $CO_2$ is taken as a representative (proxy) of GHGs in scientific research.

The essence of the concept of sustainable development is the interaction of economic and social development and the environment, while in the paradigm of sustainable development economic goals lose their relative importance, which makes this concept of development different from all previous concepts of economic development (Cvetanović & Mladenović, 2013). The concept of sustainable development can be realized only if all three of its components are respected: economic, ecological and social. As multinational corporations are the main drivers of foreign capital and their actions change the economic environment of the host country (Voica, Panait & Haralambie, 2015), if only one of the mentioned components is neglected, which is usually the environmental component, there is no concept of sustainable development.

A man made a promise to the environment to protect it. However, in 2022, pollution records were broken at the global level, which meant a broken promise – new maximums of $CO_2$ emissions were reached, temperature records were tumbling, and the negative impacts on the climate are getting stronger and faster (UNEP, 2023). The good thing is that „awareness of environmental problems is growing in most countries and it is believed that current development patterns cannot be sustained in the long term, thus, governments are increasingly enacting legislation aimed at protecting the environment, and customers are requiring their suppliers to incorporate best practices and demonstrate compliance with environmental requirements“ (ISO, 2017, p. 8). „The publication of the ISO 14001 standard for environmental management systems (EMS) has proved to be very successful, as it is now implemented in more than 159 countries and has provided organizations with a powerful management tool to improve their environmental performance“ (ISO, 2017, p. 8). „An environmental management system helps organizations to identify, manage, monitor and control their environmental issues in a „holistic“ manner“ (ISO, 2015, p. 3). ISO 14001 is a universal standard that maps the requirements for an environmental management framework that companies regularly deliver and achieve better environmental performance in reducing costs and waste, and express management and stakeholders who develop them in a sustainable way (Shah, Singh, Tripathi, Hussain & You, 2022).

Transnational companies represent key carriers of foreign direct investments (FDI) and key players in international trade (Stojanović Jovanović,

2008). With the FDI growth, $CO_2$ emissions in the host country also grow, because investors from countries with strong environmental protection laws seek refuge in countries where such regulations are weaker, thus, such countries are considered pollution havens. Numerous studies confirm that Serbia and the countries in the region are pollution havens (Jun, Zakaria, Shahzad & Mahmood, 2018; Acharyya, 2009; Koçak & Şarkgüneşi, 2018; Bakhsh, Rose, Ali, Ahmad & Shahbaz, 2017; Behera & Dash, 2017). The assumption is that countries with high ISO 14001 adoption rates absorb the largest share of world exports, thus, „if countries with high ISO 14001 adoption rates also absorb the bulk of world exports, then trade could become a vehicle to encourage ISO 14001 adoption" (Prakash & Potoski, 2006, p. 351).

This paper aims to determine whether the environmental issues and trade affect the ISO 14001 certification in the Republic of Serbia. The first part of the paper presents an overview of the previous research made on the subject of effects that environmental issues and trade have on ISO 14001 certification. The second part is about ISO 14001 certificates in Serbia and the world – a brief overview. The third part of this paper presents data and methodology used in study. The fourth part is about results and discussion about the research results, and the fifth part of the paper presents conclusions and guidelines for future research.

## 2. Literature review

A group of authors (Arimura, Darnall, Ganguli & Katayama, 2015) concluded that institutional pressures arising from differences in regulatory settings between countries, as well as within countries, are related to ISO 14001 outcomes, thus, Japanese ISO 14001-certified facilities will reduce the use of natural resources compared to non-certified facilities, as natural resources are strictly regulated in Japan. Another group of authors (Fura, Sroufe & Hajduk-Stelmachowicz, 2023) analyzed the benefits of EMS implementation, in accordance with the requirements of the ISO 14001 standard, on the example of manufacturing companies in Poland. For research purposes, primary data – collected by surveying companies, and secondary data – including financial information, were used. The results revealed significant differences in the companies' perception of benefits from the application of the ISO 14001 standard, depending on factors such as: origin of capital, geographical scope of activity, financial condition, etc. Among the most significant benefits are: compliance with legal requirements, image improvement, increase in the number of customers, as well as increase in operational efficiency. Authors (Vomero Reis, de Oliveira Neves, Hikichi & Gomes Salgado, 2018) came to the conclusion that the companies' benefits from ISO 14001 certification can be classified into internal, external and relations benefits. Also, they concluded that the impact of certification on financial and organizational performance is positive. They highlighted the following as important benefits in the company's business results: improvement of internal processes, prevention of potential problems and a larger number of stakeholders. Hayat and Das Lohano (Hayat & Das Lohano, 2024) analyzed the factors influencing a company's decision to adopt ISO 14001, on the example of 245 companies listed on the Pakistan Stock Exchange. The results

showed that older companies and those that have already implemented the ISO 9001 standard are more likely to adopt the ISO 14001 standard. Likewise, a manufacturing company's decision to adopt ISO 14001 is strongly influenced by pressure from foreign customers, as well as companies that show higher levels of competitiveness are more predisposed to ISO 14001 adoption. Gorlova (Gorlova, 2023) concluded that the sustainability of the model of individual environmental behavior of employees in the company represents the ability to transfer environmental values from the workplace to private life.

On the other hand, the results of research conducted by Gomes dos Santos and de Oliveira e Aguiar (Gomes dos Santos & de Oliveira e Aguiar, 2019) showed the existence of weak correlations among countries international trade and motives to get certification. Therefore, Bouziri and Diaye (Bouziri & Diaye, 2015) found that ISO 14001 standard's coverage rate is positively related with the number of ISO 9001 certifications, as well as with the trade openness measured as the ratio export to GDP. A group of authors (Liu, Yuan, Hafeez & Li, 2020) revealed that the existence of a positive motivation for trade openness in developing countries affects the growth of ISO 14001 certification, because there is an awareness that it is the main tool for dealing with trading partners that have a high level of environmental management on the international market.

## 3. ISO 14001 certificates in Serbia and the world – a brief overview

A recent survey conducted by Jovanović (Jovanović, 2023) included a questionnaire of 18 questions, where the greatest focus was placed on answers related to the implementation of the ISO 14001 standard and the inclusion of environmental activities in the company's operations. The research was conducted on a sample of 179 companies that have the obligation to submit data on sources of pollution to the National Register of Pollution Sources in Serbia. Of the 59 companies that responded to the questionnaire, 33 have implemented the ISO 14001 standard, while 26 companies have not. In companies that have declared that they have implemented the ISO 14001 standard, the management states that the implementation contributed to the improvement of environmental performance, market competitiveness, efficiency and profitability.

Serbia has significant natural resources (arable land, hydro potential, coal, wood, copper, etc.), however, the level of environmental degradation is high, mostly because individuals and organizations still do not have a developed awareness of the conservation of natural resources, which are limited and rare. Also, a big problem is the pollution brought to the Serbian market by polluters – foreign companies, in whose home countries environmental legislation is strict, and, as Serbia sees the key to the rapid economic growth in foreign capital, foreign investors are offered various incentives in order to attract them. The most endangered is the air. In recent years, air quality in Serbia has degraded to a large extent. „In total air emissions of pollutants, the greatest share related to $SO_2$ and $NO_x$, thus, the greatest share of $SO_2$ emissions is related to the section of electricity, gas, steam and air

conditioning supply (about 92%), the section of manufacturing (about 3%), other sections of economic activities (about 3%) and emissions from households (about 2%)" (Statistical Office of the Republic of Serbia, 2022, p. 36).

Therefore, in the following figure (figure 1) it is possible to see the trend of the number of ISO 14001 certificates in the last decade in Serbia.

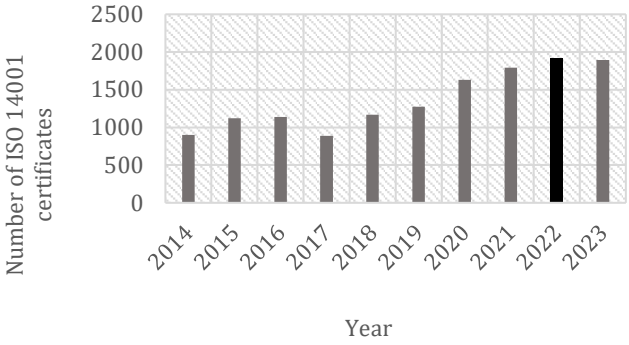


*Figure 1: Number of ISO 14001 certificates in Serbia, in the last ten years.*
*Source: ISO (n.d.), Author's creation.*

From 2014 to 2016, there was an increase in the number of ISO 14001 certificates in Serbia, hereafter, in 2017 there was a significant decrease (887), and from 2018 to 2022 there was a constant increase in the number of certificates, with the maximum value in 2022 (1921), while in 2023, that number dropped to 1892.

The following figure (figure 2) represents the trend of the number of ISO 14001 certificates in the last five years in world, by industrial sectors.

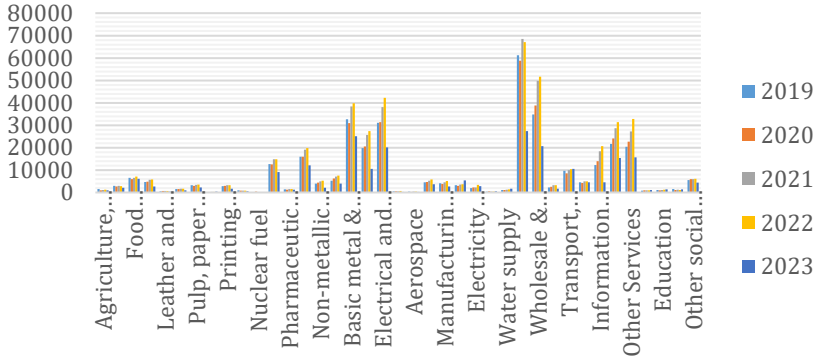


*Figure 2: Number of ISO 14001 certificates in world, in the last five years, by industrial sectors.*
*Source: ISO (n.d.), Author's creation.*

The largest number of ISO 14001 certificates was achieved in 2021 in the construction sector (68551), and then in the wholesale & retail trade (51695), in 2022. A significant number of certificates was also recorded in the electrical and

optical equipment sector (42235) in 2022, as well as in the basic metal & fabricated metal products sector (39741), and engineering services sector (31377), also in 2022. The lowest number of ISO 14001 certificates was achieved in the nuclear fuel sector (66) in 2023, the publishing company sector (151) in 2019, and the gas supply sector (330) also in 2019.

## 4. Data and methodology

For the purposes of this study, the data were collected from the official website of the World Bank – World Development Indicators and World Bank – Worldwide Governance Indicators. The observation period is from 2006 to 2023, given the availability of data. The research was conducted on the sample of one country – the Republic of Serbia. The objective was to examine the linear relationship between the following variables – *ISO* (the number of ISO 14001 certificates in Serbia), *Trade* (trade openness as the sum of exports and imports of goods and services measured as a share of gross domestic product (World Bank, n.d.a)), *$CO_2$* (emissions of carbon dioxide), *Energy* (energy intensity as an indication of how much energy is used to produce one unit of economic output (World Bank, n.d.b)), *GDP* (Gross Domestic Product per capita as the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products (World Bank, n.d.c)), and *Regulation* (regulatory quality as percentile rank among all countries (ranges from 0 – lowest, to 100 – highest rank) (World Bank, n.d.d)). To that end, Pearson product-moment correlation was applied, to analyze more than two variables at once. Correlation is a statistical technique used to describe the relationship between two variables. In other words, correlation is a numerical value that describes three characteristics of the relationship between two variables, X and Y: direction, shape, and strength. Most often, the term correlation is used in the context of a linear relationship between two or more continuous variables and is expressed as Pearson product-moment correlation (Schober, Boer & Schwarte, 2018). Table 1 gives definitions of variables with their unit and sources.

*Table 1: Definition of variables, unit, and data source*

| **Variable** | **Definition** | **Unit** | **Source** |
|---|---|---|---|
| **lnISO** | The number of ISO 14001 certificates in Serbia | Total number | World Bank |
| **lnTrade** | Trade openness | % GDP | World Bank |
| **lnCO2** | $CO_2$ emissions | kt | World Bank |
| **lnEnergy** | Energy intensity | MJ/$2017 PPP GDP | World Bank |
| **lnGDP** | GDP per capita | Current US$ | World Bank |
| **lnRegulation** | Regulatory quality | Rank (0-100) | World Bank |

In order to achieve linearity, all values are logarithmized by the natural logarithm (ln). Statistical data processing was performed using IBM SPSS Statistics 25 software. The missing data for variable ln$CO_2$ are from 2021 and 2023, for lnEnergy is for 2023, and for lnRegulation is also for 2023.

## 5. Results and discussion

Before calculating the Pearson's correlation coefficient, the relationship of the variables represented by the scatter matrix is analyzed (figure 3).

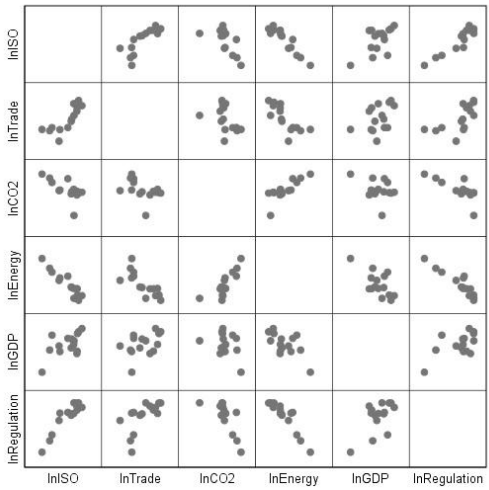


*Figure 3: Relationship between the number of ISO certificates, trade openness, $CO_2$ emissions, energy intensity, GDP per capita, and regulatory quality in Serbia.*
*Source: SPSS output.*

The figure shows potential bivariate relationships between the analyzed variables. It can be concluded that there is probably a positive, very strong linear relationship between lnISO and lnTrade, lnISO and lnGDP, lnISO and lnRegulation, lnTrade and lnGDP, $lnCO_2$ and lnEnergy, thus, positive strong linear relationship between lnTrade and lnRegulation, and lnGDP and lnRegulation. Furthermore, there is probably a negative, very strong linear relationship between lnISO and $lnCO_2$, lnISO and lnEnergy, lnTrade and lnEnergy, $lnCO_2$ and lnRegulation, lnEnergy and lnGDP, and lnEnergy and lnRegulation, as well as negative correlations that are not statistically significant (lnTrade and $lnCO_2$, and $lnCO_2$ and lnGDP). The next step is to calculate the Pearson's correlation coefficient (R).

Based on the results obtained for the entire observed period, from 2006 to 2023 (table 2), it can be concluded that there is a positive correlation between lnISO and lnTrade, due to the positive value of correlation coefficient ($R = 0.844$). Since $0.80 < 0.844 < 1$, this is a very strong correlation, thus, since $p < 0.01$, there is a statistically significant relationship between the observed variables. There are also five more positive, statistically significant and very strong correlations between lnISO and lnTrade, lnISO and lnGDP, lnISO and lnRegulation, lnTrade and lnGDP, $lnCO_2$ and lnEnergy, and two positive, strong and statistically significant correlations between lnTrade and lnRegulation, and lnGDP and lnRegulation.

*Table 2: Correlation between the number of ISO certificates, trade openness, CO2 emissions, energy intensity, GDP per capita, and regulatory quality in Serbia, from 2006 to 2023.*

| | | **lnISO** | **lnTrade** | **ln$CO_2$** | **lnEnergy** | **lnGDP** | **lnRegulation** |
|---|---|---|---|---|---|---|---|
| **lnISO** | R | 1 | 0.844** | -0.649** | -0.948** | 0.689** | 0.903 |
| | p | | 0.000 | 0.009 | 0.000 | 0.002 | 0.000 |
| | N | 18 | 18 | 15 | 17 | 18 | 17 |
| **lnTrade** | R | 0.844** | 1 | -0.418 | -0.806** | 0.711** | 0.604* |
| | p | 0.000 | | 0.121 | 0.000 | 0.001 | 0.010 |
| | N | 18 | 18 | 15 | 17 | 18 | 17 |
| **ln$CO_2$** | R | -0.649** | -0.418 | 1 | 0.806** | -0.344 | -0.375** |
| | p | 0.009 | 0.121 | | 0.0000 | 0.210 | 0.002 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 |
| **lnEnergy** | R | -0.948** | -0.806** | 0.806** | 1 | -0.728** | -0.884** |
| | p | 0.000 | 0.000 | 0.000 | | 0.001 | 0.000 |
| | N | 17 | 17 | 15 | 17 | 17 | 17 |
| **lnGDP** | R | 0.689** | 0.711** | -0.344 | -0.728** | 1 | 0.537* |
| | p | 0.002 | 0.001 | 0.210 | 0.001 | 0.000 | 0.026 |
| | N | 18 | 18 | 15 | 17 | 18 | 17 |
| **lnRegulation** | R | 0.903** | 0.604* | -0.735** | -0.884** | 0.537* | 1 |
| | p | 0.000 | 0.010 | 0.002 | 0.000 | 0.026 | |
| | N | 17 | 17 | 15 | 17 | 17 | 17 |

*R – Pearson's correlation coefficient; p – significance level; N – number of observations*
***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*
*Source: SPSS output.*

There is a negative correlation between lnISO and ln$CO_2$, since there is the negative value of correlation coefficient (R = -0.649). Moreover, given that 0.60 < 0.649 < 0.799, this is a strong correlation (p < 0.001, thus, there is a statistically significant relationship between the observed variables). There are also five more negative, very strong, statistically significant correlations between lnISO and lnEnergy, lnTrade and lnEnergy, ln$CO_2$ and lnRegulation, lnEnergy and lnGDP, and lnEnergy and lnRegulation.

As well, two negative correlations can be observed – one of medium strength (between lnTrade and ln$CO_2$) and the other is weak (between ln$CO_2$ and lnGDP), but they are not statistically significant (0.121 > 0.001 and 0.210 > 0.001).

It is shown that greater market openness, regulatory quality and GDP per capita in Serbia will affect the increase in the number of ISO 14001 certificates (there is a strong positive influence on the ISO 14001 certification). On the other hand, it has been shown that the increase in $CO_2$ emissions and energy intensity has a negative effect on ISO 14001 adoption.

## 6. Conclusions

The contribution of this study lies in the ecological aspect of sustainable development, as it examines the relationship between environmental issues, trade and the number of ISO 14001 certificates in Serbia. The relationship between environmental issues (proxy $CO_2$ and energy intensity), market openness and the number of ISO 14001 certificates in Serbia was examined using Pearson product-moment correlation. The variables gross domestic product (GDP) and regulatory quality are also included in the analysis, as they are considered important for this study, and the idea is to extend the research with a regression analysis where these two additional variables would be taken as control variables. The research results revealed that there is a positive, very strong, statistically significant relationship between trade openness and the number of ISO 14001 certificates, which means that as the market openness of a country increases, so does the number of ISO 14001 certificates, because only in this way countries, and especially developing ones, can survive in the global market competitors – companies that are ISO 14001 certified and comply with strict environmental legislation. Another significant correlation was discovered – a very strong, negative, statistically significant relationship between number of ISO 14001 certificates and $CO_2$ emissions. This would mean that if the number of companies that adopt the ISO 14001 standard increases, the environmental responsibility and environmental protection activity will be greater, which will lead to a decrease in $CO_2$ emissions in the country.

The recommendation to future researchers of this issue is to expand the existing model with a regression model, as well as to have more research in this area in Serbia and the region.

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# HEALTHCARE SERVICE QUALITY ON PATIENT LOYALTY IN ZAMBIA

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***Abstract***

*The Zambian government faces significant challenges in providing adequate healthcare services to its citizens. In response, Zambia has implemented the National Health Policy, which aims to ensure equitable access to high-quality, cost-effective healthcare as close to families as possible. This study investigates the impact of brand image, patient satisfaction, and patient loyalty on the quality of healthcare services in Zambian health facilities. Findings reveal a strong correlation between healthcare service quality and the factors of patient satisfaction, brand image, and patient loyalty. Patients prioritize factors that contribute to a positive healthcare experience, including courteous and attentive medical personnel, efficient service delivery, effective treatment, a clean and hygienic environment, and access to modern technology. Using qualitative analyses, key issues affecting the provision of good healthcare in Zambia are identified in this study, including rising medical costs that burden patients and may delay or prevent them from seeking necessary care, and disparities in access, particularly in rural areas, which create geographic barriers to healthcare services. Also, this study recommends that successful training programs can enhance staff abilities in communication, service delivery, and treatment effectiveness. Building a patient-centered healthcare system in Zambia requires a focus on continuous improvement and frequent feedback. Policymakers can consider a multifaceted strategy to improve affordability, with public-private partnerships being particularly effective for funding critical infrastructure development projects, such as new clinics or upgraded communication networks in remote locations.*

***Key words****: brand image, patient loyalty, patient satisfaction, healthcare service quality, Zambia*

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# 1. Introduction

Improving access to high-quality healthcare is crucial for raising global life expectancy and overall living standards. To achieve this, leaders must collaborate to address key issues regarding the planning, funding, and delivery of public health services. Access to quality healthcare is a fundamental human need and advancing health care is vital for reducing poverty and fostering human development (World Bank, 2024). Africa's healthcare sector, despite facing significant challenges and disparities compared to other regions, presents substantial growth opportunities. While South-East and South Asian countries, once behind African nations in health outcomes, have now surpassed them in many indicators, Africa's progress has been slow. As a result, the continent's health outcomes are expected to lag behind global standards for some time (Phiri, 2019).

The Ministry of Health (MOH) is implementing the National Health Strategic Plan to ensure equitable access to affordable, high-quality healthcare close to communities. However, the government recognizes that broader health determinants exist beyond the health sector, committing to fostering healthy lifestyles and well-being through a cross-sectoral approach. The country faces a high burden of infectious diseases alongside a rising prevalence of non-communicable diseases. Structural and social inequalities—such as poverty, inequality, and marginalization—further exacerbate health risks (National Health Strategic Plan, 2022). Despite efforts to reduce HIV, malaria, and maternal and infant mortality, the low-resource health system, high disease burden, and poor infrastructure, particularly in rural areas, continue to pose significant challenges. To effectively address the social determinants of health, all sectors must prioritize health and well-being in policy development.

# 2. Literature Review

Zambia, a landlocked country in Southern Africa, spans 752,612 square kilometers and has a population of approximately 19.6 million, divided into 10 provinces. Lusaka and Copperbelt are predominantly urban, while the other eight provinces are largely rural (ZamStats, 2022). With a rapid population growth rate of 2.7% per year, the population is expected to double within the next 25 years, increasing the demand for jobs, healthcare, and other social services. As public awareness of health rises, Zambia's healthcare industry is expanding, but the country still faces a high burden of communicable diseases alongside a growing prevalence of non-communicable diseases, contributing to elevated mortality rates (MOH, 2024).

Achieving Universal Health Coverage (UHC) is essential for meeting health-related targets under Sustainable Development Goal 3 (SDG3), and this is directly tied to the performance of Zambia's health systems. Service quality in healthcare is crucial for patient satisfaction and loyalty. Hospitals must focus on providing high-quality services to meet patient expectations, which can encourage repeat use of hospital services (Pai & Chary, 2013). Service quality is measured by the gap

between patients' expectations and their actual experiences (Albert et al., 2005). Brand image also plays a key role in influencing consumer decisions, with a positive brand image being established through consistent value generation and understanding different customer needs (Wu, 2011). Hospitals that build strong brand images are motivated to maintain high service quality, directly impacting patient satisfaction.

Patient satisfaction, a key determinant of loyalty, encourages repeat visits to the same healthcare provider, regardless of competitor offerings. Quality care fosters strong bonds between patients and institutions, allowing hospitals to better understand and meet patient expectations. By prioritizing positive experiences and minimizing negative ones, hospitals can enhance overall patient satisfaction (Ajmal et al., 2022).

The National Health Strategic Plan (NHSP) 2022-2026, developed within the broader national and health sector development framework, aims to achieve national health objectives in alignment with Vision 2030. While there has been significant progress in health service delivery and system strengthening, critical gaps remain, particularly in addressing the health needs of women, children, adolescents, and vulnerable populations, which remain major challenges.

### 2.1 Study Gaps

While a significant body of literature exists on quality assessment in the health sector, limited research has specifically focused on identifying factors that enhance or inhibit healthcare service quality in Zambia. A review of the literature reveals a scarcity of studies that examine the relationships between hospital brand image, patient loyalty, and satisfaction in relation to healthcare service quality. Previous research on patient loyalty has predominantly centered on service performance (Moliner, 2009; Chang et al., 2013). Among these, satisfaction has been consistently identified as the key factor in determining patient loyalty (Moliner, 2009; Chang et al., 2013). This study seeks to address this research gap by empirically investigating patients' perspectives on the quality of medical services in hospitals. Specifically, it explores the associations between patient satisfaction, brand image, and patient loyalty in relation to healthcare service quality. Furthermore, the study identifies inefficiencies within the healthcare system and suggests strategies for improving service quality in Zambia.

### 2.2 Research Questions

*RQ1: In what ways will brand image, patient satisfaction and patient loyalty impact the healthcare service quality in Zambia?*

*RQ2: What can be the strategies and best practices to improve the healthcare sector in Zambia?*

## 3. Frameworks

Along with the study variables, a description of the frameworks is provided, focusing on how they connect to the research approach and objectives. Figure 1 demonstrates the relationship that the independent variables brand image, patient satisfaction and patient loyalty have on the dependent variable for Research Question 1. The relationships among patient satisfaction, patient loyalty, and brand image on healthcare service quality dimensions will be explored.

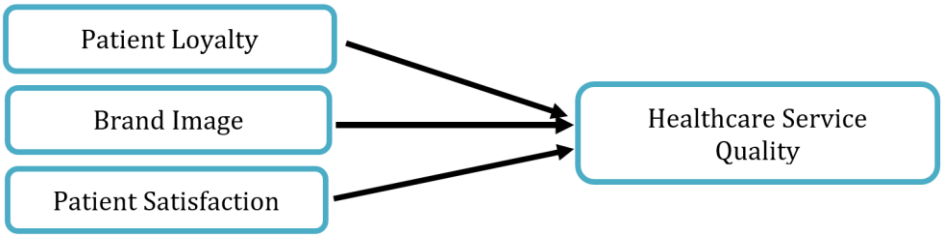


*Figure 1: Research Framework*
*Source: Somaiya & Hara (2023, p.10)*

Meanwhile, Figure 2 below illustrates the research framework which demonstrates the different strategies that are being explored summarizing the common strategies which have been implored and aims to refine them. It aims to reorient healthcare delivery in which patient needs, preferences, and values honored.

*Figure 2: Research Framework*
*Source: Authors*

## *4.* Methodology

This study employed a qualitative research methodology, which, as described by Mosadeghrad (2014), involves the analysis of primarily verbal data. It focuses on understanding phenomena from the perspectives of participants, seeking to

establish relationships and explain the causes of changes in social facts. One of the key advantages of qualitative research is its ability to provide in-depth insights into the subject being studied.

The population for this study consisted of individuals who had visited a medical institution more than once. The research was conducted in Lusaka, the capital of Zambia, which has a population of 3 million within the country's total population of 19.6 million (ZamStats, 2022). Lusaka was chosen due to its high density and concentration of medical institutions, making it an ideal location to gather diverse perspectives on healthcare. The large population in Lusaka offers a broad range of experiences, making it easier to capture a true picture of patient perspectives, which is essential to the research (Ajmal et al., 2022).

The study gathered both primary and secondary data. Secondary data was sourced from a review of journals, reports, and articles published between 2010 and 2023, which provided a foundation for the qualitative analysis. Primary data was collected through semi-structured questionnaires, which allowed for a more detailed examination of how independent variables affect healthcare service quality. Additionally, open-ended questions and interviews were conducted with both medical staff and patients to obtain valuable insights into strategies for improving the healthcare sector.

The data was analyzed qualitatively using thematic analysis, which helps reduce bias and ensures the reliability of the study (William & Mosner, 2019). Thematic analysis involves grouping data into themes that emerge naturally during the research process, helping to answer the research questions.

# 5. Results

## 5.1 Research Question 1

The survey responses overwhelmingly emphasize the critical importance of quality improvement in Zambia's healthcare system in Table 1.

*Table 1: Summary of Study Results for RQ1*

| Factor | Description | Impact |
|---|---|---|
| **Brand Image** | | |
| Brand Reputation | Well-known brands perceived as offering good service and trustworthy | Major factor for many |
| Positive Word-of-Mouth | Recommendations from past patients | Increases trust and comfort level |
| Familiarity | Preference for known brands over unknown ones | Reduces anxiety about seeking medical care |
| Cost | Financial limitations may prioritize affordability over brand | Some prioritize affordability |
| Service Availability | Choosing a hospital with the necessary service | May be more important than brand for some |
| **Patient Loyalty** | | |

| Factor | Description | Impact |
|---|---|---|
| Positive Prior Experience | Kind staff, efficient service, effective treatment | Most important factor for return visits |
| High-Quality Care | Modern facilities, up-to-date equipment | Contributes to trust and positive perception |
| Specific Services Offered | Facility catering to specific needs | Important for some |
| Convenience | Easy access, short waiting times | Improves patient experience |
| **Patient Satisfaction** | | |
| Cultural Sensitivity | Understanding and respecting diverse backgrounds | Increases trust and willingness to participate in treatment |
| Open Communication | Improves trust and outlook on recovery | Feeling heard, respected, and informed |
| Efficient Service Delivery | Timely diagnoses, proper medication, clear instructions | Leads to shorter stays, faster recovery, and fewer errors |

*Source: Authors*

At the core of healthcare lies patient well-being, and quality improvement initiatives are essential for better health outcomes. By implementing evidence-based practices and protocols, healthcare providers can deliver treatments that are proven to be effective, resulting in higher recovery rates and improved overall health. A key aspect of quality improvement is minimizing errors and enhancing safety measures, as fewer errors lead to safer care and better patient outcomes.

Survey participants highlighted the connection between brand recognition and the perceived quality of care. Many respondents believed that well-known hospitals are likely to have strong reputations, built on consistently delivering high-quality service. Positive word-of-mouth plays a crucial role, as a hospital with a recognized brand often benefits from favorable experiences shared by former patients.

The survey also identified key factors influencing a patient's decision to return to a healthcare provider. A positive prior experience was the most significant factor driving repeat visits. Efficient service delivery—ranging from registration to treatment—not only reduces patient stress but also makes patients feel that their time is valued. Most importantly, receiving effective treatment that addresses their health concerns fosters a sense of confidence in the facility's capabilities, encouraging future visits.

In healthcare, service quality is more than a matter of courtesy—it serves as a foundation for a patient's journey toward recovery and overall well-being.

### 5.2 Research Question 2

The study responses highlight potential solutions to address challenges and build a stronger healthcare system in Zambia, as shown in Table 2.

*Table 2: Summary of Results*

| Challenges | Impact | Solutions |
|---|---|---|
| Rising healthcare costs | Financial burden preventing access to essential services | Invest in preventative care to mitigate chronic diseases and potentially reduce overall healthcare costs. |
| Disparities in access to care | Uneven distribution of resources leading to limited access for remote & low-income areas | Invest in infrastructure (clinics, hospitals) in underserved areas and leverage telemedicine/mobile health clinics to bridge geographical gaps. |
| Integration challenges | Difficulty integrating new technologies due to interoperability, data security, and equitable access concerns | Adopt user friendly systems to allow more users to operate the information systems seamlessly. |
| Lack of qualified healthcare workers | Workforce shortage, especially in rural areas, leading to long wait times and potentially compromised care quality | Invest in training programs to increase healthcare workers and incentivize them to work in rural areas (scholarships, loan forgiveness). |
| Limited infrastructure and resources | Shortage of doctors, nurses, and medical equipment, particularly in rural areas | Invest in infrastructure (clinics, hospitals) and medical equipment, especially in rural areas. |
| Financial accessibility | Challenges ensuring healthcare affordability for all Zambians | Implement policies to improve healthcare affordability (e.g., financial mechanisms, social safety nets). |

*Source: Authors*

One key recommendation is the construction of more clinics and hospitals, particularly in underserved rural areas, to improve access to care. This investment in infrastructure would ensure essential medical services are brought closer to the populations most in need. Additionally, investing in training programs to increase the number of qualified healthcare workers, particularly with a focus on deploying them to rural areas, is critical for addressing the healthcare workforce shortage.

Technology also plays a pivotal role in overcoming geographical barriers by connecting patients in remote areas with qualified healthcare providers through telemedicine and other digital health solutions. Building strong partnerships between governments, healthcare providers, NGOs, and other stakeholders is essential for developing sustainable solutions to the challenges faced by Zambia's healthcare system.

The responses highlight key workplace conditions essential for reliable service delivery, patient safety, and quality care. Ensuring a safe environment for both patients and healthcare professionals involves strict safety protocols, infection control, and regular equipment maintenance.

Effective leadership, committed to good governance and regulatory compliance, is essential for the success of the healthcare system. Strong leadership fosters accountability, continuous quality improvement, and adherence to ethical standards. Access to well-maintained, up-to-date equipment and adequate resources is vital for healthcare professionals to perform accurate diagnoses, provide necessary treatments, and deliver high-quality care.

Lastly, ensuring manageable workloads for healthcare workers is necessary to prevent burnout and promote a culture of safety. This can be achieved through proper staffing, efficient workflow design, and appropriate task delegation.

## 6. Discussion

This study provided a comprehensive analysis of the complex relationship between patient experience, healthcare service quality, and the Zambian healthcare system. First, the findings emphasize the critical role of patient-centered care. A system that prioritizes open communication, treats patients with dignity and respect, and demonstrates empathy fosters trust and leads to better health outcomes. Second, the research underscores the importance of brand image. Positive patient experiences help build a strong brand reputation, which attracts new patients and fosters loyalty.

Training healthcare workers to stay current with the latest evidence-based practices and treatment protocols is also crucial. This, combined with clean, well-maintained facilities and modern technology, enhances patient interactions, reduces frustration, and builds trust between patients and providers.

Affordability should not be a barrier to essential healthcare in Zambia. Policymakers can adopt a multi-pronged approach to improve healthcare affordability. One solution is the implementation of government-subsidized health insurance plans to serve as a safety net, particularly for low-income citizens. Additionally, targeted programs can be developed for vulnerable populations such as children, pregnant women, and the elderly.

By addressing key areas—affordability, accessibility, infrastructure, workforce development, preventative care, and quality control—Zambia can strengthen its healthcare system, ensuring it is more robust and equitable for all its citizens.

## 7. Conclusions

This study on healthcare service quality in Zambia highlights key factors influencing patient choice and satisfaction. The findings stress the importance of a patient-centered approach that not only emphasizes clinical expertise but also fosters clear communication, respectful interactions, and cultural sensitivity. A positive brand reputation, built on prior positive experiences, emerged as a crucial factor for patients, underscoring the need for healthcare facilities to invest in building trust and consistently delivering high-quality care.

However, the study also reveals significant challenges impeding the full potential of Zambia's healthcare system. Rising medical costs, unequal access to care, and a shortage of qualified personnel present substantial obstacles to achieving equitable healthcare for all Zambians. These challenges are further compounded by inadequate infrastructure and resource constraints. The proposed solutions provide a strategic roadmap for overcoming these barriers and advancing the healthcare system towards greater equity and efficiency.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE BALANCING ACT OF MANAGING FINANCIAL LIMITATIONS WHILE ACHIEVING MISSION SUCCESS: A STUDY OF NONPROFIT ORGANIZATIONS

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***Abstract***

*The challenges faced in balancing financial sustainability with mission-driven objectives due to limited resources and competing demands are relevant to nonprofit organizations (NPOs) as much as business organizations. This research aims to explore the complex landscape of analyzing resource allocation, decision-making processes, and stakeholder engagement faced by NPOs, using research methods involving survey, interview, and literature reviews. This study further investigates how NPOs manage funding limitations with other key areas of focus, including the impact of resource constraints on program delivery, the role of stakeholder engagement in decision-making, and the effectiveness of different funding strategies. The findings reveal a significant relationship between robust stakeholder engagement and increased donor support. Moreover, effective resource allocation is associated with enhanced organizational performance. Although NPOs frequently face the challenge of balancing short-term financial requirements with long-term strategic goals, adept stakeholder management and strategic resource distribution can greatly enhance organizational sustainability and impact. The goal is to offer practical insights for NPOs and their leaders to enhance performance while maximizing social impact. It also contributes towards a better understanding of the factors influencing NPO sustainability and for the creation of effective policies and support mechanisms.*

***Key words:*** *NPOs, funding, resource allocation, decision-making, social impact, sustainability.*

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# 1. Introduction

Nonprofit organizations (NPOs) play a crucial role in addressing various social issues within society. Nevertheless, their activities are frequently hindered by financial constraints, requiring them to allocate resources carefully and make strategic decisions. The sustainability and ability of an organization to achieve its mission and engage stakeholders and donors depend on the effectiveness of its decision-making process (Bryson, 2018).

Previous research has examined the challenges in decision making. However, there is a gap in understanding the specific strategies that can maximize effective resource management while managing financial limitations and its impact on program implementation. The most beneficial decisions for nonprofit organizations are those that emerge from the collective wisdom of a diverse group of individuals (Drucker, 2006).

The research uses a mixed-methods approach to identify effective strategies for resource distribution, stakeholder involvement, and sustainable planning. This study aims to offer valuable recommendations for NPOs to enhance their resilience, financial sustainability, and social impact by analyzing quantitative survey data in conjunction with qualitative insights obtained from interviews.

## 1.1 Background

Finding a delicate balance between often conflicting priorities can be a complex undertaking. To strike a balance among these competing priorities, NPOs must stay flexible, adaptable, and responsive to their changing environments. By carefully assessing trade-offs and making informed decisions, NPOs can improve their chances of achieving long-term sustainability while increasing their social impact. According to Young (2001), nonprofit organizations place a strong emphasis on their social missions, viewing revenue generated from commercial activities as a means to achieve these missions. According to Lichfield (2005), balancing the main objective of the organization for which it is set up, is to achieve its primary goal and make a visible positive difference in the community, is crucial. The Brinkerhoff and Brinkerhoff (2011) study focused on showcasing the efficacy of various programs and interventions, emphasizing the importance of efficient resource utilization to enhance the intended outcomes. It is a priority to secure the organization's sustained financial stability and guarantee its perpetual capacity to accomplish its stated mission (Ebrahim & Rangan, 2014).

NPO's typically operate with tighter budgets and fewer resources compared to for-profit business organizations. This scarcity demands careful resource allocation, making decisions based on maximizing impact within limited means (Salamon, 1987). For nonprofits that are solely dependent on crowdfunding, it is a huge challenge as the program implementation is purely dependent on the monetary receipts of the donors.

While for-profit organizations face their own set of challenges in making decisions, nonprofits encounter unique difficulties due to their mission-driven

nature and resource constraints. Here are some key issues that NPOs face when making decisions.

Nonprofits serve diverse stakeholders, including donors, beneficiaries, staff, and the community. Balancing the needs and expectations of these groups can create conflicting pressures and complicate decision-making processes (Jeffery et al., 2009).

Pressure from stakeholders is a significant factor that organizations must consider and address. Stakeholders, including shareholders, employees, beneficiaries, and the community, exert pressure on organizations to act in certain ways or achieve specific outcomes. This pressure can come in various forms, such as demands for increased transparency, ethical behavior, environmental sustainability, or social responsibility. Organizations need to carefully manage stakeholder pressure to maintain their reputation, ensure long-term success, and meet the expectations of their diverse stakeholders. By effectively engaging with stakeholders, organizations can build trust, foster collaboration, and align their actions with the interests and values of those who have a stake in their operations.

According to Ebrahim & Rangan (2014), the urgency of addressing immediate needs can sometimes overshadow long-term strategic planning. Striking a balance between addressing present challenges and investing in sustainable future growth is crucial. The distinction between short-term and long-term focus is crucial in strategy and decision-making. A short-term focus prioritizes immediate results but can overlook long-term consequences, posing risks despite its benefits for urgent issues. In contrast, a long-term focus emphasizes sustainable growth and future goals, requiring patience and the willingness to forgo immediate rewards. While short-term gains can be tempting, they may lead to negative outcomes like ethical compromises or underinvestment in innovation. Balancing both perspectives is essential for sustainable growth, as each has its own advantages and disadvantages depending on the context and objectives.

Quantifying the impact of nonprofit activities can be challenging due to intangible benefits and long-term outcomes. This makes it difficult to evaluate the effectiveness of different options and demonstrate their value to stakeholders due to lack of reliable data appropriate measurement tools (Lichfield, 2005). However, by developing appropriate evaluation frameworks and methodologies, one can improve their understanding of their influence. In our study, we gathered data through semi-structured interviews and surveys. These data were analyzed to determine the extent of the impact each programming implementation had.

The goal of this study is to understand how nonprofit organizations effectively balance multiple objectives, including social impact, resource management, donor satisfaction, stakeholder pressure, and organizational sustainability, to ensure long-term success. Figure 1 illustrates the development of a concept model to understand the role of identified objectives for NPOs as the basis for decision-making.

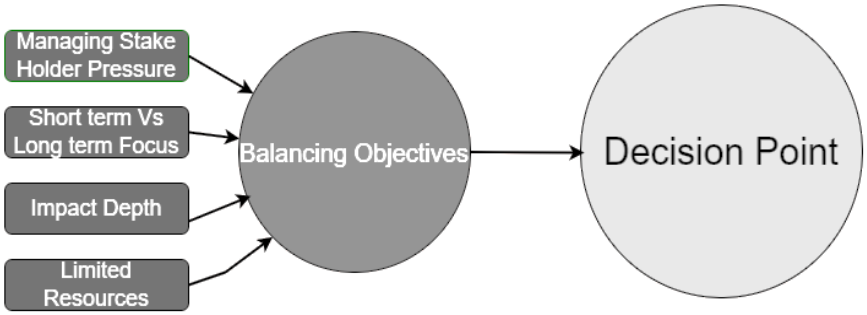


*Figure 1: Concept model*

By combining qualitative and quantitative insights, this study provides a comprehensive understanding of the challenges and opportunities faced by NPOs in this environment. The qualitative component, which includes structured interviews and survey questions, allows for a deeper exploration of the nuanced experiences and perspectives of NPO leaders and staff.

### 1.2 Interviews

To explore the complex interactions nonprofit organizations face in balancing financial constraints with their objectives, a mixed-methods research approach was utilized. This method aimed to provide a comprehensive understanding of the challenges and strategies NPOs encounter.

The research began with semi-structured interviews with key stakeholders, including NPO leaders, staff, and board members, to gather diverse perspectives on their experiences. These qualitative interviews featured open-ended questions that allowed participants to share their narratives about navigating financial limitations while pursuing their mission-driven goals. This interview was also helpful in framing a survey form.

Ultimately, the study aimed to contribute to the existing body of knowledge on nonprofit management and provide actionable recommendations for NPOs seeking to enhance their financial sustainability while remaining true to their mission. Through this investigation, the researchers sought to empower NPO leaders with the tools and understanding necessary to navigate the complexities of their operational landscape effectively.

### 1.3 Surveys

A structured survey was created and was conducted to collect data from a representative sample of NPO's. The poll asked questions about how resources were allocated, how decisions were made, how stakeholders were involved, and how well the organization performed.

Key NPO stakeholders, such as promoters, directors, program managers, and board members, participated in semi-structured interviews. These interviews

provided detailed insights into the difficulties and approaches NPOs use while making decisions, as well as helping to create the survey form.

We conducted a thorough literature review to identify prior research on NPO decision making, resource allocation, and stakeholder engagement. This provided a theoretical foundation as well as a background knowledge for the study.

This is an ongoing study on decision making in NPOs for the past sixteen months, targeting a sample population of 380 respondents. However, for this study, we selected twenty prominent and active leaders serving the nonprofit sector, and fifteen of them responded.

## 2. Results and findings

### 2.1 Results

The ongoing research has a sample size of 380, however, we selected twenty active and prominent leaders at this stage of study. Out of them 15 responded to this survey. The findings are listed below in Figure 2, under the survey results:

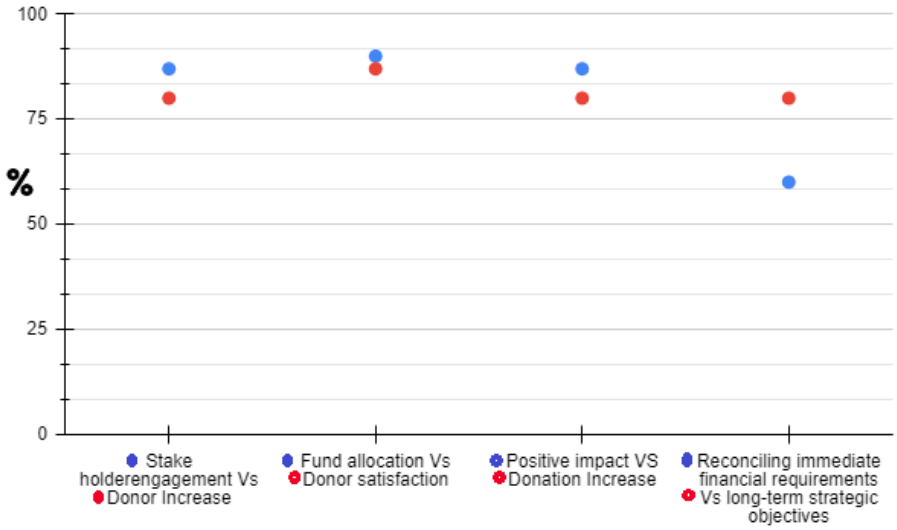


*Figure 2: Survey results*

### 2.2 Findings

The interviews and surveys conducted yielded several important insights, emphasizing the prominent themes and patterns that surfaced from the participants' responses.

### 2.2.1 Stakeholder engagement and donor growth:

**Correlation:** The survey's findings show a substantial positive relationship between growing donor contributions and successful stakeholder engagement. NPOs are more likely to obtain funds and support if they place a high priority on fostering relationships with stakeholders.

**Specific findings:** 80% noted an increase in donor contributions attributed to this effective engagement.

### 2.2.2 Resource allocation and organizational performance:

**Positive impact:** The data collected points to a clear connection between effective resource management and overall organizational success. NPOs that have good prioritization and resource allocation skills have a higher chance of succeeding in their objectives and producing favorable results, including a higher level of donor satisfaction.

**Specific findings:** 87% of the respondents assert that such effective fund allocation led to enhanced donor satisfaction and has led to increased program effectiveness.

### 2.2.3 Balancing immediate needs and long-term goals:

**Challenges:** A significant percentage of NPOs reported having trouble balancing short-term funding needs with long-term strategic goals. This frequently involves making hard choices regarding the distribution of resources and program priorities.

**Strategies:** To address this challenge, successful NPOs often employ strategies such as strategic planning, data-driven decision-making, and partnerships.

**Specific findings:** 80% of the respondents, remained committed to achieving these long-term objectives despite the constraints posed by the immediate availability of funds.

## 3. Discussions

The results of the survey show how important resource allocation and stakeholder participation are to NPO success. A positive correlation exists between effective stakeholder engagement and donor growth, highlighting the need for strong stakeholder relationships. Additionally, efficient resource distribution directly impacts organizational performance, with well-managed NPOs more likely to achieve their goals.

However, balancing immediate financial needs with long-term strategic objectives poses a significant challenge. This conflict requires careful consideration and strategic planning.

The research conducted by Kurien and Varghese (2021) regarding the financial sustainability of nonprofit organizations in northeast India revealed that 80% of participants acknowledged the substantial influence of donor relationships

on the financial viability of these organizations. Furthermore, 57% of the respondents reported that income diversion significantly affected their organization's financial sustainability.

Future research should explore the specific strategies NPOs use to manage stakeholder expectations while ensuring financial sustainability. Investigating the role of technology in enhancing resource allocation and stakeholder engagement could also provide valuable insights. Such studies could yield practical recommendations for NPOs to improve their performance and impact.

## 4. Conclusion

This study underlines the relationship that exists between nonprofit sector achievement of objectives and managing financial limitations. The factors that influence the execution of objectives must be thoroughly examined and managed. By investigating the significant roles of stakeholder involvement, resource distribution, and strategic planning, this study offers important perspectives on the challenges and prospects encountered by NPOs. While robust stakeholder involvement and effective resource utilization are crucial for the success of NPOs, the continuously evolving landscape of the nonprofit sector demands continuous adaptation and innovation. Future research could assess how emerging technologies affect NPOs' capacity to navigate funding limitations and fulfill their social objectives. Ultimately, by comprehending the elements that impact NPO performance, policymakers, funders, and leaders within the nonprofit sector can work together to devise strategies that foster a more supportive environment for these essential organizations.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EFFECTIVE MANAGEMENT OF CCS PROJECTS: ADVANCING WITH AN INTEGRATED CCS MODEL

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***Abstract***

*Drawing from past experiences in implementing carbon capture and storage (CCS) projects and the previously proposed model for managing them, this paper seeks to refine the model and expand our understanding to encompass the various aspects of these endeavours – including social, economic, ecological, technical, and more. The paper begins with a concise introduction to the topic of CCS and presents the key elements of an integrated CCS model that could be advantageous for both academia and practice in examining and managing CCS projects and related initiatives. Furthermore, we continue by explaining how the model should be utilized and how its core elements can be modified to improve the management of CCS projects and align it with industry best practices. Consequently, the outcome of the paper is an advanced integrated CCS model that functions as a conceptual framework for managing CCS projects. This model calls for further refinement to establish detailed, task-by-task guidelines that will clarify both conceptual and practical issues. Nevertheless, this paper offers valuable insights into the effective management of CCS projects and stimulates discussion on resolving the somewhat ambiguous perspectives on integrating all critical aspects of CCS endeavours, which demand substantial effort from both industry and society.*

***Key words:*** *CCS, Decarbonization, Sustainable Project Management, Oil and Gas Industry, ESG.*

## 1. Introduction

Global efforts to reduce $CO_2$ emissions and transition to a net-zero economy have elevated carbon capture and storage (CCS) as a viable solution to effectively tackle these challenges of the modern society Although the concept of CCS has been established in academic and practical fields for several decades, it has recently experienced a significant surge in interest as a means to slow climate change and

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mitigate its associated impacts. However, the widespread adoption of CCS remains somewhat uncertain due to the complexity of these endeavours, which we identified as an opportunity to enhance the management of CCS by introducing a model that addresses the various aspects of CCS implementation – geological, ecological, economic, and social. Consequently, this paper aims to advance the practice of CCS, primarily in the oil and gas industry, as well as from a broader perspective.

### 1.1 Carbon Capture and Storage

Carbon capture and storage (CCS) is a technology designed to remove $CO_2$ from various industrial and power sources and permanently store it in deep geological formations, underwater, or other secure locations to prevent future leakage (Leung et al., 2014; D'Amore et al., 2020; Steele et al., 2021). The most common form of CCS is enhanced oil recovery (EOR), which encompasses two aspects – the geological storage of captured $CO_2$ and the increased oil production due to better utilization of the oil field, thereby simultaneously addressing the issue of $CO_2$ emissions and achieving economic benefits (Riley, 2010; Hill et al., 2013; Leung et al., 2014). Consequently, CCS is acknowledged as a vital strategy for enhancing decarbonization efforts and attaining sustainability goals, thus mitigating the impact of climate change on nature, society, and the economy (Cook, 2012; Leung et al., 2014; Shirmohammadi et al., 2020).

Recent trends in CCS research focus on safety, scalability, public acceptance, machine learning, and cost efficiency, as well as the integration of these elements into roadmaps for successfully navigating CCS initiatives, leading to the development of the Integrated Phased Model for CCS Implementation (Küng et al., 2023; Yao et al., 2023; Liu et al., 2023; Fominykh, 2024).

### 1.2 Integrated Phased Model for CCS Implementation (IPM-CCS)

The Integrated Phased Model for CCS Implementation (IPM-CCS), introduced by the author earlier this year, serves as a comprehensive guideline for deploying CCS initiatives across any industry, regardless of the scale or complexity of the implementation. The IPM-CCS is structured into six subsequent phases, which can overlap and occur concurrently when feasible and reasonable. Between these phases, multiple checkpoints are established to assess the phase deliverables and facilitate decision-making regarding the acceptance of deliverables or the need for further alignment with the phase requirements. The core principle of this model is to enable the continuous development of project deliverables, ensuring that the project remains aligned with the strategic goals of the company and contributes to safe, responsible, and cost-effective CCS implementation.

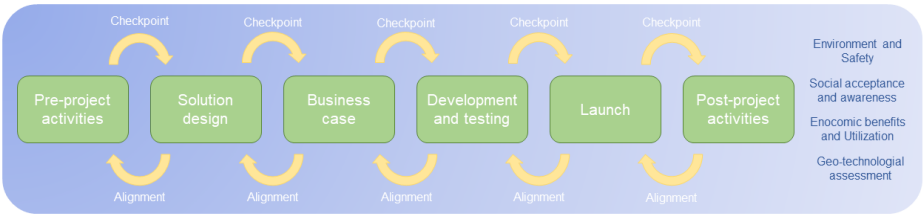


*Figure 1: IMP-CCS*

As depicted in Figure 1, the IPM-CCS comprises the following phases: pre-project activities, solution design, business case, development and testing, launch, and post-project activities. Each phase includes recommended steps to be conducted during the implementation of a CCS initiative, which allows for the acceptance of ongoing changes and ensures the continuity of the project. This approach is distinctive due to its quasi-agile nature; however, due to numerous technical, geological, physical, and other constraints of CCS projects, various issues arise when attempting to shift entirely to fully agile methods and models.

## 2. Methodology

The methodological framework of this research consists of data collection and analysis activities that were conducted to gain a comprehensive understanding of CCS, theoretical frameworks for managing these endeavours, and potential enhancements to advance industry practices.

### 2.1 Data collection

We conducted a systematic literature review to identify key insights into the management of CCS projects. Initially, the literature pool contained over a hundred papers; however, we narrowed our focus to those that exclusively examined various aspects of managing CCS and similar complex projects. Consequently, the systematic literature review in this study encompasses more than twenty papers that discuss the explanation of CCS and its components, different management approaches for CCS projects, and the latest developments in enhancing current practices within the oil and gas industry. It is important to note that we employed a mixed-methods approach in our systematic literature review, thereby organizing existing knowledge about CCS and transforming it into new theoretical concepts that reduce uncertainties surrounding the management of such projects.

### 2.2 Data analsis

We categorized the identified papers into two groups: 1) core elements of CCS and its management, and 2) innovative strategies for managing complex projects. For each category, we analysed the current state, challenges, trends, and particularities, thereby pinpointing their intersections to propose potential enhancements to CCS practices, applicable not only to the oil and gas sector but to

industry as a whole. Furthermore, we employed case analysis to deepen our understanding of managing CCS projects by examining various CCS initiatives implemented worldwide, with a particular focus on the CO2 EOR project at the "Rusanda" oil field and the construction of Europe's first *HiPACT* plant. By integrating new findings into the existing model, we structured and refined the IPM-CCS that will be presented as follows.

## 3. Results

The IPM-CCS, introduced earlier, provides fundamental definitions of the steps involved in each phase of the model (Fominykh, 2024). Nonetheless, managing CCS projects goes beyond these steps, delving into risk assessment, technological feasibility, and scalability, which are crucial for the successful deployment of CCS technology and for meeting the dynamic societal demands regarding general safety and environmental protection. Therefore, the IPM-CCS will be further developed by detailing its adaptations in line with the aforementioned considerations.

Larkin et al. (2019) proposed an integrated risk assessment framework that identifies three groups of factors influencing CCS implementation: 1) government and industry factors; 2) environmental risk factors; and 3) socio-economic factors. The authors recommend that these factors should be regularly assessed and reassessed as CCS implementation progresses, complementing the IPM-CCS and its established practice of multiple checkpoints at the beginning and end of each phase of the model. However, Larkin et al. (2019) also outline ten phases of risk assessment that facilitate risk mitigation based on the risk factors and stakeholders involved, thereby offering a structured approach to ensure that technical, environmental, economic, social, and regulatory requirements are met throughout the CCS implementation process. Therefore, the integrated risk assessment framework should be adopted as the standard risk assessment practice and integrated into the checkpoints as an essential gatekeeper before progressing to the next phase of implementation, as proposed within the IPM-CCS.

The technical feasibility of CCS endeavours was not explicitly addressed in the previous version of the IPM-CCS, although it encompasses the selection of potential technological solutions, aligning them with project-specific requirements (such as site characteristics, type of geological formations, seismic parameters, capture or storage capacity, etc.), and concurrently developing and testing these solutions. Therefore, the pre-project phase of the IPM-CCS should incorporate a comprehensive techno-economic analysis, which also includes the assessment of the technology readiness level, thereby eliminating technical barriers to implementing certain CCS solutions or deferring their implementation until a minimum set of technical requirements is met (Dziejarski et al., 2023; Rowaihy, 2024). Furthermore, it is notable that the assessment of technological feasibility also extends through other phases of the IPM-CCS, necessitating the abandonment of CCS implementation if any significant but irresolvable risks emerge, even at advanced stages of the project, such as during the testing or launching phases (Küng et al., 2023; Liu et al., 2023). Upon the implementation of CCS solution, i.e., during the post-project

activities phase, the focus shifts to leakage prevention which is shared responsibility of both the implementor and the government; while the model considers this to some extent, it is more broadly a matter of long-term corporate and social responsibility.

Given that the issue of scalability of CCS technology has not been fully addressed within the IPM-CCS model, it is crucial to acknowledge that the technical feasibility, general safety, and cost-effectiveness of CCS implementation are the main factors affecting the potential for broader deployment; therefore, the pre-project activities and development-related phases of the model are critical in determining the level of scalability (Küng et al., 2023; Golombek et al., 2023; Shu et al., 2023). Scalability as such is determined by the number of potential storage sites (Hill et al., 2013; Küng et al., 2023), available technologies for capturing and storing captured $CO_2$ (Markewitz & Bongartz, 2015; Dziejarski et al., 2023), possibilities for low-cost implementation of CCS (Kuckshinrichs & Vögele, 2015; Küng et al., 2023), ensuring that safety requirements are met (Goren et al., 2024), and provision of social acceptance (Schumann, 2015). Additionally, scalability in terms of the simultaneous implementation of multiple CCS projects does not fall within the current scope of the IPM-CCS and could potentially be considered for further development.

In summary, the initial version of the IPM-CCS has been expanded to include new perspectives on risk assessment, technological feasibility, and scalability, integrating these considerations into the existing phases of the model. As a result, the structure of the model remains unchanged, but its qualitative dimension has been enhanced, offering a more thorough understanding of the complexity of CCS implementation and the comprehensiveness of activities required for the successful delivery of these projects.

## 4. Discussion

The current IPM-CCS is adequate for individual initiatives, such as constructing and operating a *HiPACT* plant or carrying out a $CO_2$ EOR project in the "Rusanda" oil field, which are viewed as exemplars of operational excellence in the CCS domain (Okazaki et al., 2018). Stemming from this experience, the IPM-CCS could be applied to the construction of similar projects or the further modification of existing *HiPACT* or EOR plants, considering technical, geological, health, safety, and other enhancements to the initially implemented solution. Given the potential of the project implemented at the "Rusanda" oil field, especially in terms of technological and operational excellence and the capacities for capturing, transporting, and storing CO2 (Karas & Nesic, 2019; Fominykh, 2022), the IPM-CCS could influence a broad spectrum of CCS projects globally and serve as a roadmap for the successful implementation of such initiatives, irrespective of the industry, geographic location, and technological solutions employed. Furthermore, the IPM-CCS could transcend the scope of individual projects and contribute to the advancement of standards, policies, and regulations concerning environmental and safety considerations, social acceptance and awareness, economic benefits and monetization, as well as ongoing geo-technical assessment, which are represented

in the model as the critical dimensions that encompass an operational CCS plant (Fominykh, 2024).

The qualitative improvements made to the IPM-CCS through this research have not directly modified its structure but have highlighted the need for further refinement of the model, thereby elevating it to the level of a framework for managing CCS initiatives. Accordingly, the further refinement of the model should concentrate on creating step-by-step guidance for conducting CCS initiatives that includes developing detailed risk assessment tool, compiling a list of thorough acceptance criteria for each checkpoint, and establishing comprehensive post-project oversight. These enhancements will finalize the model and tailor it for large-scale implementation, thereby elevating CCS practices to new heights and promoting their broader adoption.

## 5. Conclusions

The IPM-CCS facilitates the successful implementation of CCS initiatives and, as such, can also be viewed as an instrumental tool for navigating the success of decarbonization efforts. The wider application of the IPM-CCS in the oil and gas industry and across various sectors will hinge on advancements in both CCS technology and the model itself, thus the authors recommend enhancing the model to facilitate large-scale implementation and applicability across industries. In the future, we can anticipate the evolution of integrated frameworks for CCS implementation that weave together project management, environmental, social, and governance (ESG) aspects, as well as carbon capture, transport, storage, and utilization considerations, thus enabling a comprehensive and high-performing approach to CCS initiatives.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ENTERPRISE DATA MANAGEMENT: DESIGN OF A CONCEPTUAL MODEL FOR EFFECTIVE DATA GOVERNANCE FRAMEWORK IN LARGE ORGANIZATIONS

*Chadwick Thompson Okoye*[1]

***Abstract***

*Managing large volumes of data is crucial for the success of large organizations in the digital age. This research proposal aims to evaluate the impact of data governance frameworks on data quality and strategic business outcomes. We want to identify the critical factors contributing to the successful implementation of data governance and understand stakeholder perceptions of its benefits, challenges, and barriers. To achieve this, our study will employ a quantitative approach. We will collect data through surveys targeting key stakeholders such as data managers, IT professionals, and business analysts. These surveys will gather insights into the use and impact of data governance frameworks, focusing on data quality, compliance, and strategic business outcomes. By analyzing this data, we aim to uncover meaningful trends and relationships that can inform better data management practices. Our findings will provide valuable insights for large organizations, helping them enhance their data management practices, ensure regulatory compliance, and achieve better business outcomes. By addressing the challenges and leveraging new technologies, this research aims to offer practical, actionable recommendations for improving data governance in today's complex data environment.*

***Key words****: Data Governance, Data Quality, Strategic Business Outcomes, Large Organizations, Stakeholder Perceptions, Enterprise Data Management, Data Security.*

## Introduction

In the current digital era, the production of data is exceptional, underscoring the critical role of Enterprise Data Management in organizational success. This comprehensive approach involves the effective management of data assets

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throughout their lifecycle in an organization, encompassing collection, storage, organization, integration, and distribution of data from diverse sources, including internal systems, external partners, and Internet of Things (IoT) devices.

Enterprise Data Management is crucial in converting unprocessed data into actionable insights that inform critical business decisions. Efficient data management enables organizations to streamline operations, stimulate innovation, and gain a competitive advantage. It offers valuable benefits such as heightened data accuracy, uniformity, and dependability, vital for informed decision-making and attaining strategic business goals (Frank et al., 2024).

Data governance is critical in Enterprise Data Management, as it entails establishing guidelines, protocols, and positions to guarantee accurate, consistent, and secure data management. Organizations utilize data governance frameworks to uphold data quality by outlining data standards, ownership, and stewardship responsibilities. They also ensure adherence to regulatory mandates, such as the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA), which enforce stringent data handling and protection guidelines (Silva and Soto, 2022).

Data governance is not just about managing data, but about fostering a culture of accountability and transparency within organizations. It ensures that data is not only accessible and reliable but also protected, mitigating the risks of data breaches and unauthorized access.

The evolving landscape of data management introduces new complexities and opportunities. Emerging technologies such as big data analytics, artificial intelligence (AI), machine learning, and blockchain are transforming how organizations handle and utilize data. These technologies enable organizations to quickly process large volumes of data and derive actionable insights, enhancing decision-making capabilities (Udeh et al., 2024).

It is important to remember that effectively using new technologies with our data can be a complex task. We need a plan that can adapt to new technologies and handle all the complicated parts of modern data, while also ensuring data integrity, safety, and compliance with regulations. In summary, this research underscores the importance of robust data management strategies for large companies, which leverage new technologies to improve data management, tackle the challenges, and capitalize on the opportunities presented by the evolving data landscape.

### 1.2 Motivation for the Study

Managing data in large organizations is crucial in today's digital era. Effectively dealing with data comes with unique challenges due to its sheer volume and the rapid evolution of new technologies like AI, machine learning, and blockchain. Large organizations need help creating robust data governance frameworks to ensure data quality, security, and regulatory compliance. With proper governance, organizations can prevent data breaches, inaccuracies, and legal issues, thus avoiding substantial fines and damage to customer trust.

Our research aims to tackle these challenges by creating a conceptual model tailored for large organizations, enabling them to handle their data more effectively.

The potential benefits of this model, such as improved data management and operational efficiency, make this research a valuable investment.

Identifying the key factors contributing to successful data governance is another crucial aspect of our research. We greatly value stakeholders' perspectives in this process, as their insights will play a pivotal role in shaping the course of this research. This is a collaborative effort, and your input is essential.

### 1.3 Importance of Data Governance in Maintaining Data Quality and Compliance

Effective data governance is crucial for improving data quality in large organizations. It involves establishing policies, procedures, and standards to manage data and ensure its accuracy, completeness, and consistency. This is essential for making informed decisions and improving operational efficiency. Effective data governance provides a structured framework for managing data as a strategic asset, leading to improved data quality. A systematic approach to data governance can ensure the development of clear policies and procedures to enhance data quality and compliance with regulatory requirements (Khatri & Brown, 2010). Implementing robust data governance practices benefits organizations dealing with large volumes of data by helping them manage the complexity and variety of big data, ensuring better data quality, and supporting effective decision-making (Malik, 2013). A detailed nine-step data governance framework helps organizations improve data quality by treating data as a strategic asset. This approach includes setting priorities, connecting teams, establishing policies, and implementing ongoing data quality monitoring (Huff & Lee, 2020). Data governance positively impacts enterprises' performance and compliance by clearly defining responsibilities and processes for data management, enhancing data quality and operational efficiency (Martijn et al., 2015). Understanding and addressing the data quality needs of data consumers, rather than solely relying on technical metrics, can significantly improve data quality and its usability within organizations (Wang & Strong, 1996). Effective data governance is essential for maintaining high data quality in large organizations. Establishing comprehensive policies, procedures, and frameworks can ensure data accuracy, completeness, and consistency, enhancing overall performance and decision-making capabilities.

Data governance is essential for organizations to comply with rules and regulations. It involves creating and enforcing policies for managing data. This is crucial for maintaining data accuracy, integrity, and security. It helps organizations avoid penalties and feel secure.

For example, data governance is crucial for meeting rules in the financial sector. Financial institutions must control data entry, test data for accuracy, and ensure data integrity. These practices are required by regulations like Sarbanes-Oxley (SOX) and Basel II, which aim to prevent fraud and financial misstatements (Burniston, 2015).

High-quality data is essential for following rules. Poor data can lead to fines and reputational damage. Effective data governance ensures that an organization's

data is accurate and reliable, essential for compliance with various regulations (Mahanti, 2022).

Implementing comprehensive data governance frameworks also helps organizations follow data privacy rules like the General Data Protection Regulation (GDPR). These frameworks typically include policies for data protection, risk management, and regular audits to ensure continuous compliance. These structured approaches help organizations manage data privacy effectively while meeting regulatory demands (Kabanov, 2016).

Integrating compliance activities with strategic governance practices can significantly improve business performance. Organizations that align compliance-related activities with their strategic goals can better manage risks and improve accountability. This integration creates a culture of compliance that meets regulatory requirements and strengthens overall business strategy, highlighting the potential for growth and success through effective data governance (Héroux & Roussy, 2020).

The evolving landscape of corporate governance underscores the increasing importance of compliance functions. Traditionally handled at the board level, compliance now involves structured frameworks imposed by regulatory bodies to ensure that firms adhere to legal, regulatory, and social norms. This shift underscores firms' need to adapt their behavior to these norms, ensuring robust corporate governance (Griffith, 2016).

In summary, data governance is essential for ensuring compliance with rules and regulations. It helps maintain high data quality, implement solid frameworks, and integrate compliance activities with business strategies. Effective data governance helps organizations avoid legal and financial repercussions and enhances their performance and **accountability.**

## 2 Methods

A quantitative methodology will be employed to achieve this research objective. This approach will involve collecting and analyzing numerical data to evaluate the impact of data governance frameworks on data quality and business outcomes in bigger organizations. Surveys will be distributed to data managers and IT professionals to collect stakeholders' perceptions of data governance's benefits, challenges, and barriers.

Statistical methods will be used to assess the relationship between data governance implementation and improvements in data quality. Additionally, factor analysis will help identify and prioritize the key elements contributing to successful frameworks. Using quantitative data, the study aims to provide objective insights and support the development of a tailored conceptual model for effective data governance in complex organizational environments. This methodology ensures the findings are grounded in real-world data, making them applicable and valuable for practitioners.

### 2.1 Data Collection Strategy

We plan to gather data for this research using a structured survey method. The survey will target key stakeholders in large organizations, such as data managers, IT professionals, and business analysts. We will ask questions about the use and impact of data governance frameworks, focusing on data quality, compliance, and strategic business outcomes.

We will distribute the survey online to reach a wide range of perspectives. It will consist of a mix of multiple-choice and open-ended questions to collect both quantitative and qualitative data. This will allow us to gather specific metrics and allow participants to share their experiences and insights in their own words.

To ensure a high response rate, we will send reminders and offer a summary of the research findings as an incentive. Once collected, the data will be analyzed using statistical methods to identify trends and critical factors contributing to successful data governance. This approach will provide a solid basis for understanding how data governance impacts large organizations.

### 2.2 Statistical Analysis

We will start by analyzing the data collected on data governance frameworks in large organizations. We will calculate critical metrics such as means, medians, and standard deviations for data quality, compliance rates, and strategic business outcomes to summarize the data and reveal trends and patterns. Additionally, we will use frequency distributions and percentages to understand the prevalence of certain data governance practices and their perceived effectiveness.

In our regression analysis, we will use multiple regression models to examine the relationship between the implementation of data governance frameworks (independent variable) and outcomes like data quality and compliance (dependent variables). This will help us identify the strength and direction of these relationships. We will also incorporate control variables such as organization size and industry type to ensure robust results and account for potential confounding factors. The regression coefficients and R-squared values will be reported to show the model's explanatory power.

Using this combined approach, we aim to assess the impact of data governance on organizational performance. We expect to gain practical insights into which practices contribute most to data quality and compliance, ultimately enhancing our understanding of data governance and providing actionable insights to improve organizational performance.

## 3. Discussion

The research we have proposed aims to explore the impact and effectiveness of data governance frameworks in large organizations. Our goal is to understand how these frameworks can improve data quality and support better business outcomes. By surveying data managers, IT professionals, and other stakeholders, we

plan to gather insights into the current state of data governance practices and their perceived benefits, challenges, and barriers.

Our approach involves using quantitative methods to analyze the data we collect. This includes statistical analysis and factor analysis to identify key elements that contribute to successful data governance. By examining the relationships between data governance practices, data quality, and business performance, we hope to uncover practical insights that organizations can use to enhance their data management efforts.

Evaluate the Impact of Data Governance: We will analyze how the implementation of data governance frameworks affects data quality and strategic business outcomes. This involves collecting data through surveys and using statistical methods to assess these relationships.

Identify Key Success Factors: Through questionnaires and factor analysis, we aim to pinpoint the critical factors that contribute to the successful implementation of data governance frameworks. This will help organizations prioritize their efforts and resources to achieve better results.

Understand Stakeholder Perceptions: By gathering and analyzing stakeholders' views on the benefits, challenges, and barriers of data governance, we can develop strategies to address common concerns and create a supportive environment for effective data management.

Throughout our research, we will ensure ethical standards by obtaining informed consent from participants, maintaining their privacy and confidentiality, and being transparent about our research objectives and methods. This approach will help us build trust with participants and ensure the reliability of our findings.

## 4. Conclusions

In today's digital era, large organizations must implement effective data governance to manage vast amounts of data efficiently and securely. Our proposed research aims to explore the impact of data governance frameworks on data quality and strategic business outcomes to provide valuable insights that can enhance data management practices in complex organizational environments.

In conclusion, our research strives to offer a comprehensive understanding of how data governance frameworks affect large organizations. By examining the relationship between data governance and quality, identifying critical success factors, and understanding stakeholder perceptions, we aim to provide insights that can significantly improve data management practices.

The results of this research will be based on real-world data and will have direct applicability to practitioners in the field. By addressing the challenges and leveraging the benefits of data governance, organizations can enhance their data quality, maintain compliance with regulations, and achieve better strategic business outcomes. Ultimately, this research will contribute to the development of more effective and efficient data governance frameworks that cater to the complex needs of today's data-driven world.

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# IN THE FACE OF NEW GLOBAL BUSINESS CHALLENGES WITH STRONG RESPONSIBILITY OF THE INDIVIDUAL TOWARDS WORK

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***Abstract***

*Regardless of the fact that new global challenges bring many new ways to improve the company's business with the dizzying progress of new technologies, human resources will continue to be the most valuable resources in the future that enable the company to correctly and successfully respond to the demands of new challenges. Employee responsibility is a trait that is difficult to examine and measure, and the impact of human resource management on employee responsibility has not yet been sufficiently explored. Only responsible employees will be able to successfully overcome the new business challenges that the future brings. In order to examine the role of human resources management in defining the responsibilities of employees, a survey of employees in the public sector was conducted. The results of the research confirmed the research hypothesis - that the influence of human resources management on defining the responsibilities of employees is significant, and therefore the impact of the contribution of human resources management to corporate performance by influencing the responsible behavior of employees is significant.*

***Key words:*** *human resources management, responsibility, company, employees.*

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# 1. Introduction

In the present scenario of extreme globalization and rat race, success of the organization comes from reaching out to its people's potential talent and fostering a place for accountability and creativity. The key lies in creating an environment where employees feel empowered to take initiative, make decisions and take responsibility for their actions (Gratton, 2011). In the era of knowledge and innovation, organizations that want to remain competitive must constantly learn, adapt and develop, with human resources and their accountability being key success factors (Senge, 2014). In this regard, human capital, which consists of not only skills but also attitudes and cognitive skills of employees, is of great importance. Because people contain knowledge to an organization, it is essential to comprehend the factors that determine the users' attitude, behavior, performance so as to increase the level of responsibility, potency and effectiveness of business systems.

Among the major elements of human resources development, the area of focus is the determination and encouragement of employee responsibility. Ethical responsibility is exhibited in high ethical standards and a well-developed personal value system. This often stems from an inner urge to serve and promote the common good and is not only limited to the work place but cuts across every area of life. In a responsible organization, employees are encouraged to be responsible and human resource management is critical in achieving that. Employees generally want to associate with a business that is engaged in 'responsible business' particularly if the employee's values resonate with the company's core. Reckless and fraudulent conduct of employees, in any organization, is likely to have serious repercussions on the business, such as severe costs, loss of credibility, and expensive lawsuits.

On the contrary, employees' behaviors marked by high ethical standards, sense of fairness and sense of caring for others help in the development of good organizational culture. One of the sure methods of achieving ethical culture within the work environment is ensuring that there are policies practiced within the organization. The purpose of this paper is to help managers who wish to implement a culture of ethical behavior at the organization, that is beneficial not only to the organization but to the society as well.

# 2. Research methodology

### The aim and task of the work

The main goal of the research that will be presented in this paper was to determine whether human resources management develops awareness and takes measures to raise the level of responsibility of employees in public companies in Serbia.

### Research hypothesis

The hypothesis H0 Human resource management has a significant role in defining the responsibilities of employees in public enterprises in Serbia was put forward in the framework of this work.

**Research instrument**

For the purpose of conducting empirical research, a survey method was applied to a representative sample of respondents. The research instrument, in the form of a questionnaire, was constructed in accordance with the set objectives of the research and the defined hypothesis of the work. The structure of the questionnaire consisted of closed-ended questions, where respondents were able to select one of the offered alternative answers that most adequately reflects their individual attitude and opinion on the issue under consideration. Each statement had five response modalities: Disagree, Partially Disagree, Not Sure, Don't Know, Partially Agree, and Agree. This approach to the design of the research instrument enabled the systematic collection of quantitative data relevant to the testing of the set hypothesis and the realization of the research objectives.

**Sample research**

153 respondents participated in the research, of which 80 were female and 73 male. Analyzing the age structure of the respondents, it was observed that the largest number of respondents were in the age group of 36 to 45 years (55 respondents or 35.95%). Next in terms of representation is the age group from 46 to 55 years old (54 respondents or 35.29%), followed by the group from 26 to 35 years old (33 respondents). Age groups up to 25 years (6 respondents or 3.92%) and over 56 years (5 respondents or 3.27%) were less represented. By analyzing the educational structure of the respondents, it was determined that the largest number of respondents had completed the VSC (92 respondents or 60.13%). This representation was significantly higher compared to other levels of education: higher education (18; 11.76%; p=.000) and master's (28; 18.30%; p=.000) and doctorate (15; 9.80%; p=. 000). Regarding the type of education, the highest representation was among respondents with technical-technological education (67 respondents or 43.79%). This representation was significantly higher in relation to other types of education: social and humanistic professions (46; 30.07%; p=.013), natural and mathematical professions (20; 13.07%; p=.000) and other types of education (20 ; 13.07%; p=.000).

## 3. Results and discussion

*Hypothesis H0, which states that human resources management has a significant role in defining the responsibilities of employees in public companies in Serbia, will be examined in this chapter. In the same chapter, the numerical (n) and percentage (%) representation of respondents' attitudes towards corporate responsibility (CO) towards the wider social community within the company will be presented.*

*Table 1. Representation of the views "Human resource management attaches great importance to establishing and preserving the ethical values of the company"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 16 | 13 | 36 | 38 | 50 |
| % | 10.46 | 8.50 | 23.53 | 24.84 | 32.68 |

Based on the analysis of the data from Table 1, it can be concluded that for the attitude "Human resource management attaches great importance to establishing and preserving the ethical values of the company", the most dominant answer is "I agree", which has 50 respondents, i.e. 32.68%. Its frequency is higher compared to the attitude "Partially agree" (38 respondents, 24.84%, p = .131), significantly higher than the attitude "I'm not sure, I don't know" (36 respondents, 23.53%, p = .076), and significantly higher than the frequency of the attitude "I do not agree" (16 respondents, 10.46%, p = .000) and the attitude "Partially disagree" (13 respondents, 8.50%, p = .000).

The frequency of the response "I partially agree", present in 38 respondents or 24.84%, is significantly higher than the frequency of the attitude "I am not sure, I do not know" (36 respondents, 23.53%, p = .076), as well as significantly higher in relation to the position "I do not agree" (16 respondents, 10.46%, p = .000) and the position "Partially disagree" (13 respondents, 8.50%, p = .000).

Furthermore, the analysis shows that the attitude "I agree" clearly prevails compared to the other options, which indicates a high level of agreement among respondents that the management of human resources in companies attaches importance to ethical values. Differences in the frequency of attitudes further confirm the significant perception of the role of management in preserving ethical standards, while relatively lower rates of disagreement and indecision emphasize the consensus among respondents.

These results indicate that human resource management plays a key role not only in setting, but also in maintaining ethical norms within organizations, which can significantly influence corporate culture and general business practices. Observed differences among respondents' attitudes additionally underline the importance of strategies used by HR management in promoting ethical values in the business environment.

*Table 2. Representation of the views "Human resource management encourages individual responsibility of employees through the development of the internal locus of control, i.e. believe that what will happen depends on their actions"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 31 | 12 | 24 | 26 | 60 |
| % | 20.26 | 7.84 | 15.69 | 16.99 | 39.22 |

Based on the analysis of the data from Table 2, it can be concluded that for the attitude "Human resource management encourages individual responsibility of employees through the development of the internal locus of control, i.e. the belief that outcomes are the result of their actions", the most common answer is "I agree",

with 60 respondents or 39, 22%. Its frequency is significantly higher than the frequency of the attitude "I do not agree" (31 respondents, 20.26%, p = .000), significantly higher than the attitude "Partially agree" (26 respondents, 16.99%, p = .000 ), as well as significantly higher than the frequency of the attitude "I'm not sure, I don't know" (24 respondents, 15.69%, p = .000) and the attitude "Partially disagree" (12 respondents, 7.84%, p = .000). The frequency of the attitude "I do not agree", with 31 respondents or 20.26%, is significantly higher than the frequency of the attitude "Partially agree" (26 respondents, 16.99%, p = .000), significantly higher than the attitude "I am not sure /na, I don't know" (24 respondents, 15.69%, p = .000), as well as significantly higher than the frequency of the attitude "I partially disagree" (12 respondents, 7.84%, p = .000).

*Table 3. Representation of the views "The strength and content of the culture in the organization affects the ethical behavior of employees"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 42 | 23 | 10 | 40 | 38 |
| % | 27.45 | 15.03 | 6.54 | 26.14 | 24.84 |

Based on the analysis of the data from Table 3, it can be concluded that for the position "The strength and content of the organizational culture affects the ethical behavior of employees", the most dominant answer is "I do not agree", with 42 respondents or 27.45%. The frequency of this attitude is higher than the representation of the attitude "Partially agree" (40 respondents, 26.14%, p = .796) and the attitude "I agree" (38 respondents, 24.84%, p = .603), and it has significantly higher frequency compared to the attitude "I partially disagree" (23 respondents, 15.03%, p = .008) and the attitude "I'm not sure, I don't know" (10 respondents, 6.54%, p = . 000).

*Table 4. Representation of the views "Human resource management encourages responsible behavior of employees towards their colleagues"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 18 | 10 | 19 | 48 | 58 |
| % | 11.76 | 6.54 | 12.42 | 31.37 | 37.91 |

Based on the analysis of the data from Table 4, it can be concluded that for the position "Human resource management encourages responsible behavior of employees towards their colleagues", the most common answer is "I agree", with 58 respondents or 37.91%. Its frequency is higher than the frequency of the attitude "Partially agree" (48 respondents, 31.37%, p = .231), significantly higher than the frequency of the attitude "I'm not sure, I don't know" (19 respondents, 12.42%, p = .000), as well as significantly higher than the frequency of the attitude "I do not agree" (18 respondents, 11.76%, p = .000) and the attitude "Partially disagree" (10 respondents, 6.54%, p = .000). The representation of the attitude "I partially agree", which has 48 respondents or 31.37%, is significantly higher than the frequency of the attitude "I'm not sure, I don't know" (19 respondents, 12.42%, p = .000),

significantly higher than the attitude "I do not agree" (18 respondents, 11.76%, p = .000), as well as significantly higher than the frequency of the attitude "Partially disagree" (10 respondents, 6.54%, p = .000).

*Table 5. Representation of the views "Human resource management encourages employees to build responsible, honest and long-term relationships with customers/users"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 39 | 21 | 20 | 34 | 39 |
| % | 25.49 | 13.73 | 13.07 | 22.22 | 25.49 |

Based on the analysis of the data from Table 5, it can be concluded that for the attitude "Human resource management encourages employees to build responsible, honest and long-term relationships with customers/users" the most dominant answer is "I don't agree", with 39 respondents or 25.49%. Its representation is equal to the position "I agree" (39 respondents, 25.49%, p = 1.000) and the position "Partially agree" (34 respondents, 22.22%, p = .503), while it is significantly higher in compared to the attitude "I partially disagree" (21 respondents, 13.73%, p = .010) and the attitude "I'm not sure, I don't know" (20 respondents, 13.07%, p = .006).

*Table 6. Representation of the views "Human resources management encourages the undertaking of activities among employees that are morally aligned with the morals of the social community"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 40 | 24 | 22 | 35 | 32 |
| % | 26.14 | 15.69 | 14.38 | 22.88 | 20.92 |

Based on the analysis of the data from Table 6, it can be concluded that for the position "Human resources management encourages the undertaking of activities among employees that are morally aligned with the morals of the social community" the most common answer is "I do not agree", with 40 respondents or 26, 14%. Its representation is higher than the representation of the position "Partially agree" (35 respondents, 22.88%, p = .507) and the position "I agree" (32 respondents, 20.92%, p = .282), and significantly higher from the frequency of the attitude "I partially disagree" (24 respondents, 15.69%, p = .025) and the attitude "I'm not sure, I don't know" (22 respondents, 14.38%, p = .011).

*Table 7. Representation of the views "Human resources management encourages employees to be self-efficacious in their work, to make independent decisions regarding their work and to take responsibility for the consequences of their decisions"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 34 | 16 | 14 | 62 | 27 |
| % | 22.22 | 10.46 | 9.15 | 40.52 | 17.65 |

Based on the analysis of the data from Table 7, it can be concluded that the position "Human resource management encourages employees to be self-efficacious in their work, make independent decisions regarding their work and take responsibility for the consequences of their decisions" is the most prevalent. The largest number of respondents, 62 of them (40.52%), express the position Partially agree, whose representation is significantly higher than the position I do not agree (34; 22.22%; p=.001). Also, this attitude has a significantly higher frequency than the attitude I agree (27; 17.65%; p=.000), as well as the attitude Partially disagree (16; 10.46%; p=.000), and the attitude I'm not sure/ na, I don't know (14; 9.15%; p=.000).

*Table 8. Representation of the views "Human resource management sets an example of responsibility for all employees"*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 25 | 14 | 15 | 39 | 60 |
| % | 16.34 | 9.15 | 9.80 | 25.49 | 39.22 |

Based on the analysis of the data from Table 8, it can be concluded that the attitude "Human resource management sets an example of responsibility to all employees" is most represented in the form I agree, which was expressed by 60 respondents, i.e. 39.22%. This frequency is significantly higher than the frequency of the attitude Partially agree (39; 25.49%; p=.011), as well as the attitude I do not agree (25; 16.34%; p=.000), the attitude I'm not sure, I don't know (15; 9.80%; p=.000) and the attitude Partially disagree (14; 9.15%; p=.000). The frequency of the attitude Partially agree, expressed by 39 respondents, i.e. 25.49%, is also significantly higher than the frequency of the attitude I do not agree (25; 16.34%; p=.000), the attitude I'm not sure, I don't know (15; 9.80) %; p=.000) and the attitude Partially disagree (14; 9.15%; p=.000).

*Table 9. Representation of the views "Human resource management encourages decision-making among employees based on moral qualities."*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 46 | 23 | 27 | 27 | 30 |
| % | 30.07 | 15.03 | 17.65 | 17.65 | 19.61 |

Based on the analysis of the data from Table 9, it can be concluded that for the attitude "Human resources management encourages decision-making among employees based on moral qualities" the most common answer is "I do not agree", with 46 respondents, i.e. 30.07%. Its representation is significantly higher than the representation of the attitude "I agree" (30 respondents, 19.61%, p = .035), and it also has a significantly higher frequency compared to the attitude "I'm not sure, I don't know" (27 respondents, 17.65%, p = .011), with the attitude "Partially agree" (27 respondents, 17.65%, p = .011), as well as with the attitude "Partially disagree" (23 respondents, 15.03 %, p = .002).

*Table 10. Representation of the views "Employees are not evaluated solely according to the results achieved, but also according to the methods by which those results were achieved."*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 46 | 23 | 15 | 35 | 34 |
| % | 30.07 | 15.03 | 9.80 | 22.88 | 22.22 |

Based on the analysis of the data from Table 10, it can be concluded that for the position "Employees are not evaluated solely according to the results of their work, but also according to the methods by which those results were achieved" the most common answer is "I do not agree", with 46 respondents, i.e. 30 .07%. This attitude is more prevalent compared to the attitude "Partially agree" (35 respondents, 22.88%, p = .155) and the attitude "I agree" (34 respondents, 22.22%, p = .120), and has significantly higher frequency compared to the attitude "I partially disagree" (23 respondents, 15.03%, p = .002) and the attitude "I'm not sure, I don't know" (15 respondents, 9.80%, p = . 000).

*Table 11. Representation of the views "Human resource managers are aware of the importance of organizational commitment".*

| | I don't agree | I partially disagree | I'm not sure, I don't know | I partially agree | I agree |
|---|---|---|---|---|---|
| n | 28 | 25 | 17 | 61 | 22 |
| % | 18.30 | 16.34 | 11.11 | 39.87 | 14.38 |

Based on the analysis of the data from Table 11, it can be concluded that for the position "Human resource managers are aware of the importance of organizational commitment" the most common answer is "Partially agree", with 61 respondents, i.e. 39.87%. Its representation is significantly higher than the attitude "I do not agree" (28 respondents, 18.30%, p = .000), and also significantly higher compared to the attitude "Partially disagree" (25 respondents, 16.34%, p = .000), with the attitude "I agree" (22 respondents, 14.38%, p = .000), as well as with the attitude "I'm not sure, I don't know" (17 respondents, 11.11%, p = .000) (Šikoparija, 2023).

## 4. Conclusions

In every workplace, the accountability or responsible business ethics might not always be available, however, it becomes very important while dealing with the customers by providing quality service and meeting the compliance system and avoiding unnecessary paying of large fines and lawsuits. Responsible and ethical culture in the company should be initiated from the management of the organization and should include defining the pressure for compliance with the ethical standards which may be beneficial to bottom-line performance, brand protection of the company and increased employee, users and customers satisfaction. In the course of a business operation, a sense of responsibility cuts across all employees, be it business personnel, team leader or a supervisor. Fair and responsible practices

should be observed by the workers in their interactions among themselves as well as with their clientele.

Practicing a good ethical behavior is a morale boost to the management of the company and good social relationships with customers. Employees can also be very loyal to an employer especially a trustworthy employer whom the employees will do their utmost to work for the good of the employer. People are eager to engage in their life's work where everybody is treated and customers are treated properly, and companies are engaged in good and responsible business. Peter Drucker, the father of modern management, points out: "Efficiency is doing things the right way; effectiveness is doing the right things" (Drucker, 2006). This idea points out the significance of formulating a proper strategy in human resource administration, since there is a concern not only on the efficiency of the said function but also the results obtained from the proper actions of the employees. This hypothesis was confirmed by the external results of the study - management of human resources does play an important part in the distribution of roles among employees of public companies of the country of Serbia. The findings of the study provide a platform for a heightened appreciation and a more active shift towards the human resource supply in the public. Please take this course of action in relation to each employee so that every worker assists towards the realization of the objectives of the organization and the betterment of society as a whole. We believe that the findings and shortcomings of this research provide an adequate framework for human resources management improvement together with employees' accountability enhancement. In such instances, a number of specific areas or processes of implementation have been specified or defined that may be addressed in order to be able to achieve the intended objectives in this case. First, redefining the selection and recruitment process is a fundamental starting point.

The application of advanced selection tools that precisely determine the necessary dimensions of candidates, particularly focusing on ethics and a predisposition to responsibility, can be very effective in promoting the development of responsible organizational culture. The motivational focus may also be taken by the introduction of an incentive scheme that is new, focuses on the results and quality of work performed. It has been established that while measurement of job performance outcomes includes quantitative aspects, other aspects such as ethics and the participation in organizational culture are also rewarding performance. Employees in the organization can also be empowered through appropriate training courses that would enhances freedom and responsibility. As Michael Porter emphasizes: "Innovation is a central outgrowth of competitive advantage" (Porter, 1990). For this reason, implementing programs that enable employees to use discretion and decide how to do their work within the scopes of their responsibilities can foster creativity and ownership. Such workshops, coaching and mentoring can foster the development of an internal locus of control in an individual, thereby encouraging an individual sense of responsibility. This is in line with the opinion of Daniel Pinka who claims: "Control leads to compliance; autonomy leads to engagement" (Pink, 2009). Devising ways to foster such ethics as volunteer programs and community projects helps bring the organization closer to wider

society. Aligning performance with social welfare objectives means that any organizational policy or operational guideline has to be consistent with ethical principles and societal expectations. This is vital in relation to the public management sector since citizens' trust is paramount. Last, but not least, creating an atmosphere that promotes self-efficacy and responsibility, where taking the initiative and with it the responsibility for decisions taken is encouraged can help organizations develop significantly. Dave Ulrich, one of the world's leading human resources experts, emphasizes: "Human capital is becoming a key differentiator of organizational success. Organizations that effectively develop, engage and retain talent will outperform those that do not" (Ulrich, 2017). This belief further affirms that management of the employees and their trust is not only a moral duty of organizations in the public sector but a strategy for survival and growth of the entities in the long term. The practical relevance of this investigation is pertinent to the possibility for human resources managers to change their strategies depending on their performance in creating adequate constructs in order to fortify the central factors that describe the roles of employees. This entails an ongoing assessment of what actions have been executed and to what effects, and the willingness to modify plans as per the requirements of the organization and society. John Kotter, an expert on leadership and change, points out: "Organizational culture can eat strategy for breakfast" (Kotter, 2011). With this analogy, it is worth emphasizing the pressing need to create and strengthen an organizational culture that promotes proper behavior as even well formulated strategies can go to waste in the absence of appropriate culture. Further tendencies of investigations can be aimed at more precise differentiation of employees' attitude according to their demographic characteristics and broadening their training and development programs. In addition, these measures can be incorporated over an extended period in order to examine the effects of measures taken and the dynamics of organizational performance and accountability of employees. Gary Hamel, a leading expert on innovation management, notes, "The most important thing managers must do is to eliminate the barriers that stand in the way of natural human initiative, imagination, and passion" (Hamel, 2007). This stresses the need of establishing workplace conditions favorable to employee's proactivity and accountability.

It can be concluded that this research has shown that there has to be sustained and strategic resource commitment towards the management of human capital as well as the enhancement of personnel accountability in the government institutions in Serbia. Application of the suggested reforms can make a considerable difference not only towards achieving specific organizational goals, but also towards enhancing efficiency and effectiveness of the overall public sector, which ultimately benefits citizen welfare and societal development. Finally, the words of Peter Senge, creator of the "learning organization" concept, provide an inspiring perspective for the future: "The organizations that will really thrive in the future will be those that discover how to harness people's commitment and capacity for learning at all levels of the organization" (Senge, 1990). This vision emphasizes that the path to a responsible and efficient public sector is inseparable from continuous learning, development and empowerment of employees.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE AHP APPROACH IN SELECTING CANDIDATES FOR THE POSITION OF STRATEGIC PLANNING MANAGER

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***Abstract***
Over the last few decades, strategic planning has been associated to organisation performance. This means that each organization needs ''right'' person (or persons) on the position of strategic planning manager. Therefore, one of the tasks of Human Resource Management (HRM) is to select this ''right'' candidate according to some criteria. The main idea of this study is to present the usefulness of multicriteria decision-making methods (MCDM) for selecting the most appropriate candidate for the position of Strategic Planning Manager. The applied method is the Analytical Hierarchy Process (AHP), as one of the most popular MCDM methods. The results show that this quantitative method can assist managers to effectively evaluate candidate's overall suitability for the mentioned position.

***Key words:*** *AHP, HR, decision support systems*, selection process

## 1. Introduction

Over the last few decades, the application of information and communications technologies (ICT) and decision-making techniques have influenced the problem of personnel selection (PPS) become an attractive area of research. The task of human resource management (HRM) is to select the candidates who best-match the needs of the organizational strategy by contemporaneously considering multiple and interdependent evaluation criteria (Wanous; Boerlijst and Meijboom, cited in Chang et all, 2013). Thus, to make more objective decisions, HRM has to consider the applicant`s characteristics, interests, potential impacts, and results. Seen as a multicriteria decision-making (MCDM) problem, the PPS can be solved faster and more efficiently. MCDM implies quantitative methods and techniques that minimize subjective judgment in the process of distinguishing

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between an appropriate and inappropriate candidate and give a hierarchical structure for selecting and evaluating the right candidate (Gholec & Kahya, cited in Shahhisseini & Sebt, 2011). The Analytic hierarchy process (AHP) is one of the most popular MCDM methods, for its simplicity of the application. As such, it fits for organizing and analyzing complex decisions based on math and psychology (Duan et al., cited in Salehzadeh & Ziaeian, 2024).

The literature abounds with different examples of AHP application in HRM, but not for the position of strategic planning manager. By applying the AHP method, the main idea of this paper is to present an effective and efficient way of selecting candidate for the position of strategic planning manager.

### 1.1 Literature Review

PPS is a complex task that includes, at one side, the results of job analysis, and, at the other side, the analysis of personal and other characteristics of each candidate, making the base of parameters for finding the most appropriate candidate for needed job position. Dating from the end of the 19th century, when Hugo Münsterberg applied ability testing in selecting candidates for the job of electric train motormen (Khoranni & Ehsani, 2015); it has been developed rapidly over the last three decades, when the accelerated development of MCDM methods and artificial intelligence have enabled a wide range of application of these methods in many different sectors: health-care (Gajić-Stevanović & all, 2008), constructing projects (Shahhisseini & Sebt, 2011), tourism (Filipović, 2007; Gardašević-Filipović, 2012), banking (Kenger & Organ, 2017), marketing (Sadeghpour et all, 2017), information systems (Samanlioglu et all, 2018; Luo & Xing, 2019; Mishra et all, 2020; Karabasevic et all, 2018), production (Ulutaş et all, 2018), bussiness (Hanefi & Agarwal, 2021), in a ready to wear sector of textile industry (Danişan et all, 2022).

A sufficient number of organizations still use the approach to this problem that assumes a rational framework, where the objective qualifications of individuals are corresponded to the job requirements. This approach considers that a high-quality candidate is one who fits to organizational culture, values, etc. (Judge & Ferris, 2002). Therefore, the decision maker (DM) should select the best-match candidates who fulfill the needs of the organizational strategy by considering multiple and interdependent evaluation criteria (Chang et all, 2013). In this complex process, MCDM methods can contribute and facilitate the decision-making process using interdependent criteria.

Recently, a nice review paper regarding the application of decision-making methods in HRM occured (Salehzadeh & Ziaeian, 2024). This paper includes the list of relevant articles that consider the application of decision-making methods (AHP, ANP, FAHP, Electre-AHP, TOPSIS, fuzzy neural networks, linear programming, SAW). Khorami's and Ehsani's (2015) earlier review of the application of MCDM methods used in selecting candidates besides the mentioned, has analysed the PROMETHEE and the fuzzy MULTIMOORA method. The application of the CoCoSo method in this area is given in (Popović, 2021). Hanefi and Agarval presented in their paper the AHP application to the selection of a marketing manager among ten employees working in the marketing department of the observed organization

(Hanefi & Agarval, 2021),. On the other hand, Shahhosseini and Sebt used the AHP for a competency-based selection of the most appropriate candidate in relation to customer satisfaction, performance value and number of projects (Shahhosseini & Sebt, 2021). Personal qualities of managers (HR manager (Danişan et all, 2022), health-care manager (Gajić-Stevanović et all, 2015), manager in bussiness (Hanefi & Agarval, 2021) and controller (Petrlić, 2021)) are considered in several papers.

As seen in existing literature, the problem of selection candidates demands development of decision-making criteria, based on job analysis and competency criteria. The competency hierarchies are mostly made for employees, not including the position of strategic planning manager.

### 1.2 Method

The study aims to apply the AHP method in the PPS for the position of strategic planning manager. In that context, the first phase was to define the objective and criteria. This included an investigation of the available literature, and the analysis of the selecting criteria for similar positions. The second phase involved consulting four HR experts and strategic planning managers, who wanted to remain anonymous, about the needed criteria. As a result, the criteria and sub-criteria for the desired position are created.

The AHP method, developed by T. L. Saaty (Saaty, 1980), proposes the most acceptable solution from a set of defined criteria and attribute values for each alternative. It decomposes complex problem into levels, creating unidirectional hierarchy structure that shows the relationships between the objective, criteria, sub-criteria, and alternatives. This method is implemented in several steps: defining objective; structuring elements in criteria, sub-criteria and alternatives in one direction hierarchy; making a pair wise comparisons of the elements in each group; calculating weightings and consistency ratio; evaluating alternatives according weighting for each observed criterion and ranking. The final order of alternatives in the model is determined and the most suitable option is selected according to the chosen criteria. The consistency of the pairwise comparison matrix is measured with consistency ratio (CR) index, according the formula $CR=CI/RI$, where CI is the consistency index $CI=(\lambda_max-n)/(n-1)$, with $n$ (the order of the observed matrix) and $\lambda_max$ (the maximal characteristic root of the observed matrix); and RI is random consistency index (see, for example, Haznadarević et all (2020)). If $CR < 0.1$, the pair wise comparison matrix is logically consistent. Otherwise, it is necessary to review pair wise comparisons and find the reasons for high inconsistency in the assessment (Shikdar et all, 2011, cited in Haznadarević et all, 2020). After that, the above calculations should be made again. Final step includes the selection of the alternative with the highest value. Saaty, Gardašević-Filipović, Haznadarević et al and Siekelova et al have presented in their papers a detailed explanation of the method (Saaty, 1980; Gardašević-Filipović, 2012, Haznadarević et al, 2020; Siekelova et all, 2021).

## 2. Results

Strategic planning manager is a middle management position. To apply the AHP, the following goal is defined: to select one person to the position of strategic planning manager.

The first phase of application of the AHP method included setting a goal and defining criteria. At this phase, the authors consulted literature and came up with proposals, and then, in a brainstorming session, together with HR professionals and strategic planning managers, defined criteria and sub-criteria. At the end of the process, three criteria (organizational, personal and communicational skills) and related sub-criteria were defined, according to importance (see Figure 1). Then, the proposed selection model was applied on the sample of three fictional candidates (A1–A3).

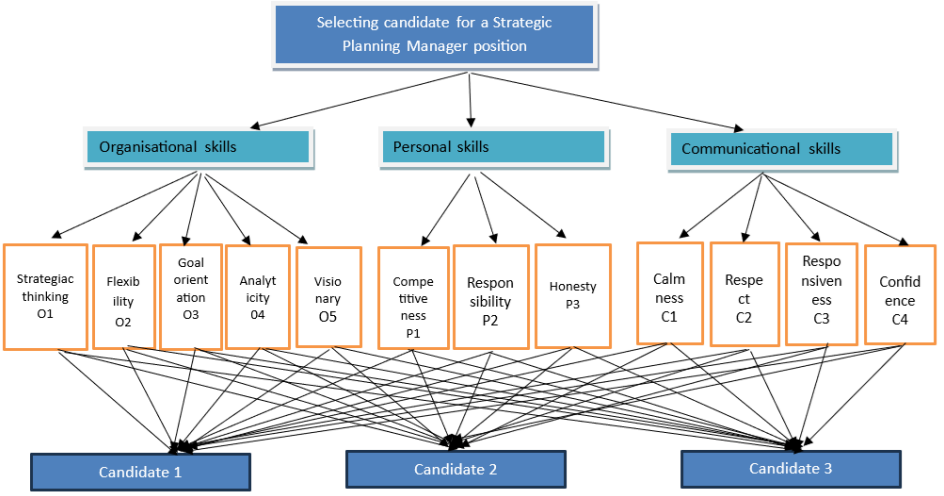


*Figure 1: Categorization of criteria and sub-criteria for the AHP application*

*Source: Authors*

The alternatives are evaluated according the proposed sub-criteria by the HR team, in scale 1-5, where 5 is the best matching, and 1 is the worst (see Table 1).

*Table 1: The alternatives*

| Candidate | O1 | O2 | O3 | O4 | O5 | P1 | P2 | P3 | C1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1** | 4 | 5 | 3 | 4 | 4 | 5 | 5 | 5 | 3 | 5 | 4 | 4 |
| **A2** | 5 | 5 | 5 | 5 | 5 | 4 | 2 | 3 | 4 | 5 | 3 | 4 |
| **A3** | 4 | 2 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 3 | 4 | 4 |

### 2.1 Calculating the weights of criteria and consistency ratio

The next phase involved pair wise comparisons of elements in each group. The expert team, defined above, is asked to compare each pair of criteria and sub-

criteria, and to asign the coresponding evaluation based on Saaty's scale. Thus, a comparison matrices for criteria and sub-criteria are created. The normalized eigenvector is calculated as well as the maximal eigenvalue. These are required values for the verification of the subjectivity of decision making, and calculation of consistency.

The consistency is checked for each comparison matrix (see Table 2). For this purpose, the column sums are calculated and the matrix is normalized. Then, based on these comparison matrices, the weights of criteria are calculated (see the third column of Table 2). Then, to gain weight, the average of each row is calculated, for each matrix. CIs were less than 0.1 (see Table 2); therefore, the relative importance criteria were considered acceptable.

*Table 2. CI and CR values of the relative importance matrix for each sub-criterion*

| Criterion | | w | CI | CR | CR<0.1 |
|---|---|---|---|---|---|
| **Strategic thinking** | O1 | 0,2449 | 0.02 | 0,04 | YES |
| **Flexibility** | O2 | 0,0220 | 0.01 | 0.02 | YES |
| **Goal orientation** | O3 | 0,1933 | 0.02 | 0.04 | YES |
| **Analycitcy** | O4 | 0,0564 | 0.02 | 0.04 | YES |
| **Visionary** | O5 | 0,0204 | 0.02 | 0.04 | YES |
| **Competitiveness** | P1 | 0,1085 | 0.04 | 0.07 | YES |
| **Responsibility** | P2 | 0,1286 | 0.02 | 0.03 | YES |
| **Honesty** | P3 | 0,0308 | 0.05 | 0.08 | YES |
| **Calmness** | C1 | 0,0185 | 0.04 | 0.07 | YES |
| **Respect** | C2 | 0,1071 | 0.05 | 0.08 | YES |
| **Responsiveness** | *C3* | 0,0090 | 0.03 | 0.06 | YES |
| **Confidence** | *C4* | 0,0605 | 0.01 | 0.02 | YES |

### 2.2 Evaluating candidates

At this stage, HR experts evaluated each candidate according to the defined criteria, using a five-point numerical scale. Each candidate is evaluated according to the degree of possession of the corresponding characteristic defined as a sub-criterion (see Table 3).

## 3. Discussion

This phase included evaluation of the alternatives according weightning. By calculating the relative weights concerning each criterion, an optimal alternative is selected. The calculated weight vector of criterion *w* (see Table 3, column *w*) indicates that the criterion "organisational skills" (O1) has the greatest significance (0.2449) compared to other criteria. In addition to the above, the criterion "responsiveness" (C3) with a specific weight of 0.009 has the lowest impact to the selection.

*Table 3. Optimal alternative selection*

| | w | A1 | w×A1 | A2 | w×A2 | A3 | w×A3 |
|---|---|---|---|---|---|---|---|
| **O1** | 0,2449 | 4 | 0,9795 | 5 | 1,2244 | 4 | 0,9795 |
| **O2** | 0,0220 | 5 | 0,1101 | 5 | 0,1101 | 2 | 0,0440 |
| **O3** | 0,1933 | 3 | 0,5800 | 5 | 0,9666 | 3 | 0,5800 |
| **O4** | 0,0564 | 4 | 0,2255 | 5 | 0,2819 | 3 | 0,1692 |
| **O5** | 0,0204 | 4 | 0,0816 | 5 | 0,1020 | 3 | 0,0612 |
| **P1** | 0,1085 | 5 | 0,5427 | 4 | 0,4342 | 5 | 0,5427 |
| **P2** | 0,1286 | 5 | 0,6432 | 2 | 0,2573 | 5 | 0,6432 |
| **P3** | 0,0308 | 5 | 0,1541 | 3 | 0,0925 | 5 | 0,1541 |
| **C1** | 0,0185 | 3 | 0,0556 | 4 | 0,0741 | 5 | 0,0926 |
| **C2** | 0,1071 | 5 | 0,5353 | 5 | 0,5353 | 3 | 0,3212 |
| **C3** | 0,0090 | 4 | 0,0359 | 3 | 0,0269 | 4 | 0,0359 |
| **C4** | 0,0605 | 4 | 0,2418 | 4 | 0,2418 | 4 | 0,2418 |
| | | | 4,185227 | | 4,346985 | | 3,865325 |
| | LEVEL | | 2 | | 1 | | 3 |

The optimal alternative was chosen by multiplying relative weights of the alternatives (according to the appropriate criterion) by the weight vector *w*, and then by summing the corresponding results (see the last row of the Table 3). According to this calculation, candidate A2 has the highest value an is the one that is considered optimal. The results also show that there is little difference between candidate scores in the ranking (3,86 vs 4,18).

## 4. Conclusions

Selecting the right candidate for the job position is one of the key tasks of HRM. Therefore, selection requires objective decision-making process rather than the personal judgments. This study examined possible application of AHP in selection process for the position of strategic planning manager. HR professionals were consulted and the AHP method was used to obtain dependence weights of the criteria and the modified, and then to rank the candidates. The assessments of the relative importance were confirmed by checking the consistency ratio. The proposed model was created for the application within a real manufacturing system and has increased the objectivity of the selection by quantifying the required criteria, and reducing the selection time. Although it is adopted to manufacturing organization, this model can be used for selecting strategic planning manager in any organization. By applying the AHP method, one can see how much each sub-criterion affects the choice of an alternative. Those with the smallest influence can be omitted and others can be considered instead. In this sense, the application of the

AHP method provides not only the selection of candidates, but also the validity of the criteria.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# AN OVERVIEW OF OVERTOURISM: CAUSES AND IMPACTS

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***Abstract***

*Overtourism is a major challenge in tourism today, which manifests itself in destinations exceeding their carrying capacity and leading to negative economic, environmental and socio-cultural consequences. This phenomenon is due to inadequate tourism management and global trends that promote cheaper travel, the popularity of short trips and seasonality. Overtourism results in the destruction of natural and cultural heritage, overcrowding, higher cost of living, commercialization of culture and dissatisfaction of locals and tourists. The aim of this article is to analyze the causes and consequences of overtourism. Special attention should be paid to the promotion of sustainable tourism, the control of tourist numbers and the management of resources to protect local communities and the natural environment. The paper seeks to provide recommendations for balanced tourism development that ensures the long-term sustainability of destinations while reducing the negative impacts on local communities and culture.*

***Key words:*** *overtourism, sustainable tourism, tourism destination*

## 1. Introduction

The rapid growth of global tourism has brought considerable benefits, but has also led to the pressing problem of overtourism. Defined as an excessive influx of tourists that exceeds the capacity of a tourism destination, overtourism has become a critical issue for policy makers, residents and industry stakeholders. This phenomenon is driven by several factors, including affordable travel options, the proliferation of social media showcasing beautiful destinations, and a lack of effective management strategies. As a result, many popular tourism destinations are

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overcrowded, which has a detrimental impact on local communities, the economy and the environment.

The phenomenon of overtourism emerged prominently in 2016, when Skift, a prominent media and marketing company specializing in travel, first introduced the term. It serves as a warning about the potential dangers posed to popular tourism destinations worldwide, highlighting the inevitable negative repercussions that arise when tourism develops without adequate planning. According to Ali (2016), it is crucial to address the economic, ecological, and socio-cultural impacts of tourism to achieve sustainable growth. The term is crafted to provoke concern regarding the consequences of unregulated tourism, urging stakeholders to take notice (Ali, 2018). In recognition of its growing relevance, the Oxford English Dictionary designated "overtourism" as the "word of the year" in 2018, defining it as "an excessive number of tourists visiting well-known destinations, causing harm to the environment and negatively impacting the lives of local residents" (Lexico, 2022).

The aim of this paper is to delve into the causes and impacts of overtourism. Overtourism impacts communities, economies, and ecosystems, fundamentally altering the character and viability of tourism destinations. Through an examination of its impacts, this study underscores the urgent need for a shift in tourism practices that prioritize sustainability.

## 2. Understanding Overtourism

Overtourism is a relatively new term used to describe a persistent problem, as Dodds and Butler (2019) note. Concerns about the negative impacts of tourism have been around since the 1960s, but the scale of these problems has increased significantly over time. The term refers to the excessive negative impacts that tourism can have on local communities and the natural environment. In contrast to mass tourism, which simply refers to a high volume of tourists, overtourism refers to situations where even a relatively small number of tourists can overwhelm the capacity of a tourism destination (Koens et al., 2018).

Several factors contribute to the rise of overtourism, including lower travel costs due to low-cost airlines, the increasing popularity of middle-class travel and the accessibility of affordable accommodation options such as Airbnb (Goodwin, 2019). In addition, aggressive marketing by destination management organizations and technological advancements in online bookings continue to drive tourism growth (Gowreesunkar & Seraphin, 2019). Poorly planned tourism development and inadequate management frameworks exacerbate these problems and make it more difficult to control overtourism (İçöz & Bozkurt, 2021).

The core problem of overtourism is that it leads to traffic congestion and overcrowding in popular tourism destinations, which significantly affects the quality of life of residents. The causes are often due to changes in tourist behavior and tourism policy models (Żemła, 2020). Overcrowding not only affects the everyday experiences of locals, but also leads to tourist dissatisfaction as tourists struggle to enjoy the attractions of the destination (UNWTO et al., 2018). Scientists

point out that overtourism occurs when tourism exceeds the carrying capacity of a destination, resulting in environmental degradation and a lower quality of life for locals (Peeters et al., 2019; Higgins-Desbiolles et al., 2019).

In larger destinations, the impact of overtourism can be concentrated in certain areas, while in smaller destinations it is often more difficult for locals to escape the presence of tourists and tourism infrastructure (Dodds & Butler, 2019). In places such as Venice and Barcelona, this has led to a negative perception of tourism, resulting in movements such as anti-tourism, where residents actively resist the influx of tourists (Araoz, 2011; Oklevik et al., 2019; Capocchi et al., 2019). These reactions are also symptoms of unsustainable tourism growth (Milano et al., 2019).

In order to combat overtourism, the goals of sustainable development must be prioritized. Rather than focusing solely on increasing tourist numbers, destination management should carefully consider which types of tourism should be promoted and which should be restricted (Benner, 2019). Butler and Dodds (2022) emphasize that despite the recognition of global trends contributing to overtourism, there is still a reluctance to effectively manage or reduce excessive tourist numbers at all levels, from local to international.

## 3. Impacts of Overtourism

Overtourism has increasingly strained relations between local communities and tourists, leading to a growing sense of frustration and hostility towards tourism. The concerns expressed by residents often go beyond the mere inconvenience of overcrowding and touch on deep-seated social, economic and environmental issues that threaten their quality of life (Hristov et al., 2021). The overwhelming influx of tourists puts immense pressure on local services such as restaurants and parking lots, causing significant disruption and dissatisfaction within the community (Butler, 2018).

From a socio-cultural perspective, overtourism changes the structure of communities and makes them less liveable for locals. The influx of tourists can marginalize the local population, as their needs are often overlooked in favor of the needs of the tourists. Cultural differences can lead to misunderstandings and conflicts, while problems such as crime and the commercialization of local culture can threaten the social integrity and safety of the tourism destination. There is a risk that traditional ways of life may be diluted or lost because outside influences and behaviors are not in line with local values. Economically, overtourism can drive up the cost of living, making everyday expenses a greater burden for locals due to rising prices. It also creates a heavy reliance on tourism for economic stability, which can be risky when tourist numbers fluctuate. Furthermore, the funds often go towards the maintenance of tourism infrastructure, leaving fewer funds for projects that directly benefit the locals. The reputation of the tourism destination itself can be threaten if the burden of overtourism is felt by tourists and residents alike. The ecological consequences of overtourism are also a cause for concern. High levels of pollution, problems with waste disposal and the destruction of natural landscapes

are the result of increasing activities. Infrastructure development often prioritizes the needs of tourists rather than the everyday needs of local residents. In addition, the overcrowding of many tourist hotspots endangers both the natural environment and cultural heritage and undermines the unique features that attracted tourists in the first place (Peeters *et al.,* 2019).

These interlinked impacts highlight the wider challenges posed by overtourism, which threaten not only the sustainability of destinations but also the wellbeing of the people who call these tourism destinations home. The unchecked growth of tourism can strain public resources, disrupt social cohesion, and erode the very cultural and natural assets that make a tourism destination attractive in the first place. As tourist numbers grow, local authorities may struggle to keep pace with the demand for infrastructure upgrades, leading to inadequate public services and increased wear and tear on facilities. This can further exacerbate the frustration of residents, who may feel that their needs are deprioritized in favor of accommodating tourists.

## 4. Examples of Overtourism

Venice, a city in Italy is facing major challenges due to overtourism, particularly cruise tourism, which poses a threat to its sustainability (Benner, 2019). Local residents report that the influx of around 30,000 cruise passengers a day during the high season negatively impacts both their culture and the environment (Haince, 2016). In recent decades, Venice has experienced a dramatic increase in tourist numbers, which reached 5.5 million in 2019. Although the COVID-19 pandemic caused a drop to 1.3 million in 2020, numbers rose again to 5.7 million in 2023 (Statista, 2023). The city's economy relies heavily on tourism, but this has caused many locals to move to surrounding areas as they no longer want to live in their own city. Fears have been expressed that Venice could become a "museum city" without its original inhabitants (González, 2018). The high cost of living and the decline in quality of life, which is reflected, for example, in the fact that traditional stores are being replaced by low-quality souvenir stores, are contributing to this exodus (Venezia Autentica, 2022).

Amsterdam's (Netherlands) tourism industry has experienced considerable growth, fueled by significant investment in marketing and the rise of low-cost airlines, making the city a prime destination for travelers. However, this success has led to serious challenges, including a significant increase in poorly regulated vacation rentals such as Airbnb, which are exacerbating the housing crisis by taking properties out of the local market. Residents are increasingly frustrated as their neighborhoods become overrun with tourists, giving the impression of living in a theme park rather than a vibrant city. The influx of tourists has contributed to a homogenization of the city center, which has lost its unique character. Young families in particular struggle to find affordable housing, as many apartments are rented exclusively to tourists, resulting in a loss of community and essential services (Responsible Travel 2024).

Barcelona, Spain, is another notable example of overtourism. The challenge lies in the simultaneous arrival of many tourists, about half of whom are day-trippers, mainly from cruise ships. These tourists usually have little time to explore the city, which means that the main attractions such as the Sagrada Familia and Parc Güell are overcrowded. As a result, they spend little time outside of the major tourist centers, leading to dissatisfaction among both residents and other tourists (Responsible Travel 2024a).

## 5. Conclusion

Overtourism poses a significant threat to the sustainability and quality of life of many popular tourism destinations around the world. As the influx of tourists exceeds the carrying capacity of these places, the negative consequences go beyond the inconvenience of overcrowding and affect local economies, social structures and the natural environment. This phenomenon disrupts the daily lives of residents, leads to the commercialization of cultural heritage and places an undue pressure on infrastructure and public services. In addition, environmental degradation through pollution, resource depletion and habitat loss threatens the very attractions that draw tourists in the first place.

To overcome these challenges, it is imperative to adopt sustainable tourism practices that prioritize the needs of local communities and the preservation of cultural and natural assets. Efforts should focus on managing tourist numbers, promoting off-peak travel and diversifying the tourism offer to reduce the concentration of tourists in certain areas. Enforcing stricter regulations on short-term rentals and encouraging the development of alternative, less-visited tourism destinations can also ease the burden on popular locations.

Ultimately, balanced tourism development requires a shift from simply maximizing tourist numbers to improving the quality of the tourism experience for both locals and tourists. With a holistic approach to tourism management that emphasizes sustainability, responsible tourism practices and collaboration with stakeholders, tourism destinations can mitigate the negative impacts of overtourism while ensuring their long-term resilience and attractiveness.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DISCUSSION ON SERBIA'S WASTE MANAGEMENT CHALLENGES AND FUTURE DIRECTIONS

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***Abstract***
*Despite global efforts to reduce emissions and mitigate the effects of climate change, these measures have largely failed to curb the ongoing impacts. Achieving sustainability in the face of evolving environmental conditions requires participation from every country. However, significant discrepancies exist among nations regarding their contributions to environmental degradation, their contingency and sustainability efforts, and their capabilities to balance economic growth with environmental protection. Consequently, expecting equal financial contributions and governance efforts from all countries is unrealistic. This discussion presents the problem for low-income countries to adopt adequate waste management regulation to protect its own interests and the environment. It is informed by a comprehensive literature review, encompassing scientific papers, policy documents, government reports, guidelines, and international frameworks.*
***Key words****: waste management policy, national policy, sustainable strategies, mitigation measures, sustainability, climate change*

## 1. Introduction

The global socio-political and environmental landscape is characterized by a complex web of relationships. Each nation must prioritize the protection and advancement of its national interests while actively engaging in the global economy. However, nations do not start from an equal footing; developed countries often hold significant advantages in the marketplace and exert considerable cultural influence. This dynamic can affect the social status of populations in less fortunate nations, which have struggled to establish peace and stability over the past half-century.

While this paper primarily focuses on the environmental aspects of waste management policy development, the authors emphasize the critical importance of understanding these regulations within the broader context of social equality and future sustainability. This holistic approach is essential to comprehensively address the interrelationships impacted by waste management. Scientific analysis has

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demonstrated that the intensity, speed, and spatial distribution of industrial waste are significantly influenced by human activities—such as lifestyles and the reliance on fossil fuels for both industrial processes and daily living (UN Environment Program, 2024). Without targeted actions for climate change mitigation, these levels are expected to rise even further. By 2050, it is imperative that we achieve an 80% reduction in greenhouse gas (GHG) emissions (UNDP Serbia, n.d.f.).

The distribution of industrial waste has an unequal impact on various social groups, often resulting in those who contribute the least to the problem suffering the most. This disparity is frequently linked to access to cheaper resources and the unfair treatment of labor, commonly referred to as "cheap labor." The burden of providing low-cost raw materials often falls on countries that are already politically destabilized. For instance, nations like the Democratic Republic of the Congo, rich in natural resources, have experienced significant economic turmoil exacerbated by corporate corruption. Here, powerful multinational corporations exploit the country's resources while disregarding the welfare of local communities, leading to environmental degradation and social unrest. Developed countries leverage this situation to export dirty industries and secure resources for their own benefit, often at the expense of the nations from which these resources are extracted. As a result, the responsibility for managing industrial waste and mitigating its environmental effects predominantly falls on countries lacking the political power or financial resources to implement necessary environmental measures.

For example, Serbia faces significant challenges in this regard. With inadequate economic power to sustain long-term investments and a lack of enforcement mechanisms to combat corruption and misuse of public resources, Serbia struggles to fulfill its environmental commitments and protect its ecosystems.

The research presented in this paper is grounded in two primary principles: first, to assess the current situation in the Republic of Serbia and examine existing legislative measures concerning industrial waste management; and second, to evaluate how these strategies and policies have evolved to pave the way for a justifiable transition to sustainable waste management practices and a circular economy (RES Foundation, 2016). The arrangement of propositions aims to address specific gaps in the literature, focusing on information transparency (UNDP Serbia, n.d.g), the UN Framework Convention on Climate Change, waste management strategies, and policy development instruments (FAOLEX, 2020).

Two central research questions are posed: 1. Is it possible to develop a unified industrial waste management strategy that encompasses all governmental sectors in Serbia, allowing for the ambitious adaptation and integration of their goals in line with global climate change initiatives? 2. What challenges does Serbia, as a developing country, face in effectively implementing industrial waste reduction initiatives and securing sustainable development in the global market?

## 1.1 Methods

### Research Design

This study employs a mixed-methods research approach, utilizing both qualitative and quantitative analysis to examine waste management policies in the Republic of Serbia. The research methodology is grounded in relevant information derived from published documentation, scientific literature, and principles of policy analysis.

### Data Collection

The research followed key steps commonly used in Regulatory Impact Studies, Cost-Benefit Analysis, and Strategic Environmental Assessments. The specific methodologies encompassed the following steps:

- Defining the Scope: The research scope was established to identify the nature, coverage, boundaries, level of detail, and extent of the waste management issues addressed in Serbia (OECD, 2020).
- Identifying Risks and Setting the Baseline: A comprehensive understanding of the risks associated with waste management policies was conducted. A baseline was established to measure and understand the differences presented by potential policy alternatives, essential for assessing various scenarios and options (Treasury Board of Canada Secretariat, 2007).
- Setting Objectives: Objectives for the waste management policy were defined, encompassing measures such as introducing new environmental taxes, setting performance targets, and establishing limitations. The focus of these objectives was on the practical pathways for achieving desired outcomes (Lee & Walsh, 1992).
- Identifying Options: Various viable alternatives were identified for regulatory and non-regulatory comparison. These options were assessed within the established scope, with one alternative serving as a baseline for comparative analysis (Australian Government, 2020).
- Early Scenario/Options Assessment: An early assessment of scenarios and options was conducted to facilitate timely modifications to the proposed policies (Lee & Walsh, 1992).
- Stakeholder Engagement and Consultation: Stakeholder engagement was prioritized throughout the research process, providing valuable insights and facilitating the design of alternatives at all assessment stages (OECD, 2020).
- Adopting Proper Indicators: Suitable indicators were selected for assessing and comparing the impacts of different policy alternatives, enabling effective monitoring of regulatory performance in the future (OECD, 2020).

**Operationalization**

Operationalization, as discussed by Bhattacherjee in "Social Science Research: Principles, Methods, and Practices," was integral to the research design. This process allowed for the integration of researchers' perceptions, theories, hypotheses, and assumptions into the study. Researchers articulated reference claims or assumptions and sought confirmation or disconfirmation, thus establishing a robust research framework. The operationalization process involved defining and measuring theoretical constructs, determining the level of measurement, attributes, and procedures necessary for data collection. This step was critical for ensuring scientific validity in the research design. The choice of measurement influenced the development of data collection instruments and the selection of analytical methods.

**Information Sources**

To support the research, information was gathered from diverse sources, including international and national legislative bodies, technical reports, books, conference papers, research articles, and relevant websites within the last decade. Keywords guiding this search included “Serbia,” “obligation,” “mitigation,” “adaptation,” and “industrial waste.”

Reports referenced utilized specific terms such as “Waste management policies,” “Food and Agriculture Organization of the UN,” “Regulation on Waste Management and Measures,” “UN Environment Program,” “ECOLEX,” “Paris Agreement,” “UNECE,” and “Law on Waste Management” (UNECE). Certain resources were excluded based on the absence of relevant keywords related to policy regulation, sustainable mitigation strategies, climate change, and local waste management governance (Energy community Secretariat, 2021).

**Classification of Information**

Information classification was conducted based on findings related to waste management benefits (FAOLEX, 2020), inter-institutional collaboration, adaptation actions (Berkhout, 2011), GHG emission reduction, environmental sustainability, waste management regulations in Serbia (Noges et al., 2010), local development, monitoring and reporting, climate strategy, and climate action planning (FAO, 2021).

The study primarily focused on the strategies and policies of international and national legislation in the Republic of Serbia, emphasizing the critical role of industrial waste management and its importance within the framework established by the Food and Agriculture Organization of the UN (UNDP Serbia, n.d.b).

## 2. Discussion

Greenhouse gas (GHG) emissions are recognized as a primary driver of the intensification of climate change. To date, Serbia has met its legal obligations regarding the preparation of relevant documentation. This includes long-term strategies under the Low Carbon Development Strategy (LCDS) and waste

management policies, which are complemented by mid-term plans aimed at reducing GHG emissions through sustainable industrial strategies outlined in the GHG Emission Mitigation Plan over the next five years, also known as the Nationally Determined Contributions (NDC) (FAO, 2021).

However, it is concerning that the absence of a crucial document committed to greenhouse gas (GHG) emission reduction reflects significant shortcomings in the economic development strategy of the country, which is vital for its enduring presence in the global market. This omission is particularly troubling given that the incurred capital and operational costs associated with sustainable initiatives are expected to be substantial. Currently, there is insufficient infrastructure to support a transition to a sustainable economy focused on GHG reduction. Moreover, the government is planning to invest in the raw material extraction industry, a major contributor to global GHG emissions and a source of persistent environmental pollutants. The anticipated benefits of emission reductions through the implementation of technologies reliant on these mined resources are unlikely to materialize swiftly enough to avert catastrophic damage from climate change and industrial environmental degradation.

The primary focus of this paper is on the industrial waste management policies and strategies in the Republic of Serbia, which are essential prerequisites for the country's accession to the European Union (UNDP Serbia, n.d.e). The "Climate Strategy and Action Plan" (FAO, 2021) was created to promote cross-sectoral interaction and includes specific objectives concerning waste management (OECD, 2018). However, due to the disparity between government investments, development targets, and the actual implementation of this action plan, the authors contend that it lacks the necessary enforcement measures to be effective without appropriate waste management laws or regulations. Consequently, this research aims to investigate how the intentions articulated in these policy documents are translated into practical reality.

As part of the Law on Waste Management (United Nations Serbia, 2021), the EU Green Agreement, which includes provisions for Strategic Low-Carbon Development (UNDP Serbia, n.d.d), requires the integration of waste management plans within the broader framework of energy and climate (Integrated National Energy and Climate Plans – NECPs) for a decadal period, with the first report due by 2030 (UNDP Serbia, n.d.f). This document aims to secure policies and measures for decarbonization across various sectors (UNECE); however, its focus primarily addresses energy consumption. Although this document is not directly covered by the Paris Agreement, it remains relevant to Serbia as a member of the Energy Community Treaty (EnZ) (Ekstrom et al., 2018). Serbia is therefore obligated to deliver a long-term strategy document by June 30, 2024, which will incorporate permanent industrial waste strategies aligned with climate change measures (FAOLEX, 2020).

In addition to the three key components—mitigation, adaptation, and technology—financing plays a crucial role in effective implementation (Res Foundation, 2016). The Green Agenda is designed to facilitate the transition from coal to renewable energy sources and to drive investment in this area. The Green

Agenda and Industrial Policy (Coffey & Thornley, 2015) for the Western Balkans aim to address the commitments of all member nations to create a climate-neutral Europe by 2050 (UNDP Serbia, n.d.f). This commitment is reflected in the Sofia Declaration, which Serbia signed in November 2020, supporting inclusivity among all parties, including the United Nations. This underscores the importance of inter-sectoral governance (OECD, 2018; UNECE) and the unification of waste policies as key components of significant legislation.

Despite these frameworks, Serbia has faced challenges due to a variety of changing circumstances that have negatively impacted its progress. In particular, the lack of appointed laws, undefined timeframes, and uncertainties regarding the economic sector have further hindered the country's financial stability. Moreover, critical issues related to GHG emission reductions and the integration of industrial waste management policies are often overlooked. Consequently, the sharing of vital data among authorities is frequently inadequate, hampering the prompt and effective implementation of legislation.

### 2.1 Identifying Risks and Setting the Baseline

Serbia faces several significant challenges in securing an effective waste management response, particularly in light of its international obligations, including the Paris Agreement, the UN Environment Program, and the UNECE (UNECE), as well as its accession to the European Union. On one hand, Serbia must meet substantial requirements for both mitigation and adaptation measures, which will in turn inform the incorporation of effective industrial waste management policies to address climate change risks (Abbass et al., 2022).

To this end, five pivotal features must be prioritized: (1) the provision of waste data planning; (2) early warning systems and disaster relief; (3) the identification of adaptation opportunities; (4) the dissemination of information regarding industrial waste management impacts; and (5) the supervision of critical infrastructure developments. These initiatives should be implemented from both public and private sectors, establishing necessary prerequisites for society that cater to both immediate and long-term needs (Berkhout, 2011).

On the other hand, to position itself as a global leader in combating climate change, the EU has established ambitious goals and standards for mitigating GHG emissions from industrial waste. Central to EU legislation is the Directive on the establishment of a trading scheme for emission units, which aims for a 40% GHG reduction by 2030 compared to 1990 levels, with even more stringent targets set for 2050 (UNDP Serbia, n.d.f). As Serbia works toward EU membership, it is imperative that it accelerates its climate change and waste management measures (UNECE) to ensure legislative implementation aligns with EU standards (UNDP Serbia, n.d.g).

Moreover, Serbia must adhere to EU standards not only in terms of pace but also in the efficiency of its legislative measures (Ekstrom et al., 2018). This alignment is essential for achieving compliance with EU unification requirements and IPA guidelines (UNDP Serbia, n.d.e). To facilitate this, significant transformations in current regulations are needed. Specifically, the implications of

Chapter 27—Environment and Climate Change, excessive reliance on fossil fuels (UNEP, 2024), and the recorded increase in carbon intensity present considerable challenges for the genuine implementation of effective waste management policies and a circular economy (UNECE) in Serbia. Consequently, the forthcoming Law on Waste Management United Nations Serbia, 2021) must align with the previously mentioned UN Environment Program and address municipal solid waste disposal (FAOLEX, 2020).

However, keeping pace with EU directives can be daunting. The establishment of an emission trading system in Serbia (UNDP Serbia, n.d.d) is vital for improving industrial waste management and stems from the adaptation of certain regulations (UNECE). This system faced delays due to the transition to EU legislation, which envisaged the adaptation of laws transposing the MMR Regulation (IPA 2013) into national legislation by 2018 (UNDP Serbia, n.d.e), (UNDP Serbia, n.d.h).

As a result, Serbia must continue to await the introduction of new laws on waste management that will define its approach to GHG emission reduction in response to evolving climate conditions (Noges et al., 2010) and the management of industrial waste. Nonetheless, by enhancing the country's resilience, the government can secure a brighter economic future for its citizens and promote the growth of a green and circular economy, thereby strengthening Serbia's competitiveness in the global market (Res Foundation, 2016).

The most critical aspect of Serbia's current situation that jeopardizes national interests is its role as an alternative source of critical raw materials for the European Union, which seeks to reduce its dependency on China. The EU Green Deal and Critical Raw Materials Act pose significant challenges for the EU in sourcing materials internally, increasing pressure on countries like Serbia to provide essential resources. Accordingly, Serbia finds itself in a lose-lose situation: it cannot compete effectively in global markets without the support of the EU, yet EU demands for resources often lead to environmental degradation and pose risks to human health. This dilemma is exacerbated by the absence of adequate waste management laws and a governance environment prone to corruption, which further complicates Serbia's ability to meet EU demands sustainably

### 2.2 Setting objectives and Suggestions

The adoption of the Low-Carbon Development Strategy serves as a protection document that should offer a new direction for the development of Serbia as a country that wants to secure rightful waste management practices (FAOLEX, 2020). Providing a brief description of regulated by-laws, availability, and methods for information sharing on GHG emissions through different sectors is of great importance as for industries that have crucial impact on it.

In this regard, it is desirable that the exhibited industrial waste management policy draft clearly states which strategy implies which sector and within which time frame these sustainable strategies are to be employed. Most significantly, the draft should emphasize the significance of each work carried out.

While in previous cases, for instance, a period of two years was planned for the finalization and implementation of the Low-Carbon Development Strategy (UNDP Serbia, n.d.d) and the Program for Adaptation to Changed Climate Conditions, the goal of the current Rule will have to be to reduce GHG emissions, comply with public documents, and to transparently, efficiently and correctly report on waste management information verification, within observed industries and fulfillment of the obligations, with which one is obliged through UN Environment Program (UNECE).With the reliance on the Paris Agreement, observation of human activities that lethally impact climate change must be reported, as the insurance of cost-effective climate change measures.(OECD, 2014)

Current laws on climate change in Serbia observe system regulations and their limitations for greenhouse gas emissions (hereinafter: GHG). Systematically, this adaptation measured for changed climatic conditions needs to be monitored regularly and reported on the matters of chosen waste strategy for low-carbon development initiatives (FAOLEX, 2020), (United Nations Serbia, World Bank Group, EU), (UNECE).

However, due to a consistent lack of crucial data within certain institutions, it may become significant for all governmental bodies to consider implying a rather complex analysis of industrial waste indicators (Coffey & Thornley, 2015) with a unified goal which is industrial waste mitigation policy, as to possibly more effectively overcome these in a unified demeanor. This is essential to be performed promptly before the situation becomes lethal for the lawful adaptation of industrial waste policy or becomes destructive to the environment and society. Thereupon, a multi-analysis (preferably longitudinal one) followed by integrated metrics can be required to better comprehend observed data correlation (Coffey & Thornley, 2015) and further implement justifiable techniques that will obtain environmental protection towards a successful national intersectoral governance (OECD, 2018), (UNEP, 2021), (UNEP, 2024), (UNECE). Having the right attitude with inclusion of all responsible authorities, will as well, further aid governments to properly prepare their future disaster and waste risk response (FAOLEX, 2020).

With this in mind, SDGs goals and all 3 pillars (economic, social, and environmental welfare)for sustainable development must be covered and straightened (United Nations Serbia, World Bank Group, EU, 2014) as certain GHG gas emitters, such as road and air traffic, predominantly affect climate change and can be significantly regulated by the incorporation of the climate change law on all national levels. (OECD, 2014).

Furthermore, Serbia should leverage the EU urgency for alternate sources of critical raw materials by demanding that the European Union (EU) ensure the enforcement of appropriate waste management activities. This includes providing legislative and financial support for every tonne of material extracted. Additionally, Serbia must actively participate in promoting socio-economic equality, treating its citizens with the same rights and protections as EU citizens. This includes fair compensation, safe working conditions, and long-term environmental protection for Serbian communities.

Without legally binding agreements and guarantees from the EU, Serbia is at a disadvantage when trying to implement new industries that primarily serve resource exports. These industries often operate outside the control of the Serbian public and do not prioritize the best interests of the local population. It is evident that without adequate support from the global community, Serbia lacks the leverage to resist EU pressures to provide cheap resources and labor, which are seen as prerequisites for accessing larger markets.

The ongoing geopolitical tensions, including conflicts in the Middle East, compound Serbia's challenges. As a major transit zone in the Balkans, Serbia finds itself in a precarious position under EU scrutiny. Therefore, it is crucial to prevent any new projects from moving forward until adequate waste management laws are implemented and enforced. Establishing a strong coalition with other countries to advocate for equitable resource management and environmental protections is essential to prevent further inequalities and ensure sustainable development.

Research indicates that countries with robust waste management policies are better positioned to engage in sustainable trade practices and uphold environmental standards (World Bank, 2021; Aaheim et al., 2022; Abbass et al., 2022). Additionally, studies show that socio-economic equity is essential for sustainable development, as marginalized communities often bear the brunt of resource extraction and environmental degradation (Berkhout, 2011).

### 2.3 Scenarios evaluation

The most probable scenario will follow the pathway of low-income countries. Losos et al. (2024) elaborate on the challenges faced by low- and middle-income countries in their fight against climate change. In her article published in Science, Elizabeth Losos discusses the interconnected crises of national debt, biodiversity loss, and climate change, emphasizing the urgent need for integrated approaches to address these global issues. The article highlights that developing countries, particularly those in the Global South, are grappling with significant levels of debt exacerbated by the impacts of climate change and biodiversity loss.

Losos argues that the current debt crisis severely limits these countries' ability to invest in sustainable development and conservation efforts. She advocates for debt relief initiatives tied to environmental goals, suggesting that restructuring debt could improve funding for biodiversity and climate resilience projects. By aligning financial incentives with conservation efforts, these countries can prioritize ecological health while simultaneously promoting economic recovery.

The article underscores the importance of collaboration among governments, financial institutions, and conservation organizations to develop policies that support both economic stability and environmental sustainability. Losos calls for innovative solutions to address the underlying socio-economic issues driving biodiversity loss and climate change, ultimately proposing a holistic strategy that recognizes the interconnected nature of these global challenges.

In summary, Losos emphasizes that effectively tackling national debt, biodiversity loss, and climate change requires a coordinated effort and an integrated

framework to foster sustainable development and environmental protection for the benefit of both nature and human communities.

These insights are particularly relevant for Serbia, which, despite its central location in Europe, grapples with similar challenges. As previously noted, without strategic alliances, Serbia lacks the capacity to avert national environmental and economic crises exacerbated by climate change and both external and internal economic pressures. Losos's analysis serves as a crucial reminder of the importance of integrated solutions and collaborative efforts in addressing these pressing issues.

To ensure a viable future, Serbia must establish legally binding alliances that mandate the implementation of the "polluter pays principle." This principle requires corporate and industrial users of the country's resources to manage waste responsibly and ensure long-term intergenerational environmental protection. Research indicates that the polluter pays principle can significantly enhance waste management practices and promote sustainable resource use (OECD, 2018; World Bank, 2020; Aaheim et al., 2022; Abbass et al., 2022).

However, developing such legal frameworks takes time, political will, and strategic effort. The current global imbalance places Serbia in a precarious position, as its closest economic partners often exert considerable negative pressures. Any alliances pursued beyond these existing relationships are likely to face scrutiny and potential political favoritism, complicating Serbia's efforts to create effective environmental policies.

This situation underscores the importance of a holistic approach to waste management policymaking, as the forces impacting waste production are frequently driven by political influences and consumer demands that span beyond national borders. An integrated policy framework can help Serbia align its environmental goals with global sustainability initiatives, ensuring that local practices contribute to broader international efforts to combat climate change and protect biodiversity (United Nations Environment Programme, 2021; Berkhout, 2011).

### 2.4. Stakeholders engagement

It is the responsibility of authorities to establish transparent monitoring, reporting, and verification systems to effectively implement the Waste Management Law (OECD, 2014). Such systems will enhance stakeholder engagement, enabling Serbia to provide robust reports to the UNFCCC and explore new avenues for national participation under the Nationally Determined Contributions (NDC) framework (UNDP Serbia, n.d.a).

To achieve comprehensive policy integration across all inter-sectoral levels (OECD, 2018), (UNECE), it is essential to implement an efficient Monitoring Mechanism Regulation (MMR) (UNDP Serbia, n.d.h), an Emission Trading System Directive (UNDP Serbia, n.d.d), (UNDP Serbia, n.d.e), and a directive for information transparency regarding greenhouse gas (GHG) emissions across various industrial sectors (Aaheim et al., 2022), (UNDP Serbia, n.d.g). Furthermore, it is crucial that representatives from all segments of Serbian society—including agriculture, industry, and both state and local authorities—are involved in the drafting of relevant documents, including the Draft Law on Waste Management (FAOLEX, 2020;

United Nations Serbia, 2021). This law, in alignment with the UN Environment Program, should be applied both nationally and internationally, serving as a regulatory framework to facilitate climate change mitigation and adaptation efforts.

In this context, transparency must be complemented by regular reporting that systematically addresses climate change indicators, such as variations in temperature, and encourages collaboration among all responsible authorities (FAO, 2021). Additionally, securing financial resources and ensuring effective dissemination of information about these resources is of paramount importance. The successful implementation of the Draft Law on Waste Management will require local municipalities (UNECE), United Nations Serbia, 2021) to adhere to established recommendations for evaluating and identifying essential policy components, thus reducing their vulnerabilities (Energy Community Secretariat, 2021). This process will necessitate comprehensive social and economic assessments to effectively gather measurable data from all communities—both industrial and social (Coffey & Thornley, 2015). Furthermore, qualitative assessments of each region and sector can be conducted to analyze their sensitivity to various industrial waste indices (FAOLEX, 2020).

### 2.4.1 Encouragement of inter-institutional cooperation and its benefits

The impact of persistent climate change has underscored the need for governments and authorities in Serbia to broaden their resilience strategies regarding effective waste management (UNEP, 2021). It is critical to create risk-informed investments, maintain ongoing progress, and promote information sharing amidst the industrial waste crisis without compromising long-term sustainability. Regular updates on crucial information systems are essential for this effort (Rosenzweig et al., 2017).

Swart et al. (2009) emphasize the importance of governance that combines both bottom-up and top-down approaches for the successful implementation of industrial environmental policies and their management. Such governance supports effective policy implementation at all national levels (Biesbroek et al., 2010).

The benefits of adopting this cooperative framework are numerous. By integrating this approach, Serbia can promote efficient resource governance (UNEP, 2021), secure bilateral funding that is invaluable for inter-institutional resource management (Aaheim et al., 2022; Res Foundation, 2016), and ultimately strengthen the national economy.

By fostering an integrated approach to combat inter-sectoral industrial waste management, Serbia can create cross-sectoral interactions (OECD, 2018) that mitigate the effects of climate change and reduce harmful industrial waste, along with their associated environmental and health risks. This strategy will also promote macroeconomic efficiency and facilitate the transition toward a circular economy (Aaheim et al., 2022; Ekstrom et al., 2018; FAOLEX, 2020; Res Foundation, 2016; United Nations Serbia, 2021). Implementing these recommendations aligns with the principles outlined in the UN Sustainable Development Goals, particularly in promoting sustainable cities and communities (Goal 11) and responsible consumption and production (Goal 12) (Brankov et al., 2019).

## 4. Adopting proper indicators

In June, the U.S. Supreme Court overturned the Chevron doctrine, a 40-year legal principle that directed courts to defer to federal agencies on regulatory interpretations when congressional legislation was unclear. Chief Justice John Roberts criticized the Chevron doctrine as "fundamentally misguided," asserting that only the courts have the authority to interpret the laws they administer. This decision is expected to lead to an increase in litigation challenging federal regulatory actions, with courts now required to independently review scientific evidence behind those regulations, rather than relying on the expertise of federal agencies.

Federal agency staff, particularly those in the Departments of Health and Human Services, Energy, and Agriculture, have historically been trained to interpret complex legislation. Under the Chevron doctrine, courts deferred to these agencies' expertise in regulatory matters. However, with the recent overturning of this doctrine, Congress may need to improve its own scientific literacy and draft more precise legislation to minimize ambiguity. Vague language in laws can invite extensive legal challenges and litigation, which may hinder effective policy implementation (Aaheim et al., 2022).

Judges will increasingly require access to scientific information as they adjudicate cases related to public health, the environment, education, and other critical issues. Currently, resources such as the Federal Judicial Center's Reference Manual on Scientific Evidence may not be sufficient to navigate this new legal landscape, where agency expertise is no longer given deference. Scientific organizations must engage actively to ensure that legislation is informed by precise scientific knowledge. Groups like the American Educational Research Association and the American Psychological Association are examples of organizations that monitor relevant lawsuits and can submit "friend of the court" briefs to provide scientific context (Abbass et al., 2022).

Looking forward, the next generation of scientists should develop a deeper understanding of how regulations affect their fields and the broader scientific community. This could be achieved through training programs that emphasize the intersection of science, law, and policy. Losing legal power, such as Chevron doctrine, the scientific community must play a more significant role in guiding lawmakers and courts to ensure that legislation, policy, legal interpretations, and oversight are informed by the best available science amidst the complexities of government policy and conflicting interests (Gonzalez et al., 2020; Berkhout, 2011).

More than ever, adopting appropriate indicators to evaluate regulatory impacts, climate change effects, and environmental consequences of industrial activities and waste is crucial. Decision-making often suffers when politicians lack a scientific foundation and approach, as has been well documented in studies examining the influence of corporate interests on politics (Stigler, 2020; Biesbroek et al., 2010). It is essential for industries to move beyond merely evaluating quarterly financial reports, which are relevant only for profit estimations, towards more holistic and sustainable measures of success.

To advance effectively in monitoring and evaluating policy and industry impacts, indicators must be grounded in physical and chemical principles and based on measurable variables. These indicators, such as land stability and pollution gradients, should be mapped in risk assessments that also incorporate social aspects and human behavior. For instance, considerations for evacuation routes, access to natural resources essential for spiritual and recreational well-being, and the availability of clean air, water, and soil are crucial for ensuring a sustainable future for generations to come.

To facilitate this discussion, the authors have initiated an extensive literature review and will further evaluate existing indicators that provide a valuable resource for decision-makers seeking valid and scientifically vetted information on efficiency of policies and regulations, such as waste management laws.

## 5. Conclusions

The necessity for both public and private investments is paramount to support mitigation efforts through structural and non-structural initiatives across all national sectors. These investments are essential for reinforcing the economic, social, health, and cultural resilience of communities, countries, and their resources. Notably, clean energy projects have attracted approximately €300 billion, highlighting the potential financial benefits of advancing climate initiatives. Thus, fostering inter-institutional cooperation toward low-carbon cities and communities is crucial for preserving vital resources and significantly driving the economies of all involved sectors (European Commission, 2021).

In Serbia, various waste management strategies have been implemented, exemplified by the Strategy for Sustainable Development and Integrated Urban Development, which addresses urban development challenges until 2030 (Government of the Republic of Serbia, 2019). This strategy positions urban settlements as catalysts for development and informs public policy effectively. The same principles can be extended to create industrial waste management policies tailored to meet sector-specific needs and address climate change initiatives.

Two research questions were addressed in this review. First, developing a unified strategy that efficiently covers all inter-governmental sectors is currently impractical due to their diverse purposes. However, a viable solution exists for ministries whose sectors share analogous characteristics, allowing for targeted substructural categorizations. Second, the challenges Serbia faces can be mitigated by strategically allocating investments across key sectors to enhance waste management and address climate change. The current strategy, if effectively implemented, can ensure Serbia's competitive advantage in the global climate change market through the establishment of necessary infrastructure and planned long-term investments (UN Environment Programme, 2020).

To support the implementation of a comprehensive policy, a standardized approach is necessary across all inter-sectoral levels, built upon international conventions and best practices (UNESCO, 2017). However, Serbia has struggled to demonstrate adequate innovation and efficiency, particularly in its infrastructure,

which has hindered overall development and inter-sectoral collaboration (OECD, 2020). As global shifts toward low-carbon economies gain momentum, it is imperative for Serbia to align its policies with frameworks established by the UN Environment Programme and the Paris Agreement, which set critical deadlines for implementing industrial waste management strategies that promote a circular economy.

This literature review has limitations, notably its focus solely on climate change policy adaptation and waste management mitigation in Serbia, without examining transboundary regulations that also affect the implementation of sustainable industrial and waste strategies (World Bank, 2018). Furthermore, the integration of these policies across the Danube region is essential for fostering more effective waste management practices that can significantly enhance local policy instruments.

Moreover, the review highlights time constraints related to the implementation of regulatory measures that Serbia is obligated to fulfill, as well as the limited quantity of research conducted on this subject. Due to strict timelines for executing international conventions, there remains a lack of pragmatic perspectives on these issues.

Despite these challenges, Serbia is well-positioned to revise its existing documentation to ensure alignment with the Paris Agreement. The National Waste Strategy serves as a crucial framework in this endeavor, incorporating both national and local strategies essential for developing innovative policies that facilitate Serbia's integration into the European Union (European Union, 2019). The EU's commitment to ambitious waste management policies requires that current and future member states adopt similar standards to promote sustainable practices.

In addition to aligning with waste management directives, Serbia must also consider EU regulations on critical raw materials (CRMs). The EU's Critical Raw Materials Act emphasizes the importance of securing a reliable supply of essential materials—such as lithium, cobalt, and rare earth elements—while minimizing their environmental impact (European Commission, 2020). This framework encourages member states to develop strategies that protect targeted resources, ensuring their sustainable extraction and use for future generations. By integrating these regulations into its waste management strategy, Serbia can safeguard its natural resources while promoting economic growth and environmental protection.

In conclusion, Serbia must prioritize the development of comprehensive strategies and policies within all institutional frameworks to foster collaboration among national institutions and authorities. This unified approach will significantly enhance the creation and implementation of genuine industrial waste management policies and facilitate the adoption of an inclusive circular economy (UNIDO, 2021) (Energy Community Secretariat, 2021). Consequently, by adapting international governance and implementing robust industrial waste reduction strategies, the government of the Republic of Serbia can foster national collaboration that will dramatically impact sustainable resource management. This, in turn, will strengthen the country's resilience to climate change and attract essential public and private investments across all levels.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE APPLICATION OF ESG INSTRUMENTS AS A FUTURE CHALLENGE FOR SUSTAINABLE DEVELOPMENT IN CORPORATE GOVERNANCE

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***Abstract***

*The European Directive on Corporate Sustainability Due Diligence (Directive 2024/1760) introduces significant advancements in promoting sustainable and responsible corporate actions within companies' global operations. This directive marks a pivotal shift in non-financial reporting and the application of Environmental, Social, and Governance (ESG) instruments, creating new expectations for businesses to align with sustainability goals. As sustainable corporate reporting becomes an integral part of the economic landscape, particularly due to the interconnected nature of domestic and EU economies through supply chains, the need for multidisciplinary research and analysis of ESG criteria has become evident. This research focuses on the legal frameworks and economic strategies that companies use to align their operations with sustainable development principles. The study will involve case studies, policy analysis, and evaluations of corporate governance models that integrate ESG standards. Its objective is to identify key success factors in incorporating ESG principles into legal and economic strategies while proposing models to enhance corporate governance. Key outcomes will include defining a model for assessing ESG performance, offering policy recommendations, and providing practical guidelines for companies to implement ESG strategies across various industrial sectors. This process will also focus on the harmonization of domestic legal systems with EU laws to ensure a seamless integration of ESG instruments into the national legal framework.*

***Key words:*** *ESG, sustainable development, corporate management*

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# 1. Introduction

Corporate social responsibility is emerging as a new imperative, especially considering the COVID-19 pandemic, bringing issues of corporate responsibility and sustainable development to the forefront more than ever before. We are witnessing a global interdependence, not only among companies but within society. In recent decades, from a regulatory standpoint, the traditional view of a company as merely a legal entity operating professionally to generate profit has proven insufficient (Dukić Mijatović et al., 2023).

In contrast to the exponential progress achieved during the era of economic liberalism, the period of economic neoliberalism has seen both the economy and society regress, deprived of the opportunity to fully harness the benefits of the last two industrial revolutions. Economic rules and policies have created structural imbalances and anomalies by brutally denying planetary limits and the laws of nature. Without corrective mechanisms in place to address systemic flaws, the economy oscillates between simultaneous supply and demand disruptions, ultimately entering a structural, multifaceted, and permanent crisis, a so-called "permacrisis." Moreover, external asymmetric shocks, such as climate change, pandemics, and geopolitical conflicts, continue to deepen, creating new cracks in the economic system (Đuričin et al., 2024).

# 2. ESG Instruments, Basic Concepts, and Theoretical Aspects

Contemporary corporate law, or corporate law of the 21st century, as Vasiljević observes, despite numerous changes at the end of the last century and the beginning of this one, differs from contract law, which is characterized by long-term regulation, by confirming its short-term nature and variability (Vasiljević, 2021). This is driven by increasing capital mobility beyond national borders, the globalization of the economy, trade agreements that open national and regional borders, cross-border mergers and acquisitions, the expansion of multinational and transnational corporate networks, the consolidation of leading global financial markets, the affirmation of the free movement of capital, the broadening process of harmonizing corporate law institutions at the regional and broader levels, the strengthening of supranational regulation in relation to national frameworks, a new balance between state regulation and self-regulation in favor of the latter, the dominance of private capital, the development of new forms of public-private partnerships, and more.

In his institutional theory of corporate social responsibility, Campbell emphasizes the importance of institutions in ensuring that market participants behave in a socially responsible manner. However, he refers to free market institutions, whose inadequate functioning was the cause of the global financial crisis that erupted at the end of 2007. This theory reflects the nature of the liberal economic system, which posits that the state's role in the market should be minimal, leaving all third parties interested in corporate operations at the mercy of the conscientiousness and morality of corporate governance and business procedures.

After the financial crisis, this was seen as a fundamental issue. Campbell illustrates this by arguing that if the purpose of corporations is to maximize profit and shareholder value, then it is logical that corporations will do whatever it takes to achieve this goal, possibly acting in socially irresponsible ways if they believe they will go unpunished (Campbell, 2007).

The dominant theme in the development of economic theory thus far revolves around differing views of various schools of thought regarding the role of two key societal institutions: the market and the state (Čukanović Karavidić et all., 2021).

In addition to financial reporting, the EU requires all large companies and publicly listed companies (except micro-enterprises) to disclose information aimed at identifying potential risks in the environmental and social spheres of their operations, as well as the impact of their activities on people and the environment. Non-financial reporting helps investors, civil society organizations, consumers, and other stakeholders assess the sustainability performance of companies as part of the European Green Deal.

Corporate sustainability, and consequently corporate social responsibility, refers to the activities of a business entity in a way that demonstrates attention to societal and environmental issues during interactions with stakeholders (Van Marrewijk, 2003). The drive for companies to operate with maximum profit, where profit is the sole goal, is tied to the early stages of capitalism. However, a significant shift has been observed since 2015, when the Paris Climate Agreement was adopted, and the United Nations proclaimed the Sustainable Development Goals (UN SDGs) as part of the 2030 Agenda.

The primary goal of the Paris Conference was to reach an agreement and adopt a new legally binding document that would define the obligations of member states of the Convention for the period after 2020, aiming to prevent global temperature increases exceeding 2 degrees Celsius, in line with scientific requirements. The preamble of the Paris Agreement emphasizes the necessity for an effective and progressive response to the immediate threat of climate change. These initiatives have significantly contributed to redefining the concept of ecological and social responsibility (Petrović Tomić, 2023).

Chronologically, the concept of sustainable development became important in the 1980s, especially after the publication of the report titled *Our Common Future* in 1987 by the World Commission on Environment and Development (also known as the Brundtland Report). Sustainable development was defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. From the year 2000 onward, the term "corporate social opportunity" has increasingly been used, implying the opportunities that arise from a company's commitment to responsible business practices. The difference from the earlier concept lies only in its enhancement. While the concept of responsible business focuses on standards that ensure the immediate image of a responsible corporate citizen, sustainable business emphasizes a business model that will promote values aligned with the general interest in the long term. More and more companies are both declaratively and substantively confirming their commitment to responsible business (I don't have to be

responsible, but I choose to be responsible because it's good business!) (Handy, 2003).

In the field of corporate law and governance on a global level, the contours of implementing sustainable development were seen in the adoption of regulations on worker and environmental protection during the 1980s, as well as the impact of business on the environment and vice versa. In recent decades, companies have shifted towards the concept of Corporate Social Responsibility (CSR), which has evolved into the ESG (Environmental, Social, and Governance) framework, aimed at quantifying and ranking companies' impact by industry in terms of sustainability. Different regulatory frameworks in the national legislation of EU member states often present obstacles to cross-border business operations. The use of the Commission's better regulation instruments is another way to ensure further integration of sustainable development into European policies (Simonelli & Iacob, 2021).

According to Vasiljević, the phenomena of financial crises, the need for environmental protection, security concerns, social unrest, abuses of contractual freedom that endanger the concept of "public order," stock market shocks with tectonic shifts in financial markets, and the systemic limitations of the philosophy of a liberal economy without an appropriate regulatory, interventionist, and developmental role of the state (the global financial crisis is precisely a consequence of the systemic deficiency of such an economic concept and cannot be explained, as some attempt, by "the greed of brokers and bankers as bad actors within liberal economics," just as Marxism did not fail "because of bad actors within its ranks" but due to a systemic defect), will lead capitalism to increasingly exhibit its moral side ("moral capitalism"—state capitalism instead of liberal shareholder or managerial capitalism) (Vasiljević, 2013). In this way, the phenomenon of corporate social responsibility in a broader sense, through appropriate regulatory and supervisory state interventions, will increasingly become a legal rather than merely a moral issue (as evidenced by the developmental path of regulating environmental protection, monopolistic behavior, and sustainable development), much like the overall developmental trajectory of law (Vasiljević, 2014).

Porter views interdependence as a two-way relationship through which the operations of firms affect society, and social conditions influence the execution of a firm's strategy and its overall business performance. He identifies four main categories of social conditions: the first involves the quantitative and qualitative conditions of doing business (available labor force, transportation, infrastructure, etc.); the second is the legal framework affecting competition (related to intellectual property, transparency, anti-corruption efforts, and investment incentives); the third is the size and sophistication of local demand (affected by product quality and safety standards, consumer rights, and fairness in public procurement); and the fourth is the presence of supporting industries and equipment manufacturers (Porter & Kramer, 2006).

When we examine the pillars of the ESG concept, as an evolution of the CSR concept, we observe the Environmental (E), Social (S), and Governance (G) pillars. ESG instruments represent a set of standards that banks and other investors can

consider if they aim to invest in environmentally and socially beneficial projects (Carroll, 1999).

The environmental criteria (E) focus on how a company incorporates ecological principles into its operations, or how its activities protect the environment. The basic environmental criteria include climate change, resource conservation, pollution and waste management, water and air quality, and biodiversity protection.

The social criteria (S) assess how a company manages its relationships with employees, suppliers, customers, and the community in which it operates, focusing on working conditions, diversity and inclusion, health and safety, human rights, and community engagement.

The governance (G) criterion of a company addresses how it manages its processes, how it rewards its managers, conducts internal audits and controls, and the rights of shareholders. It encompasses the structure of management bodies, risk control and management, ethical codes, issues of corruption, bribery, and conflicts of interest, as well as transparency and reporting.

There is no universal rule about which factors should belong to which group (Mišković et all, 2023). For example, diversity and inclusion in the workplace are sometimes categorized under Social (S) criteria, while other companies may include them under Governance (G) criteria, particularly when discussing the representation of women in top leadership positions.

Given the importance of ESG criteria, it's clear that this form of non-financial reporting, alongside financial reporting, provides a comprehensive view of a company. It is used as a framework to assess how a company manages risks and opportunities created by fluctuating market and non-market conditions. This variability reflects changes in ecological, social, and economic systems that affect the overall environment in which companies operate.

The term "ESG standards" is often mentioned, but in reality, there are no universal ESG standards in the strictest sense. There are multiple frameworks, methodologies, and standards that can be used to define criteria for measuring, disclosing, and evaluating ESG performance. Efforts to measure or compare corporate social responsibility are likely to remain an elusive goal due to the existence of numerous variables related to data and methodology.

## 3. Legislative Frameworks for ESG Instruments at the European Union Level

Sources of law relevant to the regulation of ESG criteria in the EU are numerous and complementary. Finance and reporting are regulated by the following sources: Directive 2013/34/EU on annual financial statements, consolidated financial statements, and related reports of certain types of companies[1], Non-Financial Reporting Directive[2] (NFR Directive 2014/95/EU),

[1] https://eur-lex.europa.eu/eli/dir/2013/34/oj access 1.7.2024.
[2] https://eur-lex.europa.eu/eli/dir/2014/95/oj access 1.7.2024

Corporate Sustainability Reporting Directive[1] (CSR Directive 2022/2464 EU), and Sustainable Finance Disclosure Regulation[2] (SFDR), The Taxonomy Regulation[3] and Public country-by-country reporting.

The supply chain is regulated by the following documents: the Directive on Corporate Sustainability Due Diligence[4] (Directive 2024/1760), the Conflicts Minerals Directive[5], the EU Regulation on Deforestation-Free Supply Chains[6], and the German Supply Chain Act[7].

Climate factors are legislatively addressed in the Carbon Border Adjustment Mechanism[8], the Fit for 55 Package[9], and the EU Emissions Trading System[10] (ETS).

The foundations of the circular economy are outlined in the Circular Economy Action Plan[11], the Ecodesign Directive[12], the Green Claims Directive[13], and the Sustainable Products Initiative[14].

The European Union, as a single space and market, aims to harmonize the national regulations of member states. This harmonization is implemented through three instruments that ensure the compatibility of legal rules in corporate law among member states. First is the harmonization of national regulations in corporate law, which member states must incorporate into their national legislations through adopted directives. The second instrument is the creation of new supranational organizational forms for conducting business activities, which coexist with national forms and serve as alternatives for entrepreneurs (Dukić Mijatović, 2023). The continuity of solutions in our corporate laws is clear, with the legislator intending not only to harmonize domestic legislation with EU law but also to introduce new institutes and to regulate existing ones through more precise and concrete norms (Dukić Mijatović et all, 2016). We expect this approach to be applied in the implementation of legislative solutions regarding ESG instruments. The Republic of Serbia should follow the rules and standards of the European Union,

1 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022L2464 access 1.7.2024
2 https://finance.ec.europa.eu/sustainable-finance/disclosures/sustainability-related-disclosure-financial-services-sector_en access 1.7.2024.
3 https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en access 2.7.2024
4 https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en, access 1.8.2024
5 https://policy.trade.ec.europa.eu/development-and-sustainability/conflict-minerals-regulation_en access 2.7.2024.
6 https://environment.ec.europa.eu/topics/forests/deforestation/regulation-deforestation-free-products_en pristup 2.7.2024.
7 https://www.csr-in-deutschland.de/EN/Business-Human-Rights/Supply-Chain-Act/supply-chain-act.html pristup 3.7.2024.
8 https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en pristup 3.7.2024.
9 https://europa.rs/commission-welcomes-completion-of-key-fit-for-55-legislation/?lang=en pristup 3.7.2024.
10 https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en pristup 3.7.2024.
11 https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en pristup 3.7.2024.
12 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1781&qid=1719580391746 pristup 3.7.2024.
13 https://environment.ec.europa.eu/topics/circular-economy/green-claims_en pristup 3.7.2024.
14 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en pristup 3.7.2024.

particularly the 2014 Non-Financial Reporting Directive, and pay special attention to large enterprises and their impact on aspects of corporate social responsibility, considering that entrepreneurs, small and medium enterprises, do not hold the same significance and should not be unduly burdened with such obligations (Dukić Mijatović et all, 2023).

New rules will ensure that investors and other stakeholders have access to the information they need to assess companies' impacts on people and the environment and that investors can evaluate financial risks and opportunities arising from climate change and other sustainability issues. Finally, reporting costs for companies will be reduced in the medium and long term by harmonizing the information that needs to be provided (İyigün, 2015).

## 4. Conclusion

The benefits of ESG reporting are significant and diverse. For example, the integration of ESG criteria helps companies identify and manage risks related to climate change, working conditions, human rights, corporate governance, business ethics, and other relevant factors. Similarly, a focus on sustainability can drive innovation, save resources, ensure more efficient supply chain management, reduce energy and resource costs, and increase productivity. ESG integration can open doors to various sources of capital, such as ESG funds, investors with specific ESG criteria, or institutional investors seeking sustainable business models. Commitment to sustainability, responsible practices, and transparency in reporting can significantly enhance reputation and build trust among stakeholders, including customers, suppliers, employees, investors, and the broader public. Companies recognized as socially responsible are more likely to attract loyal customers and talent. Regulatory bodies are increasingly introducing regulations that require companies to report on ESG factors or meet certain sustainability standards. ESG integration allows a company to adapt to these requirements in a timely manner and ensure compliance with regulations. This can reduce the risk of fines, legal issues, and damage to the company's reputation. Considering all of the above, we assess that the application of ESG instruments presents a challenge for the future of sustainable development in corporate governance that domestic legislation and the economy must adequately address in order to promote the common good.

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# INNOVATION AND ENTREPRENURSHIP

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# (SELF-) MANAGEMENT OF THE ICT-SUPPORTED DIGITAL NOMADISM IN CREATIVE INDUSTRIES

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***Abstract***

*The advance in technologies, especially in the ICT has facilitated new business practices in all areas of business, but it was particularly reflected in the creative industries, and much less in service industries and production industries. The Covid-19 pandemic only accelerated the process of inducing innovative practices, and one of them is remote working. The remote working can be performed from the home office, but once the working place was replaced by the home office, the location of the home office became irrelevant. It gave momentum to the rapid dislocation of the workers, to other cities and even other countries and continents. The creative industries especially proved to be the fertile ground for such practices, often called digital nomadism, and it is all supported by new ICTs. The digital nomad practices have brought rapidly different work environment, with increased productivity, influx of money to previously less developed regions in the world, accelerating their growth, and the freedom from tedious office practices, but they have also brought negative side-effects like loneliness, uncertainty, financial difficulties, increased risk, and transnational gentrification. Several countries stepped forward with facilitating digital nomadism, and managers have had to adapt to new business forms, including the HR management, new time schedules, motivational techniques and drastically changed models of organising tasks. This paper is the case study of digital nomadism in creative industries which were reshaped by the pandemic and the influx of the ex-USSR immigrants in Serbia as well as the management (and self-management) of digital nomad work.*

***Key words:*** *digital nomadism, management, IT, remote work, nomads, digitization*

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# 1. Introduction

## 1.1 Digital nomadism on the rise

The digital economy is seen as the future of economic growth worldwide (Bolesnikov et al., 2019), and the creative workers and especially the younger people have adopted the digital economy en masse. One of such adoptions is the rise of digital nomadism as a work practice. Digital nomads can be defined as location-independent remote workers, but some authors insist that there is a leisure factor included, so their definition include that they are also those who are simultaneously engaged in extensive leisure travel, while remaining at work digitally (Chevtaeva & Denizci-Guillet, 2021).

Their lifestyle is often described as (semi-)permanent (Hannonen, 2020), meaning that there are those who stay in one place almost permanently or indefinitely (it is just not their original home) and those who tend to roam, thus blending work and travel in a new form of both lifestyle and work style. Some authors define this situation as a "hybrid lifestyle" (Rainoldi, Buhalis, & Ladkin, 2022a).

Digital nomadism began to flourish during the 2010s, and the main reason for the "boom" was technological advancements (Cook, 2023). Later dynamics like Covid-19 pandemic, remote work (Zhou et al, 2024) and wars (especially Russian invasion of Ukraine) further propelled digital nomadism as a usual work practice, and the practice became subject of interest of both public and scientific communities (Hannonen, 2024).

It was first mentioned in detail by Sørensen more than 20 years ago, where it was described as a fluid mobile work practice (Sørensen, 2002), but it took some 15 years for digital nomadism to get to the point of being really noticed by academia and wider discourses (Hannonen, 2024).

There are various definitions of digital nomads, but the point and the bottomline is that digital nomads simultaneously work outside the office (remotely), but also live in a location that is not their primary home. This combination of *"working remotely"* and *"living outside the primary home"* makes their lives recognisable. The hypermobility combined with accelerated globalisation (D'Andrea, 2016) made digital nomads omnipresent. Some researchers underline their frequent constant presence in social media (Miguel et al, 2023).

Their remoteness can be diverse - because as defined by some authors – „to be remote is to be away — usually pointing to an alternate work location, such as a home, satellite office, coffee shop, or co-working location" (Spinuzzi, et al., 2019). It is important to say that the so-called *workcationers* are not included, since these are individuals who work from their holiday spot (Pecsek, 2018). Essentially, their area of expertise is also very specific since they predominantly or exclusively work within the *creative industries* (Milošević et al., 2024). This paper is orientated towards such digital nomads and this fact will be taken as a foundation and not be repeated – in further text "digital nomad" will be synonymous for the one in creative industries.

Frequently, digital nomads move to the countries where the costs of living are lower, like Serbia, Georgia or Uzbekistan for the Russian expats/digital nomads, so their standard of living (and profits) increases with wages they obtain from their remote employer (Hermann & Paris 2020).

Cybersecurity has become a new limiting factor in working remotely, including the work of digital nomads, and cybersecurity experts say that in this type of work, from different devices and for unsecured networks, new security flaws and breakthroughs can occur (Bispham et al, 2021 ), which may have either financial effects or disclosure of business secrets. There is an increased cybersecurity risk of data being handled by employees on their home computers and mobile devices where malicious hackers can compromise security measures is felt across industries (Rajkumar et al., 2023). This, and other problems and challenges, can be solved in co-working spaces (Howell, 2022).

If we move from technical issues to the issues of self-organisation, there are some other potential issues emerging from the digital nomad work style. Namely, it is most certainly not suited for everyone. There are many factors related to discipline and self-organisation that are not available to all individuals due to their mental or psychological characteristics and traits. In order to be a successful digital nomad, concentration, self-organisation of the work process, self-discipline and similar self-managing qualities are necessary - especially bearing in mind the potentially very different time zones if the digital nomad settles in a base that is very far away (Cook, 2023).

Also, a digital nomad must be sure that by going to another, distant place for work (and leisure/pleasure) they have not significantly lost the quality of life in terms of health care, that they have to chase money for survival and forget (or have no time for) business obligations, that they are able to find free time for work, a suitable internet link and connection, and, if required by the parent company, to coordinate their working hours with the company (Nash, 2018).

When they are left alone, without the supervision of middle management and without the supervision of superiors, remote workers, including digital nomads, have to find their own methods of work, patterns of business behaviour, but various psychological challenges often appear there - the two most common are that the digital nomads struggles to push themselves to work, and find motivation without supervision and company, or they work so hard and efficiently that they have a problem determining when enough is enough and "disconnect" from work, since they is not surrounded by people who simultaneously disconnect from work and from the work routine (Milošević, 2023).

Despite the advantages of digital nomadism (e.g. job flexibility, high mobility and leisure-orientated lifestyle), as well as the opportunities to meet like-minded people, one of the consequences of the lifestyle can be loneliness (Miguel et al, 2024). This can seriously compromise the effectiveness of digital nomads. Miguel and colleagues describe this with the phrase "alone on the road" (Miguel et al, 2024). Some believe that also this "breaking away from the old social fabric" and incorporation into the "new social fabric" can contribute to the problem of the lack of so-called "social citizenship" (Webb, 2024).

Also, it is very unpleasant for some people that the line between work and life is being erased, and every time becomes business time, so there can be "infinite availability" or so-called work-related extended availability (WREA), which negatively affects the well-being of the worker (Thörel et al, 2022).

What is extremely important in this paper and what is observed is that geographical distance and independence lead to new challenges for digital nomads, such as difficulties in relations with the environment, difficulties in financial stability and independence since their income often far too "random" and less steady - some of them can be left completely without means even to live or to return home (Thompson, 2018). This leads to increased stress, weak health care organisation that leads to more stress, then to high risks of integration and the like (Hermann & Paris 2020).

More recently Cook, in his four-year study of 16 digital nomads worldwide, concluded that the idealised image of stress-free work is largely a fantasy. Although some traditional office work challenges are mitigated, new ones emerge (Cook, 2023). Digital nomads can also encounter several other challenges, including the regulation of tax payments and financial contributions (such as retirement/pension fund contributions) in either their home country or the country where they are currently located, managing their pension status or so (Hall et al, 2019).

Many of the digital nomads adopt a “minimalist lifestyle” (Aroles et al, 2019), some of them feeling comfortably without their previous things and possessions, while other feel cut off from their objects and feel nostalgia. Some of digital nomads do not even maintain a “home base”, preferring to “roam endlessly” (Nash et al, 2021). These are the main challenges that further complicate the superficially glamorous and shiny lifestyle and work practice for many.

### 1.2 Methods

The research used the questionnaire sent to digital nomads around the world. The majority of them were either Serbians living and working abroad or living in the other cities in Serbia, working remotely, or the Russians living in Serbia working remotely, thought there were others too. The questionnaire contained 10 questions in three languages: Serbian, Russian and English, with the answers ranging 1-5, Likert-scale style: the respondents were instructed to answer the statements numerically, from 1 to 5, where 1- absolutely disagree, 2- partially disagree, 3- not sure/neither agree nor disagree, 4- partially agree, 5- absolutely agree.

We adopted that any answer with coefficients over 2/3 is a sign of excellent self-management (average score 4), and those between 1/2 and 2/3 (between 3 and 4) are considered satisfactory. Those below 3 (below 50%) are considered poor. The questions were the following, all of the structured positively/affirmatively: 1) I manage to organise local tax obligations on time. 2) I manage to pay my bills (including rent) on time. 3) I manage to organise payments to the pension fund/to provide myself with an old-age pension. 4) I manage to organise health care for myself. 5) I find enough motivation for self-organisation, discipline and concentration even though I am far from the workplace. 6) I have financial security (I do not feel financially insecure). 7) I have psychological security (I do not feel

psychologically insecure). 8) I don't feel lonely/I feel integrated in the new environment. 9) I do not feel increased stress. 10) I don't miss things left at home/a minimalist lifestyle with few things suits me in a new location.

The hypothesis was that self-organisation of old-age pension (statement #3), health insurance (#4) and local taxes would show the poorest results (#1). We predicted the occurrence of the increased stress (statement #9) and financial insecurity (#6). Also, the hypothesis is that the digital nomads are self-assured that they can self-manage, find self-discipline and organisation (#5), they can pay the rent and bills (#2) and have psychological security (#7). The statements that were estimated to fare in the middle are that they are more or less integrated (#8) and they are satisfied with the minimalist lifestyle (#10).

## 2. Results

83 of the respondents gave answers, some of them through email, while many others gave their answers on Google Forms anonymously. The results are shown in the following graph.

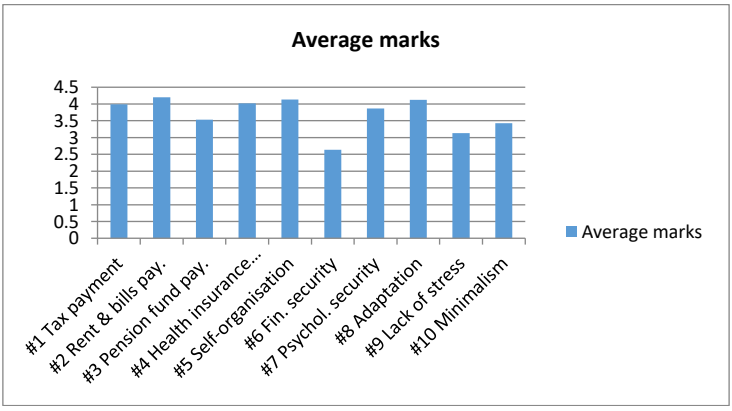


*Figure 1: Average marks given to the 10 statements in the questionnaire*

The results show that digital nomads do best in paying rent and bills in the place where they currently live (average mark 4.2), as well as in self-organisation of work even though they are far from the workplace and office (4.13) as well as in being integrated into the environment where they live and work (4.12). There are also very good results regarding the organisation of health care in the place of residence (4.02).

Answers that are satisfactory include managing to pay taxes and contributions in places of residence (borderline case with 3.99), while the psychological security is also solid, with 3.87. Pension insurance is regulated by a solid, while not so large number of respondents, and here the average score is 3.83, and a large number of them have an ambivalent attitude towards the things they left at home and getting used to a minimalist lifestyle (3.43). Stress is one of the biggest enemies of digital nomads, with a score of 3.13 for the statement "I don't feel

stressed", while the far worst is financial security, since the average score for the question "do you feel financially secure" was only 2.64.

## 3. Discussion

Since our hypothesis was that the digital nomads are well aware of what is needed to live outside your place and your "regular environment", it was presumed that they know how to organise themselves (or maybe they dislike being supervised by the middle management) and that they can pay the bills and the rent, since they choose the destinations for their life and work according to their financial estimation and the costs of living they can afford. This was proven right. Also, we presumed that digital nomads choose their destinations according to their like and taste, so they presume they will fit in. It was also proven right since the vast majority of them feel well integrated in the new environment.

The surprising result which is really comforting is that they value their health high, so in spite of our hypothesis that since they are predominantly young and adventurous, they would probably sideline health issues and therefore the health security/service payments, the digital nomads have proven the strong conscience and discipline, acting strongly in this field, regulating health services well.

The same applies to the payment of local taxes, which we presumed to be "a weak spot" for the respondent and digital nomads in whole, while the results returned a strong dedication to the matter. We also estimated that another "weak spot" would be regulation of the old-age pension, and the respondents assured us that they would not forget the old age in their young and leisure-inclining young age. This was also very encouraging. Psychological security fared poorer than in our hypothesis, proving the point of Miguel et al (2024) that they are indeed "alone on the road" sometimes.

The worst enemies of digital nomads are proven to be the minimalist lifestyle, and the randomness of their income – the things like financial security, increased stress were the true weak spots of digital nomadism, stress being the far worse adverse factor.

## 4. Conclusions

The research shows us that digital nomads are hard-working and responsible as workers and as people who want to take care of taxes, contributions and healthcare, that they are well integrated into new environments, but that things like financial security, increased stress and lack of items in a new place of living and working are the adverse factors since these are weak spots of digital nomadism.

The managers should not fear that the digital nomads would return poor business results, since it was one of their strongest spots. The destinations luring digital nomads can be rather satisfied with the new influx of their inhabitants, since their payments in the systemic areas like National Health Service and the Tax (Revenue) Service are proven to be stable, contrary to our negative presumption. Also, especially in the poor or run-down areas that have been depopulated, like

Serbia, Easter Europe and many other so-called “emerging economies” (from India and Asia to Africa and Latin America) the digital nomads can inject new energy and new money, so the destinations should work harder to attract them, building co-working spaces, good infrastructure and creating affordable digital nomad visa conditions.

The main adverse factors for digital nomads have proven to be stress in general and financial uncertainty, and these are the areas where the digtal nomads themselves can help, while local authorities can lend a hand by creating centres for psychological support or already mentioned co-working spaces which can suppress loneliness, form friendships and alleviate stress.

The potential digital nomads should question themselves which are their psychological traits and if they are ready to become ones.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CHALLENGES IN TEACHING MATHEMATICS AND STATISTICS IN MODERN TIMES

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***Abstract***
*The goal of the paper is to study the influence of different input factors, such as the results of pre-test and attitudes, on students as- sessments in learning mathematicsand statistics. The attitudes to mathematics and students environment is described with fuzzy numbers. Fuzzy theory, package is used to predict the score.positive and negative aspects.*

***Key words:*** *learning teaching, mathematics, statistics, fuyyz.*

## 1. Introduction

In the references (Shmigirilova & Ryvova, 2021) and (Stenmark & Kerr, 1991) concerning mathematical education the most important is educational assessment. The process of mathematics assessment is usually measured with terms, knowledge, skills, and so on. But in the process of teaching and learning mathematics the attitudes and beliefs towards mathematics and corresponding teaching tools and teaching materials of learners are also very important. For the teachers working at the University the most important is the studentsassessment. The students' motivation, learning styles, learning outcomes, and satisfaction in achieving good results are all very welcome during the learning process. In order to measure such attitudes and beliefs it is appropriate to use fuzzy set theory.

In this paper the Fuzzy theory is applied for the purpose of mathematics assessments. The students' data are gathered and analyzed. First, the Fuzzy ToolBox of the software package MathLab is applied to build a fuzzy decision making system in order to obtain prescribed scores and to compare it with the real final scores. Starting from data of 176 students the data for 44 students are presented. Similar thing was done by Gökmen et al. 2010.

The obtained results of data represent the contributes both to the application of fuzzy decision making system and to students' assessment. In the future the authors are supposed to apply obtained fuzzy decision making system to predict

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students scores at the beginning of the course in order to motivate students to work appropriate in their learning process.

Using Fuzzy set theory it can be concluded, in didactic point view that besides the knowledge expressed by the results od pre-test, the mention at- titudes and reliefs contributes to the students assessments.

In the second section we present the well known basic notion about Fuzzy logic, necessary for understanding the whole research. In the third section we presented the given data. In the fourth section we analyzed the influence of given data to the students' assessment.

### 1.1 Basic Notions and methods

Fuzzy set theory was introduced by Zadeh (1965) A good overview of fuzzy sets and operations with them is given in Klement, Mesiar, and Pap(2000). In the meantime, fuzzy set theory has been applied in different fields in order to model uncertanty, imprecision and vagueness. The most common application of fuzzy set theory is fuzzy control. Many devices in our homes (heaters, air-conditioners, video cameras...) use fuzzy control in order to save energy or generally improve their functionality.

Fuzzy control is actually a generalization of classical expert systems. Ex- pert systems are based on IF-THEN rules i.e.
If x is A then y is B.

The reasoning of expert systems is based on classical logic. Fuzzy control systems are based on fuzzy logic and in fuzzy control the A and B are fuzzy sets. Usually fuzzy control systems have many inputs and one output. Fuzzy system consists of many IF-THEN from which the output value is predicted based on the input value.

In this paper fuzzy systems will be used to predict student test scores from different student characteristics.

We had started our research with 202 students, but we finished with 176 first year sciences students at the Faculty of Sciences, University of Novi Sad. We lost 26 students, that be treated as a common number getting out their studies in different cases. Let us remark that all student were very motivated to take part in our research.

At the first lecture of our course the students got the pre-test consisting of 10 mathematical tasks, and 6 points was maximum for each task.

Besides the usual measuring of students' mathematical knowledge and skills (pre-test), the authors were interested in students' attitudes and be- liefs of mathematics, in particular of using teaching materials, computers for learning. These input factors are consider, by authors, as relevant ones for assessment in the learning process of the compulsory mathematical contends in our course.

Together with the pre-test the students had to answer the questionnaire about the following attitudes and beliefs: to mathematics in general, to computer, to teaching mathematics and to Geogebra.

In this paper the fuzzy theory is used to represent and examine the influence of the students' attitudes and beliefs, on their mathematical assessment. It is known

that the big problem in learning mathematics are negative attitude, even fear of mathematics, caused by failures in the past, and therefore the authors emphasize it as an important factor for the motivation for learning mathematics. (denoted by 1) or dislike (denoted by 0) mathematicians.

The authors consider that the use of package GeoGebra is very useful for understanding mathematical contents, because they have a lot of experiences in teaching and learning mathematics by using computers. The dynamic ge- ometry package GeoGebra was used, as the teaching tool, on lectures dur- ing the mentioned course: Mathematics for science students. Therefore the students' opinions about the use of computers, in particular GeoGebra are examined.

In the third column of Table 1., Table 2, and Table 3, denoted by AC the student were asked about their using computer. They were asked to choose one of the following sentences:

I have used computer for learning very often (denoted by 5);

I have used computer for learning sometimes (denoted by 4);

I have used computer for correspondences and (or) games very often (denoted by 3);

I have used computer for correspondences and (or) games sometimes (denoted by 2)

I have never used the computer (denoted by 1).

In the fifth column Table 1., Table 2, and Table 3, denoted by AG the students were asked about their using dynamic geometry programme package GeoGebra. If ones has ever used it and consider it useful then to mark with

3. If ones has never used it, but would like to use it for learning mathematics then to mark with 2. If ones has never used it and does not want to do it then to mark with 1.

Also, the ability of learning by using written teaching materials (official books and other materials) is crucial for successful learning mathematics.

Based on the inputs which were student attitude towards mathematics, student GPA and pre test scores a fuzzy controller was created using the MatLab fuzzy toolbox.

## 2. Results

The fuzzy contoller had an average prediction error of 4%. Only in the case of 5% students it predicted wrongly the students exam mark. In only 1 extreme case it missed the mark by 3. The following chart shows the predicted and the real result on the test of randomly selected 31 students.

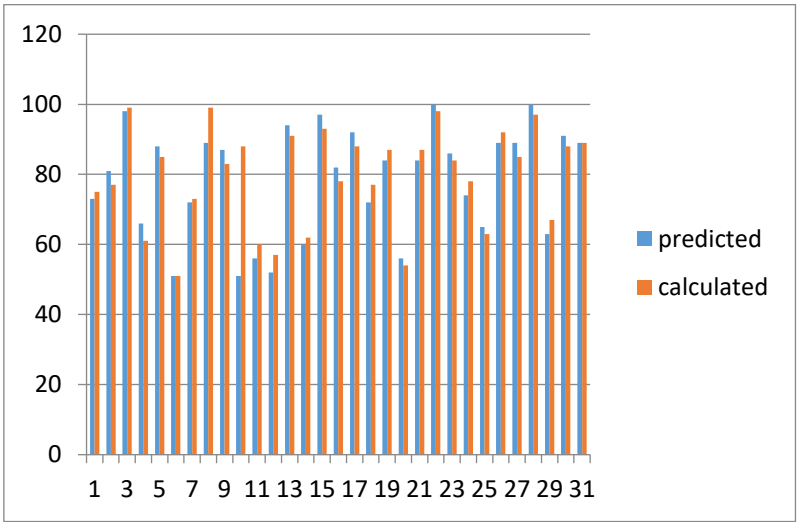


*Figure 1. Predicted and obtained student marks*

## 3. Discussion

The authors consider that the possibility of predicting the students' marks at the beginning of our mathematical course can be useful for the students to get real picture of their possible mathematical assessment, and it can be an additional external factor of motivation for them to plan their learning of mathematics and is to continue with research working with more different students.

## 4. Conclusions

The science students are very interested to understand and learn math-ematics, and to get good marks, whereas the successfulness of their studies depends on it. The goal of our research is to contribute to students' better assessment, i.e., to help students to overcome difficulties in learning math- ematics and to enable them better marks. Therefore, besides the results of pre-test, the influence of chosen factors (attitude to mathematics, teaching materials and tools) are important to be considered. The influence of the considered attitudes are significant factors for learning process (expressed as better remarks) in mathematics.

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# ŁÓDŹ AS AN EXAMPLE OF SUCCESSFUL REVITALIZATION OF POST-INDUSTRIAL CITIES

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***Abstract***

*Łódź to typowe miasto postindustrialne, które po upadku komunizmu podzieliło los innych miast w Europie Środkowo-Wschodniej. Miasto fabryk i rewolucji stało się w latach 90-tych XX wieku synonimem biedy, marazmu i braku perspektyw. Obecnie uważane jest za jedno z najbardziej dynamicznie rozwijających się miast w Polsce, między innymi dzięki przemyślanej rewitalizacji. Stare fabryki są przekształcane w przestrzenie usługowo-rozrywkowe, a stare kamienice poddawane są renowacji. Kiedyś nieatrakcyjna Łódź, dzisiaj staje się popularną destynacją pośród polskich oraz zagranicznych turystów. Łódź is a typical post-industrial city, which after the fall of communism shared the fate of other cities in Central and Eastern Europe. A city of factories and revolution, in the 1990s it became a metaphor for poverty, marasmus, and lack of perspectives. Today, it is regarded as one of the most dynamically developing cities in Poland, thanks in part to thoughtful revitalization. Old factories are being transformed into service and entertainment spaces, and old tenement houses are being renovated. Once unattractive, Łódź is now becoming a popular destination among Polish and foreign tourists.*

***Key words****: Łodź, revitalization, post-industrial cities, identity, Bilbao effect, Hanna Zdanowska.*

## 1. Introduction

For years Łódź was associated with the textile industry, for which reason it was called the Polish Manchester. The fall of communism and the economic transformation meant the closure of factories, the pauperization of society, and long years of stagnation for Łódź. In 2010, Hanna Zdanowska became the mayor of Łódź and launched a program of thoughtful and effective revitalization, following the example of the Spanish city of Bilbao. The role of this text is to demonstrate Łódź's successful path.

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In 2023, Lodz celebrated the 600th anniversary of the granting of city rights (which took place in 1423), but for many years it remained a small agricultural town, which only changed at the beginning of the 19th century when a decision was made to locate the textile industry there. Then, the town's rapid growth began, with a population of less than 1,000 in 1827, in 1865. - 40,000 and in 1914. - 540.000 (Robert, 2023: 28). There is a view that this was the highest rate of demographic growth in the history of the world. Factories were owned by Jews and Germans, and belonging to the Russian Empire resulted, among others, in an influx of Russian officials and their families. From that period comes the famous phrase describing Lodz as a city of 4 cultures, which has become one of the pillars of the city's identity today.

The city growing at a rapid pace attracted both rich capitalists and poor workers. Most of them were women. By the end of the 19th century, women made up more than half of the factory workers (Madejska 2018: 59). Łódź – a city of factories – became an inspiration for writers, including Władysław Reymont (winner of the Nobel Prize in Literature), whose novel Promised Land was translated into many languages.

During the First World War, Lodz suffered severe material and, consequently, demographic losses. Nevertheless, in 1918. it became the second largest city (after Warsaw) in independent Poland. The textile industry continued to develop, but economic crises significantly limited it (Pakuła, 2024: 199).

The communist period (1945-1989) resulted in a steady city demographic growth, but not as impressive as in the 19th century. In 1946 the population did not go above 500,000, but in the 1970s it exceeded 800,000 and was constantly growing. The overwhelming majority of the inhabitants were women, Lodz had the highest feminization rate in Poland and was therefore called the city of women (Szukalski, 2024: 521). Compared to other Polish cities, wages in Lodz were low. The state invested in other strategic industries for the economy, such as mining. The oversupply of women made it difficult to start a family. On the other hand, communist mythology idealized Lodz as a city of factories, revolution, and socialist ideals.

There were projections that Łódź would soon become a metropolis of one million people; there were even plans to build a metro. This growth trend was reversed by the political transformation, which resulted in the collapse of most factories and layoffs. For the working class, especially unskilled women, this meant mostly no prospects for new employment. At that time, the consequences of underinvestment, and poor infrastructure became evident. (In Lodz, mainly factories and workers' housing estates were built).

In the 1990s, Łódź faced many problems typical for post-industrial cities; it was associated with poverty, hopelessness, and successive corruption scandals. The other parallel problem - apart from the decline of the industry - was the low quality of the political elites (with a few exceptions). Łódź, unlike Krakow, Warsaw, Poznań and Wrocław, was not lucky to have charismatic mayors, who would think first and foremost about the thoughtful development of the city.

A new chapter in the history of Łódź started in 2010 when Hanna Zdanowska (who still manages Łódź today) became mayor. Her idea for the development of Łódź has been based on the so-called Bilbao effect and could be implemented due to the UE subsidies. A multi-faceted long process has been undertaken as part of this program, which includes:

- revitalization of post-industrial spaces
- revitalization of tenements
- infrastructure development
- construction of spectacular buildings
- tourism development.

## 1. Revitalization of post-industrial spaces

The revitalization of large, but now dormant, post-factory complexes is a phenomenon typical of post-industrial cities in the Western world. In Łódź, the first investment of this kind was opened in 2006. Manufaktura - a center of trade, entertainment, culture, and services, became one of the city's biggest attractions. In the the post-industrial, renovated buildings, museums, restaurants cafés and a cinema have been located. Between them, there is the so-called market square where concerts and cultural events are held. The whole is complemented by one of the largest shopping centers in Poland. In the following years, further post-industrial spaces were renovated: Off Piotrkowka (restaurants, bars, handicraft shops, artists' boutiques), Monopolis (cultural zone, restaurants, office space), Geyer Gardens (restaurants, services, event center) and Fuzja (entertainment venue, cultural attractions, gastronomy, apartments). Currently the WIMA factory building is being renovated to house flats, offices, and a large recreational space. The revitalized former factories attract citizens of Łódź as a place to spend leisure time. Still, they are also a showcase for the city, which, lacking the historic part of the old town, the traditional market, or the big river, promotes itself as a city of post-industrial spaces.

## 2. Revitalization of tenements

When Hanna Zdanowska took office, she promoted the slogan “City of Tenements” (“Mia100 Kamienic”, which was a play on words, as in Polish a city is miasto and a hundred is sto, wheres kamienica is tenement). The slogan was quickly changed to City of Quarters (Mia100 Kwartałów). It is not only the tenements in the representative Piotrkowska Street and its immediate vicinity that are being revitalized, but also the entire neighborhoods (Bujalski, Wesołowski). Włókiennicza and Lipowa Streets are among the symbols of these transformations - poor working-class areas have become well-kept, full of green woonefs (streets excluded from traffic). It is worth mentioning that Łódź is considered the Polish capital of woonerfs (the first one was created in 2014, there are now more than 20, and others are planned).

## 3. Infrastructure development

Infrastructure development is another idea taken from Bilbao. Without this, it is not possible to attract many tourists. Between 2011 and 2016, the central coach and bus station (Łódź Fabryczna) was modernized and is now one of the most modern stations in Poland. Currently, Łódź-Kaliska station is being renovated and the cross-town tunnel between those two stations is under construction. Between 2013 and 2015, a major project was carried out to modernize and extend the so-called W-Z route, which is the city's main east-west boulevard. On the other hand, in the North-South direction, successive renovations of individual tram lines are being carried out. The Łódź Regional Tram project aims to improve communication between Łódź and the surrounding towns to the north and south of the city (Zgierz, Pabianice).

Łódź is also at the center of a major state project called Central Communication Port (in Polish: Centralny Port Komunikacyjny - CPK). The idea of the CPK originated in the 1970s and has recurred in the political programs of many governments. It assumes the construction of a gigantic transport hub between Warsaw and Łódź (hub airport, railway, highways). Unfortunately, there is no space in this text for an in-depth analysis of this initiative. It is only worth pointing out that today the project is politically controversial, as its construction started during the rule of Law and Justice (2015-2023) and became one of the flagship investments of that era. The opposition at the time strongly criticized this idea but has continued to pursue it after taking power. Without going into details, it is worth noting that the CPK will improve the railway infrastructure in and around Łódź. The journey to Warsaw, which is currently around 90 minutes, is to be significantly reduced.

## 4. Construction of spectacular buildings

Transformation in Bilbao has been successful, thanks in part to the construction of the Guggenheim Museum, which attracts crowds of tourists worldwide. Many of them decide to extend their stay to visit other attractions, e.g., the old town, revitalized post-industrial areas along the river (Orzechowska-Wacławska, 108-109). In Łódź such flagship projects are: the EC1 and the Orientarium.

EC1 is one of Central Europe's largest Science and Technology Centres, featuring interactive installations for experiencing science. The facility also includes, among others: a Planetarium, Centre of Strip, and National Centre for Film Culture. Numerous cultural events and concerts are held in the vast spaces of EC1. The Orientarium, on the other hand, is a modern pavilion added to the Łódź Zoo which houses flora and fauna from Southeast Asia (a response to the Afrikanarium in Wrocław). The essence of Orientarium (as well as Afrikanarium) is to build a zoo of 21. century where animals live in comfortable conditions. The attractions are not only the flora and fauna but also architectural solutions or interactive games. Both Orientarium and EC1 have become part of the tourist map of Poland, thanks to which Łódź has become an alternative to Kraków, Warsaw, Wrocław or Gdańsk. Moreover,

in recent years Łódź has been experiencing a tourist boom, with more and more people visiting the city every year and increasing revenues from souvenir sales (Rekord turystów w Łodzi…).

## 5. Tourism development

The rising popularity of Łódź as a tourist attraction results from several factors. On the one hand, there are the key projects as EC1 and Orientarium, on the other hand, the authorities of Łódź skilfully invest in city promotion. Łódź's assets include its central location, airport, and close distance to Warsaw. The tourist offer concerns not only interesting ways of arranging post-industrial spaces but also coping with the lack of the traditional market, river, and old town. The main attributes of Łódź have become its multicultural legacy (orthodox churches, synagogues), Piotrkowska Street (one of the longest shopping streets in Europe), the so-called Łódź courtyards (courtyards arranged by artists next to renovated tenements), or cinematography. It is worth specifying that for years Łódź was not only a city of factories but also the film capital of Poland. The Łódź film school is popular all over the world.

Every year, more foreigners come to Lodz to study, or to work in the growing number of foreign corporations. Their visiting families are certainly boosting the statistics of the tourism boom.

## 6. Challenges and problems

Although Łódź is considered one of the most dynamically developing cities in Poland, the transformation process is fraught with challenges and problems. Due to the limited size of the text, the author will limit herself to the most important ones. Between 2015 and 2023, under the rule of the Law and Justice party, most of the money was transferred to areas managed by local authorities close to the leading party. Meanwhile, Hanna Zdanowska belongs to the Civic Platform. In addition, other problems have arisen: the COVID pandemic, meaning less revenue for the city budget (e.g. from owners of restaurants and bars), and the war in Ukraine and the influx of Ukrainian refugees, who had to be housed and supported, especially in the first months of their stay.

A major challenge is the continuing depopulation of Łódź, which, from being the second city in Poland, now ranks fourth in terms of population. On the other hand, one might ask whether Łódź needs to aspire to the role of a metropolis, especially as Warsaw is only 130 kilometers away. Perhaps its status as a big city better fits local needs and expectations, and an additional advantage may be lower prices than in the capital.

Finally, it is clear that Łódź is experiencing similar problems to those faced by other Western cities implementing the revitalization process (e.g. New York, Berlin). Although the Łódź authorities are trying to avoid the negative consequences of the process, by cooperation with experts/scientists, not everything is going as expected. Urban activists complain that often former residents cannot afford to live in the

modernized spaces (Budują miasto od nowa…). One of the examples of how revitalization creates controversies is the open market on Jaracza Street, where the modernized space remains empty during the week (the market is open only at weekends). The high rents in the new market zone have increased prices for goods that residents, mostly pensioners, cannot afford (Targ Jaracza…).

On the other hand, the revitalization processes can be viewed differently. The older, working-class generation, mainly residents of the city center and now living on low pensions, will slowly give way to younger generations. Łódź, with its numerous Western investments and lower cost of living than in Warsaw, Krakow, or Gdansk, is attracting more and more young, enterprising people from home and abroad.

## Conclusions

Łódź is considered one of the most dynamically developing cities in Poland and a model example of benefiting from membership in the European Union, but of course, money from Brussels is not the factor of change. Smart management and smart planning have played an important role. Thoughtful revitalization, inspired by the Spanish Bilbao, was consulted with numerous experts. The structural redevelopment was not accompanied by corruption scandals. Hanna Zdanowska - mayor since 2010 - has made spectacular changes to the grey, post-industrial city, thanks to which Łódź became a popular tourist destination. Her achievements are appreciated by the citizens, as she constantly wins already in the first round. In the 2018 elections, she achieved a record 70.22% of the votes (Bujalski).

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE CONCEPT OF SMART RURAL DEVELOPMENT ON THE EXAMPLE OF THE MUNICIPALITY OF PETROVAC NA MLAVI

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***Abstract***

*In contemporary society, the concept of smart rural development represents a key element in transforming local communities towards a more sustainable and economically prosperous future. This concept integrates the use of advanced technologies, digitalization, and innovation to improve the quality of life in rural areas, increase the efficiency of agricultural production, and preserve natural resources. Smart rural development enables communities to adapt to the challenges of the modern era, such as demographic changes, migrations, and climate changes, offering sustainable models for economic development that are aligned with the specificities and needs of rural areas. The implementation of this concept can significantly contribute not only to increasing the attractiveness of rural areas for living and working but also to strengthening the local economy through the development of small and medium enterprises, tourism, and alternative sources of income. The realization of smart rural development requires the active participation of all community members, as well as support from national and international policies, which presents a challenge, but also an opportunity for local communities to reshape their future in accordance with the principles of sustainability and innovation. This concept has been successfully implemented in the local community of Petrovac na Mlavi.*

***Key words:*** *smart rural development, local community, digitization, innovations, local economy, rural tourism, Petrovac na Mlavi.*

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# 1. Introduction

The concept of smart development in local communities offers the opportunity to find solutions (through digitalization, new content, sustainable production, cultural heritage, and women's entrepreneurship), by building on the real current strengths and capabilities, to stimulate further development ("Pametna sela", 2022).

This way of thinking and acting allows communities (especially in underdeveloped rural areas) to devise "smart solutions" to the challenges they face (Zelenika, 2015).

The basic mode of operation is to build on one's own local strengths and capabilities in order to engage in the process of sustainable development of their local areas (Ocsko, 2019). Such an approach allows for the development and implementation of strategies aimed at improving economic, social, and natural conditions (Ocsko, 2019). This leads to the initiation of innovation, as well as new solutions provided by modern development and business conditions (Pejanović, 2023). In addition, "smart" villages benefit from various associations and collaborations with other communities, which can be based on existing initiatives and funded from various public and private sources.

The municipality of Petrovac na Mlavi is presented in the paper as an area that falls into the underdeveloped parts of the Republic of Serbia. The way in which the local community, in its own unique and innovative way, in accordance with the needs and the effort to change something and solve specific challenges, has found solutions and created new practices in accordance with its own context, is showcased.

The municipality of Petrovac na Mlavi was chosen based on the fact that it falls into the fourth group of development of local self-government units in the Republic of Serbia – namely, devastated areas, the most underdeveloped local self-government units, and thanks to innovative thinking and the so-called smart approach, it has managed to find its place in the market and gain a relatively good position on the tourist map.

The municipality of Petrovac na Mlavi is located in eastern Serbia, in the Braničevo District ("Upoznajte Petrovac", 2024). It occupies the central part of the Mlava river basin and is situated between the Gornjak mountains and the Stig plain. It covers an area of 654.9 $km^2$ and comprises 34 settlements ("Upoznajte Petrovac", 2024).

From an administrative perspective, the municipality of Petrovac na Mlavi borders the municipalities of Malo Crniće (to the north), Despotovac (to the south), Žabari and Svilajnac (to the west), and Kučevo and Žagubica (to the east) ("Upoznajte Petrovac", 2024). It is located on one of the most important traffic routes within the Braničevo District that connects Bor, Žagubica, and Petrovac on one side, with Požarevac and the Belgrade-Niš highway on the other ("Upoznajte Petrovac", 2024). Petrovac na Mlavi, as the municipal center, is located on the banks of the Mlava River and is traversed by several regional road routes ("Upoznajte Petrovac", 2024).

The municipality of Petrovac na Mlavi is characterized by a good tourist-traffic position. It is relatively close to Belgrade (about 110 km), as the capital of the Republic of Serbia and the largest center in the country. Consequently, it has good connectivity with the "Nikola Tesla" airport. It is about 50 km away from the E-75 highway, and about 200 km from Novi Sad and Niš.

The central part of the Mlava River, between the Homolje Mountains and Stig, which the municipality occupies, provides excellent conditions for the development of agriculture, especially livestock, fruit growing, and crop farming. The municipality of Petrovac na Mlavi is also known for the production of honey and bee products.

The authors use various research methods: methods of induction and deduction, analysis and synthesis, description, comparison, observation, field research, etc. (Zelenika, 2015).

## 2. Commitment to smart rural development

The municipality of Petrovac na Mlavi has identified agriculture and tourism as its main economic sectors. This is evident from development documents as well as actual practice.

Assessing all factors important for development in the area of the municipality of Petrovac na Mlavi has resulted in a presentation of the existing situation on the ground, the overall picture related to rural development and further steps related to identifying the municipality's shortcomings and advantages as a destination compared to potential competitors (both domestically and internationally). In this way, primary steps in planning further smart rural development concepts were defined.

The goal is set to develop on the foundations of rich local, traditional, and cultural heritage, a healthy environment, a highly characteristic and attractive ambiance, authentic gastronomy, and numerous attractive contents (“Smart village: the new EU rural development frontier“, 2023).

As primary steps, the municipality of Petrovac na Mlavi has begun with the creation and adoption of necessary programme and planning documentation in which rural smart development plays a significant role in the further development of the municipality (“Program razvoja turizma opštine Petrovac na Mlavi 2021-2025“, 2022). The successful implementation of these activities has created a favorable business environment, enabled the creation of new jobs and the construction of significant infrastructure facilities whose role is to enhance the accessibility of the municipality, communal equipment, the quality of the environment, and tourist content.

The vision is for Petrovac na Mlavi to be a municipality where all citizens, especially the youth, choose to live, work, invest, and start their families. It is recognizable for its developed tourism, agriculture, and favorable business environment for investment. It is ecologically conscious, with resolved communal infrastructure and a preserved ecosystem. Health and social services are developed and accessible to all citizens, and the socio-cultural life is rich and diverse.

There are numerous ways to improve the economy of less developed areas (Prodanović Stamenović, 2022).

One of the municipality's priority goals is the establishment of a quality tourist product, an increase in the number of tourists, and revenue from tourism.

In the municipality of Petrovac na Mlavi, significant activity is directed towards the development of rural tourism, as this type of tourism is characterized by sustainability (Pejanović, 2013). The municipality has an excellent basis in the form of quality accommodation in rural households, but complete development involves following market trends. Through opportunities for diversification and investment in new technological achievements, a definitely positive contribution is reflected in the development of the local community, which in this way gains opportunities to reduce risks and generate new revenues (Pejanović & Stanojević & Radović, 2024). The entire process is guided by the primary idea that what is common practice in one local community can be a completely new practice in another local community, thus innovations are viewed in their own local context and should not be limited only to the digital context.

The basic questions that the local community in Petrovac na Mlavi has set as a platform for development are why it is necessary to apply such a concept and how the change will contribute to the local community. This has certainly led to the aspiration towards a rural environment that will contain service-oriented, innovative villages with the aim of encouraging rural agriculture and living conditions.

A series of programme and planning documents have been created, serving as a platform to support further work on various projects, which also provide the opportunity to compete for investment funds both domestically and internationally.

Through a successful campaign, interaction with the diaspora was achieved (a large number of the municipality's residents are on "temporary" work abroad), and significant capital was invested in accommodation and catering capacities, as well as in promoting the municipality in Western European countries (various presentations and performances by cultural-arts societies). Additionally, a platform for cooperation and opportunities for various projects was created, contributing to social and cultural interaction, as well as strengthening the connection with the homeland. Sustainability was also achieved through the dissemination of various information and knowledge related to cultural heritage, with which the younger generations of our people abroad had less contact.

In the municipality of Petrovac na Mlavi, a digital display offered a new effective way of cooperation and information exchange with visitors, aiming at three main development ideas focused on the environment, culture, and sustainable economic development.

This way of thinking is primarily aimed at encouraging new ideas, ways of working, and strengthening community in achieving social goals. In this way, traditional business management, which has functioned sustainably through the centuries, was also utilized, specifically the arrangement of using watermills that have had multiple owners through generations and a specific model of traditional management functioning. Millers from the municipality of Petrovac na Mlavi often

joke that their month lasts up to 40 days because the system of division depends on the percentage of ownership, and the day is divided into day and night, with multiple millers having their part of the day in 24 hours, as well as a number of days when they can use the mill and produce flour with the help of nature and without the use of electrical energy. The traditional way of working and cooperation in this context is thus an example of good practice and a response to certain social challenges and market applications.

In this way, the traditional culture of the rural areas of this region has been transferred into the digital world and, in a unique way, aims to find a common language with younger generations through modern technologies, teaching them traditional values and life in harmony with nature.

As another good example that the tradition and culture of a specific area can be a good platform for development and a completely different view and expansion of the range of offerings is the inclusion of old watermills in tourist flows where a completely new way of interaction has been developed through miller "storytelling" where millers in an interesting and authentic way tell their personal stories about the mills, and using QR codes all visitors (at any time) are enabled to get such information and thereby achieve a higher quality experience of the destination itself and gain new knowledge.

Through the networking of different factors and economic branches, there has also been a revival of agricultural production, but in the old traditional way. In addition to organic vegetable production, production of famous Homolje and Kamenovo honey and other bee products, "osmak“ corn has also been revived. This way, an exclusivity of flour from this old variety of corn, which was once produced and used for human consumption before being supplanted by new, more modern varieties of corn, has been achieved. This flour further increases its quality through the method of grinding in the mill using "cold" milling, which unlike the industrial method of production, largely retains the nourishing nutrients because it does not lead to so-called "burning" of the flour due to high speed of milling. If to this is added an authentic natural environment adorned with Homolje mountains, clean air, and the hospitality of the local community, we get a concept of development and life in a completely new, yet still old way of life, which was not so long ago characteristic of these areas, but also our country.

A connection between traditional gastronomy and modern methods of communication through digital marketing has also been achieved. In addition to actively managing and updating content on social networks, new adequate websites and web applications have been created.

One of the interesting ways of presenting gastro heritage and women's entrepreneurship is the involvement of Women's Associations. Thus, women from the "Association of Millers and Mill Workers," in cooperation with the local Tourist Organization, recorded short video presentations on how traditional specialties made from mill flour are prepared. Printed versions of cookbooks with QR codes leading to links with recipes have also been produced.

Innovation (which actually represents a more modern view and adaptation of something we already have, perhaps even for centuries) has arisen from the need

to solve specific challenges of the local community in the rural area of the municipality of Petrovac na Mlavi. Through cooperation and with the help of local institutions, solutions were found that can always be found in the external environment.

## 3. Concluding considerations

The concept of smart rural development, as demonstrated by the example of the municipality of Petrovac na Mlavi, provides local communities with new opportunities to apply innovative solutions in the fields of agriculture, tourism, and industry by relying on their own potentials (Naldi & Nilsson & Westlund & Wixe, 2015). Through the integration of traditional values such as cultural heritage and local gastronomy with modern technologies, the municipality of Petrovac na Mlavi has managed to transform its position and become a significant participant on the tourist map of Serbia.

The example of this municipality shows that digitization and innovation can successfully support economic development even in underdeveloped rural areas ("Smart rural areas – in the 21st century", 2021). Interaction with the diaspora, support for women's entrepreneurship, utilization of local resources and development of new business models have significantly contributed to the creation of new jobs and the improvement of living conditions. Petrovac na Mlavi is becoming an example of how tradition and modern technology can be combined to create a sustainable, prosperous community.

This approach confirms the importance of strategic planning in the context of rural development and emphasizes the need for continuous collaboration between local actors and the wider community to achieve common goals.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# IMPORTANCE OF INNOVATION MANAGEMENT SYSTEM IN ORGANIZATIONS

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***Abstract***

*In today's rapidly evolving technological landscape, organizations are under immense pressure to innovate. This paper explores the critical role of innovation in navigating the competitive modern market. As emerging technologies disrupt traditional business models, innovation becomes essential for survival and growth. Through the analysis of market dynamics and consumer expectations, this study reveals how innovation enables organizations to strengthen their market position and gain sustainable competitive advantages. Furthermore, the paper aims to outline practical implications for managers to foster a culture of innovation within their organizations, empowering them to drive transformative change and unleash the full potential of their teams. Additionally, it is necessary to emphasize the relevance of standards such as ISO 56001 in ensuring that effective innovation management practices are in place.*

***Key words:*** *innovation, innovation management system, standard ISO 56001*

## 1. Introduction

The market is increasingly oriented towards rapid growth and the constant development of new technologies, which imposes the need for organizations to respond agilely to these dynamic market challenges (Vrhovac et al., 2023). In order to maintain their competitiveness, organizations are obliged to continuously improve their processes, that is, to introduce innovations (Ivanova -Assoc, 2022). Innovations are born from the synergy of professional knowledge and personal skills, with creativity being a key factor. Contrary to the misconception that standards stifle creativity, modern management system standards have evolved to

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become a source of best practices that can enhance organizational performance across various domains (Zizakov et al., 2020). In fact, recent trends in management system standards demonstrate that they can be leveraged to drive improvement and innovation in organizations (Tzvetelin Gueorguiev, 2021).

Since the eighties of the twentieth century, organizations have been increasingly striving to implement standards in the field of quality systems (Delić et al., 2014). ISO 9001 promotes a systematic approach to reviewing quality management systems, allowing organizations to continually enhance their processes using relevant data and insights from the system. The implementation of ISO 9001 establishes a framework for systematically collecting, analyzing, and applying data to pinpoint areas for improvement and optimization. In recent years, there has been an increasing focus on process improvement, which has become closely tied to an organization's ability to effectively implement innovations across all areas of its operations (M. Žižakov et al., 2023).

ISO 9001 – Quality Management System serves as the foundation for management systems, and other ISO standards can be built upon it. In September 2024, the International Organization for Standardization released the first version of a standard focused on innovation management – ISO 56001:2024 – which organizations can now be certified against (*ISO - International Organization for Standardization*, n.d.). This standard is designed to enhance an organization's ability to innovate consistently and effectively (International Organization for Standardization, 2024). In today's fast-paced and ever-evolving business environment, the capacity for innovation is essential for organizational survival and growth (Ivanova -Assoc, 2022; Tzvetelin Gueorguiev, 2021). The aim of this paper is to emphasize the importance of standardization of the management system, with a special emphasis on the Innovation management system. In addition, the goal is to provide support and encourage management to improve their management system. Finally, guidelines are given that will make it easier for managers to introduce the ISO 56001 standard.

The upcoming section provides a theoretical background on the key aspects of the research. Section 3 presents a literature review in the researched area. Section 4 presents a discussion with managerial implications. The paper concludes with the most important conclusions, limitations, and suggestions for future research.

## 2. Theoretical background

This chapter presents the theoretical foundations of the key aspects of the research.

### 2.1 Innovation performance

Innovation can be seen as a company's capacity to introduce changes and enhancements within its processes. Additionally, it reflects the organization's inclination to embrace new ideas that facilitate the development and launch of new products or services, management strategies, procedures, or technologies (Chang et al., 2017; Liao & Wu, 2010). More broadly, innovations refer to new applications of

knowledge, ideas, methods, and skills that can generate unique capabilities, thereby increasing the competitiveness of the organization (Kim et al., 2012).

Establishing an innovation management system signifies a significant transformation for any organization. Central to this system is the innovation process, which encompasses activities such as identifying change opportunities, gathering and analyzing data, developing conceptual solutions, assessing potential risks, outlining advantages and benefits, and determining overall value (Ivanova - Assoc, 2022).

### 2.2 Quality management system – ISO 9001

This standard defines the requirements that the organization must meet in order to establish, implement, and maintain an efficient quality management system. It is convincingly the most applied by all management system standards around the world and is an international reference for quality management system certification (Fonseca, 2015). The standard was created in an international framework in order to define the best quality practices to be adopted, with a central focus on the expectations of users and other interested parties from the organization. ISO 9001 adopts a process approach, which includes the PDCA cycle of continuous improvement and integrates risk-based thinking, enabling not only user loyalty but also the competitiveness of the organization based on the pillars of sustainability (*ISO - International Organization for Standardization*, n.d.). Any organization that wants to improve its quality management system, meet customer and applicable statutory and regulatory requirements, and enhance customer satisfaction can use the ISO 9001 standard. It is suitable for organizations of any size and applies to all sectors, including manufacturing, services, healthcare, education, government, and non-profit organizations.

### 2.3 Innovation management system – ISO 56001

However, innovation management system: ISO 56001 provides requirements and guidance for establishing, implementing, maintaining, and improving an innovation management system, aiming to enhance an organization's ability to innovate consistently and successfully (International Organization for Standardization, 2024; Ivanova -Assoc, 2022). This standard lays out a general guideline for all types of innovation, including products, services, processes, and business models. It is applicable to all types of organizations, regardless of their nature, size, or the products and services they offer, providing a systematic approach to promoting and managing innovation (*ISO - International Organization for Standardization*, n.d.).

Establishing an innovation standard through ISO 56001 is not about limiting creativity but rather about enhancing the innovation process. It fosters a culture that values creativity while ensuring a structured execution approach. Importantly, the workflow remains adaptable to each organization's unique style, allowing for a flexible framework that can be tailored to specific needs. This ensures that the creative spirit is preserved, enhancing both ideation and execution rather than

hindering them (*Https://Www.Planbox.Com/10-Most-Popular-Iso-56001-Questions-Answered/*, n.d.).

Benefits of ISO 56001 (International Organization for Standardization, 2024):

- Enhances innovation performance and the capacity to manage uncertainty
- Increases the realization of value from innovations in products, services, and processes.
- Builds a culture of continuous improvement and sustained innovation capability.
- Improves reputation, attracting more customers, partners, and investors.
- Enhances collaboration capabilities and increases the potential to attract funding.

## 3. Literature review

Many studies have investigated the impact of quality management on innovation development in various countries. Consistent with theoretical frameworks, empirical research across the globe has consistently demonstrated a positive correlation between quality management and innovation development (Abu-Salim et al., 2019; Hamdoun et al., 2018; Honarpour et al., 2018; Lebedeva et al., 2019; Mokhlis et al., 2019; M. Žižakov et al., 2023).

Research conducted in Serbia in 2022 found that organizations that implement the ISO 9001 standard are successful in developing process innovations (M. Žižakov et al., 2021; M. Žižakov et al., 2023). The study included a diverse range of organizations across various types, activities, and sizes. Of the 264 organizations that participated in the research, which required certification to at least one standard, 238 organizations had a certified system according to the ISO 9001 standard, representing 90.2% of the sample population. This outcome is expected, as the ISO 9001 standard serves as the foundation for each system. In terms of certification frequency, the next most common standards were ISO 14001 (50.4%) and ISO 45001 (28%). These standards are often upgraded to ISO 9001 and subsequently integrate management systems (M., Žižakov et al., 2021; M. Žižakov et al., 2023). In the near future, it can be expected that the ISO 56001 standard will be one of the most common standards of the integrated management system precisely because of the increasing need for the development of innovations.

The results suggest that management systems cover most of the processes of firms, including firm innovation processes. In Spain, in 2022, a study was conducted on the impact of the Degree of Standardization and Innovation Capability Dimensions as Driving Forces for Innovation Performance, which also confirmed that the degree of standardization is a positive contributor to higher innovation performance.

Furthermore, the study's findings also corroborated the notion that the degree of standardization is a significant positive contributor to higher innovation performance, as suggested (Mir et al., 2022).

This study provides valuable insights for managers. The findings suggest that investing in implementing a management system is worthwhile, as the

implementation effort will yield a positive return. Furthermore, a higher degree of standardization across the organization can be a valuable complementary factor to the firm's innovation capability, enhancing innovation performance and ultimately driving better business outcomes (Hyland & Karlsson, 2021). They also provide support to organizations to standardize systems and encourage them to implement the requirements of the new standard ISO 56001 - Innovation Management System.

## 4. Discussion

Based on the review of the literature, it was determined that business standardization has a positive effect on innovation performance (Mir et al., 2022). The ISO 56001:2024 standard outlines requirements and guidelines for organizations to innovate efficiently and effectively, thereby enhancing their innovation capabilities and market competitiveness (International Organization for Standardization, 2024). Organizations should promptly start harmonizing their operations with the requirements of this standard in order to develop and apply good innovation management practices. The application of the requirements of the standard can significantly contribute to the improvement of operational efficiency and the market position of the organization, even without formal certification of the system (Mir et al., 2022).

ISO 56001 adopts a harmonized structure compatible with other management system standards, enabling seamless integration. Organizations can align or incorporate their innovation management system with other standards, creating synergies that enhance overall management efficiency (International Organization for Standardization, 2024).

Below are defined guidelines that will help managers to adequately approach the implementation of the requirements of the ISO 56001 standard, that is, the integration of the management system.

### 4.1 Managerial implication

Steps managers should follow:

1. Informing top management about the need, goals, and benefits of improving the system in accordance with the standard's requirements. The team, previously formed to be involved in the integration of the management system, should also be informed of these aspects.
2. Assessment, analysis, and evaluation of the system within the organization to determine the extent to which certain standard requirements are being met. Additionally, it is necessary to identify the starting elements for system improvement. During this step, the team familiarizes itself with the functioning of all processes and the existing documentation.
3. Develop an improvement program with proposals for new documentation that needs to be created and the redefinition of existing documentation. It would also be advisable to define the time required for the implementation of the entire program, i.e., the schedule.

4. Creating the documentation can involve trained employees or external consultants. Once the documentation is completed, a trial implementation is conducted to verify its quality and identify any potential shortcomings. After the trial phase and any necessary adjustments, the documents are finalized and put into practice.
5. Internal audit of the established system carried out by auditors, followed by the correction of any identified non-conformities. Finally, the system is certified by an accredited domestic or international certification body.

## 5. Conclusions

The paper emphasizes the importance of innovation, which is necessary for achieving a competitive advantage. One of the ways in which organizations can constantly improve their system is precisely by introducing certain standards, i.e. by standardizing good practices (Mir et al., 2022).

Various empirical studies have confirmed that the ISO 9001 standard has a positive impact on innovation performance, and it mainly represents the basis of any management system (Abu-Salim et al., 2019; Hamdoun et al., 2018; Honarpour et al., 2018; Lebedeva et al., 2019; Mokhlis et al., 2019; M. Žižakov et al., 2023).

In addition, the work emphasizes the new ISO 56001 standard, which focuses on the innovation management system, and it is expected that it should give even better results and an even greater contribution to innovation performance. Also, guidelines are given that make it easier for managers to implement the innovation management system, i.e., the integration of the management system.

The standard ISO 56001 was issued in September 2024, organizations will go through process of certification in the near future.

So, the proposal for future research is to carry out an empirical investigation of the impact of the innovation management system on the innovation effect because the standard ISO 56001:2024 is the first certifiable international standard for innovation management.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# TRENDS IN RURAL TOURISM: THE ENGINE FOR LOCAL DEVELOPMENT

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***Abstract***

*Over the past half-century, rural areas have experienced a decline in vitality due to various reasons, primarily caused by emigration and a decline in population. However, in recent years, especially during and after the pandemic period, rural tourism has become extremely attractive to tourists and has become a factor in revitalizing rural areas. Rural tourism, as a selective form of tourism, encompasses numerous resources, spaces, and activities that not only attract tourists but also bring significant quantitative and qualitative changes to rural settlements and the lives of local communities. The positive changes affected by the development of rural tourism are undeniable on different levels - destination level, national level, local community level or rural household level. However, it is crucial that rural tourism, given the sensitivity of rural areas, develops in a planned, careful, and sustainable manner. The aim of this paper is to highlight the trends in the development of rural tourism and the positive and negative aspects of its development. The paper will present good practices in the development of sustainable rural tourism in the Municipality of Irig (Vojvodina, Serbia). Economic benefits for all relevant stakeholders, protection of natural resources and the introduction of new ecological practices, protection, and revitalization of cultural heritage, involvement of local population in the planning and development of rural tourism, with active support from the government and non-governmental sectors through education and financing, must be key directions in the sustainable development of this form of tourism.*

***Key words:*** *rural tourism, sustainable development, Municipality of Irig (Vojvodina, Serbia), trends in tourism.*

## 1. Introduction

Over the past 20 years, rural tourism has been steadily increasing, and the onset of the COVID-19 pandemic has accelerated this growth further.

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Most rural areas around the world are facing population decline and changes brought about by industrialization and urbanization, particularly intensified in the last decades. These processes have led to a decrease in farmers' incomes, reduced agricultural employment, weakened vitality of rural communities, and infrastructure degradation.

Governments in many countries, with the support of local and regional agencies, are working to find solutions for the revitalization of these areas. Rural tourism is recognized as a significant factor in the recovery and preservation of nature, landscapes, historical sites, and traditional lifestyles. Rural areas often have unique customs and identities, and natural features such as mountains, rivers, and lakes further enhance their appeal for tourism.

Rural tourism is evolving to meet the changing needs and preferences of travelers who are seeking authentic, sustainable, and immersive experiences. By embracing these trends, rural communities can continue to attract visitors and contribute to local economic development.

The aim of this paper is to highlight the trends in the development of rural tourism. The paper will present the case of sustainable rural tourism development in the Municipality of Irig, Vojvodina, Serbia.

## 2. Tourism in Rural Areas

Rural areas can vary greatly in character – they can be suburban areas, villages in plains, or pastures in high mountains. Although there is no single definition, it can be observed that rural settlements can vary in size but are typically small, with fewer than 10,000 inhabitants and a lower population density. Additionally, agriculture is the dominant activity, and the influence of tradition and history is strong. The OECD defines a rural area as a region with a population density of 150 people per square kilometer.

Nearly all rural areas worldwide face problems of population decline and economic and political changes brought about by the powerful trends of industrialization and urbanization. These trends have intensified in recent decades, leading to a significant decrease in farmers' incomes, a reduction in agricultural employment, a decline in the vitality of rural settlements, a deterioration in the quality of infrastructure, and other issues.

Governments in many countries, in cooperation with their regional and local agencies, are trying to find ways to revitalize rural areas. Rural regions hold exceptional importance as they often act as custodians of a country's natural and cultural heritage (Singh et al., 2023). In this sense, rural tourism is recognized as one of the ways to revitalize rural areas (Yang et al., 2021). Rural areas are often characterized by unique customs and identities, traditional ways of life, historical landmarks, and natural resources such as mountains, nature reserves, rivers, lakes, and more, which attract tourists and make them appealing for tourism development.

Rural tourism can be most simply defined as any tourist activity in a rural setting. The terms often mentioned, and sometimes mistakenly equated with rural tourism, are village tourism and agritourism. Both are narrower concepts than rural

tourism. Village tourism involves tourist activities in villages, while agritourism refers to tourist activities in agritourism accommodation units.

Rural tourism has several key characteristics: it always takes place in rural areas and, on the one hand, is based on the heritage, traditions, and specific way of life and activities of the local population, and on the other hand, it is carried out in direct contact with nature. In this sense, rural tourism can take various forms, including selective types of tourism such as sports-recreational tourism, camping tourism, gastronomic and wine tourism, health tourism, cultural tourism, event tourism, religious tourism, ecotourism, and many other forms of tourism that can be realized in rural areas.

Rural tourism is based on small entrepreneurship, positively impacts the diversification of activities in rural areas, and ensures higher employment levels for the local population, with a particular focus on hard-to-employ categories such as youth, women, and the elderly.

## 3. Emerging Trends in Rural Tourism

Rural tourism has experienced significant growth over the past two decades, with rapid and sustained expansion following the onset of the COVID-19 pandemic.

For rural tourism to develop successfully, several fundamental elements are necessary – space with its natural and cultural resources, people with their knowledge and skills, and products that reflect the tradition of a specific place or area.

In addition, understanding the key trends in this field is crucial. The forms and trends in tourism that are shaping rural tourism are:

- Authentic experience: Farm stays, traditional life experiences, and farm-to-table dining are becoming increasingly popular. These allow visitors to truly experience the rural and local way of life from participating in traditional crafts to learning about regional history and customs (Anzardo et al., 2021).
- Eco-tourism and connection to nature: Travelers are becoming more conscious of their environmental impact and are seeking accommodations and activities that prioritize sustainability. Nature-based activities such as hiking, biking, camping, and wildlife watching are driving the growth of tourism in rural areas (Funduk et al., 2023; Chen et al., 2023).
- Wellness tourism and mindful holidays: Rural destinations are offering a range of wellness retreats, yoga classes, and spa treatments, catering to travelers seeking relaxation and rejuvenation (Ekonomou et., 2023).
- Digital detox: The trend towards disconnecting from technology where visitors in rural environments can experience the escape the hustle and bustle of urban life (Cai & McKenna, 2024).
- Slow travel and extended stays: Travelers are opting for longer stays in rural areas, allowing them to fully immerse themselves in the local culture and experience a slower pace of life. Additionally, rural destinations are a common choice of digital nomads (Jovičić Vuković, 2022).

- Gastrotourism: Rural areas are renowned for their fresh, locally sourced produce and unique culinary traditions and can offer farm-to-table cuisine. Visitors are seeking authentic local products to support the local economy (Arion, 2024).

Rural tourism is evolving to meet the changing needs and preferences of travelers who are seeking authentic, sustainable, and immersive experiences. By embracing these trends, rural communities can continue to attract visitors and contribute to local economic development.

Despite the positive trend of rural tourism development, the sector continues to face notable challenges related to the professional and skill development of its key stakeholders, including entrepreneurs and staff.

Moreover, rural tourism requires the support of various stakeholders. Support for the development of rural tourism is provided through the aid of national, provincial, and local institutions and organizations. This assistance is not only realized through financial incentives such as subsidies and loans but also through education, the development of specific skills needed for tourism work, as well as empowering and educating individuals in entrepreneurial knowledge and skills (Chan, 2023)

## 4. Rural Tourism in Serbia: Case of Irig Municipality

Rural tourism development brings numerous benefits (Dašić et al, 2020). Through rural tourism and the stay of foreign tourists, "invisible export" is realized, significantly affecting a country's economy. Tourism provides an opportunity for less developed areas to reach the level of developed ones in terms of opening new jobs, self-employment, and local investments. Additionally, rural tourism helps reduce disparities in economic development between rural and urban areas and regions, decreases migration from rural to urban areas, and promotes rural infrastructure development. Furthermore, it increases employment and creates better living conditions.

A particularly significant effect of this development is preserving and revitalizing traditional architecture, gastronomy, customs, and folklore while introducing foreign tourists to a particular area's culture and way of life, holds social and political significance. A substantial positive impact of rural tourism is reflected in the preservation of cultural heritage and the nature of a country (Job et al., 2020).

Local communities that have recognized the importance of rural tourism development in their municipalities achieve diversification of activities, additional collective income, creation of new jobs, improved living and working conditions, increased sales of local products, and more through rural tourism.

An example of the best practices of rural tourism development in the Republic of Serbia is the municipality of Irig, that potential lies in the area's rich cultural, historical, and natural heritage.

The municipality of Irig is located in the northern part of the Republic of Serbia, in Vojvodina, in the central part of Srem on the southern slopes of Fruška Gora. The municipality's territory is at the highest altitude of all municipal centers

in Vojvodina. Irig has a rich history and numerous cultural values. It abounds with beautiful landscapes offering views of forests and fields and fresh air. The municipality of Irig has the Fruška Gora National Park, a spa with thermal mineral springs in Vrdnik, eight medieval monasteries, and many cultural monuments. It is also home to numerous wineries and hosts various events. All of the mentioned potentials highlight the possibilities for developing various selective forms of rural tourism, including:

- Sports and recreational tourism – the area is suitable for activities such as hiking, cycling, horse riding, camping, hunting, fishing, and other activities
- Cultural tourism is realized through visits to Fruška Gora monasteries, wine routes, visits to cultural monuments, or events;
- Business tourism – the construction of modern conference spaces and the adaptation of existing ones has made the destination attractive for organizing meetings, congresses, seminars, and workshops;
- Health and Spa & Wellness tourism is developed through the use of thermal waters in the hotels in Vrdnik Spa;
- Ecotourism is realized through activities within Fruška Gora National Park, including bird watching, beekeeping, nature study, and other activities focused on nature conservation;
- Ethno tourism is achieved through visits to ethno galleries, gastronomic tourism, i.e., consumption of locally produced food, and learning about customs and old crafts, among other things.

To better understand the development of rural tourism in the municipality of Irig, it is necessary to examine changes in the number of tourists and overnight stays over a ten-year period (2013-2023).

The changes in the number of domestic and foreign tourists, in total numbers, as well as in the number of overnight stays during the ten-year period from 2013 to 2023 in the municipality of Irig, are evident (Table 1). The number of domestic tourists in the observed period increased by 4.2 times, while the number of foreign tourists increased by 17.3 times, with the total number of tourists in 2023 higher by 73,303. When looking at overnight stays, a total increase of 143,065 is also noted, with foreign tourists' overnight stays increasing by 2.1 times, and foreign tourists overnight stays increasing by 15.3 times in 2023 compared to 2013. In the years after the end of the COVID-19 pandemic (2022 and 2023), there was a significant increase in the number of tourists and overnight stays, particularly in the case of foreign tourists.

*Table 1: Tourist turnover in the municipality of Irig – period 2013-2023*

| Year | Tourists' arrivals | | | Tourists' overnight stays | | |
|---|---|---|---|---|---|---|
| | **Domestic** | **Foreign** | **Total** | **Domestic** | **Foreign** | **Total** |
| **2013** | 15,095 | 1,475 | 16,570 | 72,869 | 4,093 | 76,962 |
| **2014** | 12,210 | 2,271 | 14,481 | 52,911 | 6,833 | 59,744 |
| **2015** | 15,404 | 2,690 | 18,094 | 57,379 | 7,331 | 64,741 |
| **2016** | 19,959 | 3,618 | 23,577 | 92,258 | 8,351 | 100,609 |
| **2017** | 23,783 | 5,015 | 28,798 | 91,848 | 12,288 | 104,136 |

| Year | Tourists' arrivals | | | Tourists' overnight stays | | |
|---|---|---|---|---|---|---|
| | Domestic | Foreign | Total | Domestic | Foreign | Total |
| **2018** | 22,691 | 5,123 | 27,814 | 90,361 | 11,721 | 102,082 |
| **2019** | 23,249 | 5,451 | 28,700 | 91,978 | 12,903 | 104,881 |
| **2020** | 28,719 | 2,848 | 31,594 | 86,722 | 6,313 | 93,035 |
| **2021** | 53,545 | 8,293 | 61,838 | 124,415 | 19,620 | 144,035 |
| **2022** | 64,318 | 15,054 | 79,372 | 63,349 | 38,523 | 201,187 |
| **2023** | 64,252 | 25,621 | 89,873 | 157,380 | 62,647 | 220,027 |

*Source: Internal documentation of the Irig Tourist Organization*

By observing the number of tourists and overnight stays in the first seven months of 2024 (Table 2), it can be concluded that the most visited month was July, when 6,651 domestic and 4,149 foreign tourists stayed in the municipality of Irig. In terms of overnight stays, the highest number of both domestic and foreign tourists was also recorded in the month of July

One of the key reasons for the increase in tourist arrivals and the number of overnight stays is the significant improvement in tourism and accommodation offerings. The opening of luxury accommodation facilities, the enhancement of accommodation quality, and its quantitative growth stand out as catalysts for development. In 2012, the municipality of Irig, with Vrdnik Spa as the central point of rural tourism development, began significant changes in its accommodation structure. That year, alongside the existing Termal Hotel, the luxury Premier Aqua Hotel opened, followed by the ethno-complex Vrdnička Kula. In 2019, the Fruške Terme resort hotel started operating and expanded its spa capacities over the years. In 2022, the hotel became part of the Accor chain under its Movenpick brand through a franchise agreement. The entry of an international hotel chain is particularly important for the destination and the region, as hotel chains are standard-bearers and initiators of change in all aspects of the hospitality and tourism industry.

*Table 2: Tourist turnover in the municipality of Irig for the year 2024*

| 2024 Month | Tourists' arrivals | | | Tourists' overnight stays | | |
|---|---|---|---|---|---|---|
| | Domestic | Foreign | Total | Foreign | Domestic | Total |
| January | 4,348 | 2,151 | 6,499 | 9,442 | 4,989 | 14,431 |
| February | 5,631 | 1,937 | 7,568 | 11,275 | 3,823 | 15,098 |
| March | 5,599 | 2,154 | 7,753 | 11,928 | 4,139 | 16,067 |
| April | 5,222 | 2,458 | 7,680 | 11,277 | 4,785 | 16,062 |
| May | 5,758 | 3,774 | 9,532 | 12,609 | 8,072 | 20,681 |
| June | 5,895 | 3,539 | 9,434 | 14,892 | 7,438 | 22,330 |
| July | 6,651 | 4,149 | 10,800 | 17,907 | 10,207 | 28,114 |
| Total | 39,104 | 20,162 | 59,266 | 89,330 | 43,453 | 132,783 |

*Source: Internal documentation of the Irig Tourist Organization*

It is also necessary to address the diversification of accommodation facilities in the Municipality of Irig. According to internal data from the Irig Tourist Organization from 2024, there are 2,336 beds distributed across 1,015 registered accommodation units, most of which are located in the Vrdnik spa (916

accommodation units and 2,094 beds). The types of accommodations available in the municipality include rooms, apartments, studio apartments, holiday homes, rural tourist households, guesthouses, resorts, lodges, bungalows, and hotels, which have the largest number of accommodation units (429) and beds (1,003) overall.

Tourism development in the Irig Municipality has brought positive changes reflected in the activation of the tourism offering, the development of new services and products, the improvement of local infrastructure, a higher level of local participation in activities and events, and the growth of investments. For the local community, tourism development has increased employment opportunities for all categories of the population, raised the standard of living, facilitated the sale of local products, provided opportunities for business diversification, and more.

## 5. Conclusions

Rural tourism, while representing a small portion of the overall tourism market, plays a crucial role in revitalizing rural economies. It generates jobs, fosters economic growth, and preserves local traditions, culture, and natural resources.

For rural tourism to be sustainable, it must be carefully planned and developed in accordance with sustainability principles. This includes protecting natural resources, promoting ecological practices, preserving cultural heritage, and ensuring active community involvement in the development process. Government and non-governmental support through education, financing, and capacity-building is essential to achieving these goals.

The sustainable development of rural tourism, as seen in the Municipality of Irig, offers a model for how rural communities can thrive while maintaining their cultural identity and preserving their natural environments.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DETERMINING CRITERIA WEIGHTS IN FRUIT PRODUCTION USING FUZZY MCDM METHOD

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***Abstract***

*This research focused on the use of multi-criteria decision-making (MCDM) methods in fruit production, which requires the evaluation of numerous economic, biological, and technological factors. The complexity of decision-making in fruit production stems from the need to assess both quantitative and qualitative criteria. To address this, we applied the IMF SWARA method and the Fuzzy Bonferroni operator to determine the weight coefficients of key criteria. The research was conducted in multiple stages, utilizing a combination of different methods. In the first stage, the research team identified 11 criteria to be evaluated by various experts. In the second stage, a survey was developed, and 17 experts in the field of fruit production assessed the weight of the parameters. Finally, the determination of the criteria weights, using the IMF SWARA method and the Fuzzy Bonferroni operator, was based on the previous evaluation provided by four experts who identified themselves as belonging to the group of "University Professors". Out of a total of eleven criteria, two (C4 and C7) were identified as the most important.*

***Key words:*** *cultivars/rootstocks, ranking, fruit experts, evaluation, agriculture*

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# 1. Introduction

Competitiveness in fruit production depends on a range of factors, including economic, biological, technological, meteorological, and others. Achieving favourable economic results requires management and decision-making processes that acknowledge the existence of multiple factors and criteria, as well as the use of generally accepted methods of multi-criteria decision-making. On the other hand, research activities in fruit production and breeding involve the use of a larger number of criteria (attributes), some of which are quantitative while others are qualitative in nature. The existence of numerous criteria (attributes) and goals, both in production practice and in research activities, necessitates their systematization and the use of appropriate methods of multi-criteria analysis. This approach contributes to reducing subjectivity during decision-making (ranking), ultimately having a positive effect on the objectivity of the outcome of the given process. In recent years, a number of publications have been released in the scientific literature that deal with the practical application of multi-criteria decision-making methods in various fields of agriculture, including fruit production (Rozman et al., 2017; Vico et al., 2017; Bodiroga et al., 2022).

The wide range of application areas for multi-criteria analysis models has led to the rapid development of methods in this field. Consequently, we now have at our disposal a powerful set of methods capable of successfully solving most real-world MCDM problems. A review of numerous literature sources (Polatidis et al., 2006; Velasquez & Hester, 2013) has established that multi-criteria analysis methods can be divided into:

Multiple Attribute Decision Making (MADM) is characterized by the need to select the most acceptable alternative from a set of alternatives presented based on defined criteria. The common way of representing MADM problems is in matrix form (performance matrix or decision matrix).

Multiple Objective Decision Making (MODM) is explicitly defined by the analytical form of each criterion individually. A characteristic of MODM is that, through certain mathematical analyses, a set of multiple objective functions is transformed into a single-criterion decision-making problem. This is then solved using the standard method of single-criterion linear programming, most commonly the simplex procedure.

Regardless of the applied technique, the procedure will consist of the following phases: Defining the problem and certain key parameters; Determining the decision criteria – the model creation phase; Formulating functional relationships between the established criteria; Generating alternatives – the model solving phase, and Selecting an action in accordance with the established criteria – the solution implementation phase.

The aim of this research is to show the method of determining the weighting coefficients of criteria using the IMF SWARA method and Fuzzy Bonferroni operator.

## 2. Methods

The research was conducted in multiple stages, utilizing a combination of different methods. In the first stage, the research team identified 11 criteria to be evaluated by various experts. In the second stage, a survey was developed, and 17 experts in the field of fruit production assessed the weight of the parameters. Finally, in the third stage, the individual criterion weights were determined based on the evaluations of four experts from the group categorized as "University Professors."

### 2.1. IMF SWARA method

The IMF SWARA method was proposed by Vrtagić et al. (2021) and it contains the steps given below (Moslem et al. 2023):
Step 1: Put the criteria in descending order according to their expected importance.
Step 2: Identify a relatively lower importance of the criterion (criterion *Cj*) in relation to the previous one (*Cj−1*), and repeat it for each subsequent criterion. $\overline{\wp_j}$ represents the comparative importance of an average value.

Step 3: Define the fuzzy coefficient $\overline{\Im_j}$ :

$$\overline{\Im_j} = \begin{cases} \bar{1} & j = 1 \\ \overline{\wp_j} \oplus \bar{1} & j > 1 \end{cases}$$

Step 4: Define the obtained weights $\overline{\aleph_j}$ :

$$\overline{\aleph_j} = \begin{cases} \bar{1} & j = 1 \\ \dfrac{\overline{\aleph_{j-1}}}{\overline{\Im_j}} & j > 1 \end{cases}$$

$\overline{\Im_j}$ represents the fuzzy coefficient given in the previous step.
Step 5: Compute the fuzzy weight coefficients:

$$\overline{w_j} = \frac{\overline{\aleph_j}}{\sum_{j=1}^{n} \overline{\aleph_j}}$$

where the fuzzy relative weight of the criteria *j* is denoted by $\overline{w_j}$ , and the number of criteria is denoted by *n.*

### 2.2 Fuzzy Bonferroni operator

For averaging criteria weighs obtained by four decision-makers, a fuzzy Bonferroni aggregator was used (Ashraf et al. 2022; Nedeljković et al. 2021).

$$a_{ij} = (a_{ij}^l, a_{ij}^m, a_{ij}^u) = \begin{cases} a_{ij}^l = \left( \dfrac{1}{e(e-1)} \sum\limits_{\substack{i,j=1 \\ i \neq j}}^{e} a_i^{lp} \otimes a_j^{lq} \right)^{\frac{1}{p+q}} \\ a_{ij}^m = \left( \dfrac{1}{e(e-1)} \sum\limits_{\substack{i,j=1 \\ i \neq j}}^{e} a_i^{mp} \otimes a_j^{mq} \right)^{\frac{1}{p+q}} \\ a_{ij}^u = \left( \dfrac{1}{e(e-1)} \sum\limits_{\substack{i,j=1 \\ i \neq j}}^{e} a_i^{up} \otimes a_j^{uq} \right)^{\frac{1}{p+q}} \end{cases}$$

where $e$ is the number of experts participating in the research, and $p, q \geq 0$ are a set of non-negative numbers.

## 3. Results and discussion

### 3.1 Expert evaluation of criteria

The implementation of methods for determining weight coefficients was carried out on 11 selected criteria for ranking combinations of plum cultivars/rootstocks that are important in biotechnical research processes. Given that the selection of a combination of cultivars/rootstocks in fruit production is an extremely demanding process that includes various aspects, the following criteria are included: C1 - the number of flower buds per 1 m of fruiting twig (number/m); C2 - the number of flower buds per 1 m of 2-year old twig (number/m); C3 - germination of pollen (%); C4 final fruit set (%); C5 - trunk cross-sectional area (tree vigor, $cm^2$); C6 – Cumulative yield efficiency ($kg/cm^2$); C7 - Fruit weight (g); C8 – Flesh ratio (%); C9 Soluble solids (%); C10 - Total phenolic content in skin of fruit (mg GAE $g^{-1}$ FW); C11 - radical-scavenging activity (μmol TE $g^{-1}$ FW).

According to many authors (*Nenadović-Mratinić et al*., 2007; *Thurzó et al*., 2008; *Milatović et al*., 2014), the density of flower buds is an important parameter which indicates the potential yield of cultivars. The density of flower buds is important for determination of the intensity of pruning, because the cultivars with higher number of flower buds require heavy pruning, while the cultivars with less number of flower buds require light pruning (Milatović & Đurović, 2010).

The correct choice of the appropriate main cultivar in the orchard, as well as the selection of the appropriate pollinator, is one of the basic conditions for successful and profitable production of fruit trees. Pollination and fertilization are essential for adequate fruit set in plums. The functional ability of pollen, i.e. its germination and the growth of the pollen tube condition the processes of fertilization and fruit set.

Fruit set is one of the most significant indicators of fruit trees productivity (Glišić et al., 2012; Nikolić et al., 2012). Trunk cross-sectional area (TCSA) is considered as the most important indicator of tree vigor. Using of dwarf or semi-

dwarf rootstocks enables an increase of the number of trees and higher yield per unit area (Kosina et al., 2000). One of the most important pomological properties of cultivar is fruit weight. Fruit weight is a characteristic that is inherited quantitatively and which determines yield, fruit quality and consumer acceptability (Crisosto et al., 2004).

According to many authors, the key parameters that determine the quality and the acceptance of the fruit by consumers are the content of soluble solids and total acids, as well as ration between them. (Crisosto et al., 2004). Phenolic compounds are biologically active substances having antioxidant properties and positive effects on human health (Walkowiak-Tomczak, 2008). The skin contains about five times more phenolic substances than the flesh (Stacewicz-Sapuntzakis et al., 2001). Antioxidant activity of plum fruits is higher in comparison to other pome and stone fruits, with the exception of sour cherries. In relation to the apple it is two to four times higher (Kim et al., 2003; Cho et al., 2007). The antioxidant activity values are significantly higher in the skin than in the flesh of the fruits, which can be explained by the higher content of total phenolic compounds and anthocyanins (Stacewicz-Sapuntzakis et al., 2001). Preliminary results are related to four of 17 experts involved in project research who are university professors. Their assessment of the criteria is shown in Table 1.

*Table 1. Evaluation of criteria by four experts*

| E1 | $\overline{\wp_j}$ | E2 | $\overline{\wp_j}$ | E3 | $\overline{\wp_j}$ | E4 | $\overline{\wp_j}$ |
|---|---|---|---|---|---|---|---|
| C3 | | C4 | | C7 | | C3 | |
| C4 | (0,0,0) | C5 | (0,0,0) | C8 | (0,0,0) | C4 | (0,0,0) |
| C7 | (0,0,0) | C6 | (0,0,0) | C9 | (0.222,0.25,0.286) | C2 | (0.222,0.25,0.286) |
| C1 | (0.222,0.25,0.286) | C7 | (0,0,0) | C10 | (0,0,0) | C1 | (0.222,0.25,0.286) |
| C2 | (0,0,0) | C9 | (0,0,0) | C11 | (0,0,0) | C6 | (0,0,0) |
| C6 | (0,0,0) | C1 | (0.222,0.25,0.286) | C1 | (0.222,0.25,0.286) | C5 | (0.222,0.25,0.286) |
| C8 | (0,0,0) | C2 | (0,0,0) | C2 | (0,0,0) | C7 | (0,0,0) |
| C5 | (0.25,0.286,0.333) | C8 | (0.222,0.25,0.286) | C4 | (0,0,0) | C8 | (0,0,0) |
| C9 | (0,0,0) | C3 | (0.222,0.25,0.286) | C3 | (0.222,0.25,0.286) | C9 | (0,0,0) |
| C10 | (0,0,0) | C10 | (0.25,0.286,0.333) | C5 | (0,0,0) | C10 | (0,0,0) |
| C11 | (0,0,0) | C11 | (0,0,0) | C6 | (0,0,0) | C11 | (0,0,0) |

### 3.2 Determining Criteria Weights

After applying all steps of IMF SWARA method and fuzzy Bonferroni operator preliminary weights have been obtained as follows:

$$\underline{\overline{w_1}} = (0.083, 0.089, 0.095), \quad \underline{\overline{w_2}} = (0.089, 0.095, 0.101)$$
$$\underline{w_3} = (0.087, 0.093, 0.099), \quad \underline{w_4} = (0.108, 0.113, 0.118)$$
$$\underline{w_5} = (0.074, 0.080, 0.087), \quad \underline{w_6} = (0.085, 0.090, 0.096)$$
$$\underline{w_7} = (0.103, 0.107, 0.112), \quad \underline{w_8} = (0.085, 0.091, 0.097)$$
$$\underline{w_9} = (0.084, 0.090, 0.096), \quad w_{10} = (0.065, 0.072, 0.079)$$
$$w_{11} = (0.065, 0.072, 0.079)$$

Obtained results show that criteria C4 and C7 represent the most important criteria with crisp values of 0.113, and 0.107 respectively, while C10 and C11 represent criteria that have less significance with equal value of 0.072.

## 4. Conclusions

This paper presents the results of research that are part of the project Multi-Criteria Decision-Making in Fruit Production. Preliminary findings indicate that MCDM methods can be used to address various problems in agriculture and fruit production. Based on the previous survey and independent evaluation of criteria by experts, combined with different mathematical methods, it is possible to obtain the weighting coefficients for selected criteria. In our research, out of a total of eleven criteria, two (C4 and C7) were identified as the most important. After determining the criteria weights, an MCDM method is applied in the next phase, leading to the final ranking of alternatives—in this specific case, combinations of cultivar/rootstock.

For broader application of MCDM methods in solving multi-criteria problems in agriculture, it is necessary to inform researchers and practitioners about the potential of these methods. Since MCDM methods are not well-known among experts in agriculture, there is a need to develop a more "user-friendly" approach. A potential solution could be the creation of specific applications with a simple interface designed for a wider range of users.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# TECHNOLOGICAL INNOVATIONS IN TOURISM BASED ON CIRCULAR ECONOMY

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***Abstract***

*The circular economy represents an innovative approach to economic development that promotes the sustainable use of resources through recycling, reuse, and waste reduction. In the context of tourism, the application of circular economy principles is becoming increasingly significant, especially with the support of technological innovations that enable more efficient and sustainable practices. This paper explores technological innovations in tourism that are based on the principles of the circular economy, including smart resource management systems, digital tools for optimizing energy efficiency, applications for recycling and waste management, as well as platforms for educating tourists about sustainability. Concrete examples of successful implementations of these technologies in various tourist destinations and sectors, such as hotels, restaurants, and travel agencies, are analyzed. Through quantitative and qualitative research methods, the paper provides insights into the economic, ecological, and social benefits brought by these innovations. Special emphasis is placed on evaluating their efficiency and potential for wider application with the aim of achieving sustainable tourism development. The conclusions of the paper highlight the importance of technological innovations as a key factor in the transition to a circular economy in tourism and propose strategies for improving and expanding these practices on a global level.*

***Key words:*** *sustainable tourism, circular economy, technological innovation, resource management, energetic efficiency*

## 1. Introduction

In recent decades, tourism has become one of the fastest-growing global industries, contributing to economic development and job creation worldwide.

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However, the expanding tourism sector also carries a significant ecological footprint, including increased resource consumption, waste generation, and harmful gas emissions. The traditional linear economic model, based on the "take-make-dispose" approach, is increasingly becoming unsustainable in the context of contemporary ecological challenges. In response to these challenges, the concept of a circular economy is gaining importance as a sustainable alternative focused on resource optimization through recycling, reuse, and waste reduction (Kirchherr, Reike, & Hekkert, 2017).

The circular economy in tourism is not only a strategy for reducing the negative impact on the environment, but also a potential source of competitive advantage for destinations and businesses that implement innovative approaches. In this context, technological innovations play a crucial role in enabling more efficient application of circular principles. Innovations such as smart resource management systems, digital platforms for tourist education, mobile applications for optimizing energy efficiency, and tools for recycling and waste management are just some of the ways technology can contribute to sustainable tourism development.

Technological innovations refer to the introduction of new or significantly improved technologies that enable more efficient resource management, process optimization, and a reduction of negative environmental impacts. In the context of the circular economy, they play a crucial role in transitioning from a linear to a sustainable economic model, where resources remain in use for as long as possible.

This paper aims to explore technological innovations in tourism based on circular economy principles, analyzing their effectiveness and potential application in various sectors of the tourism industry. Using quantitative and qualitative research methods, the paper will provide insights into how the application of these technologies can contribute to economic, ecological, and social benefits, and propose strategies for enhancing and expanding best practices to achieve sustainable tourism on a global level.

## 2. Literature Review

The concept of a circular economy is increasingly attracting attention in academic and business circles due to its potential to reduce negative environmental impacts and stimulate sustainable economic growth (Geissdoerfer et al., 2017). In tourism, the application of circular principles is particularly significant, given that this sector substantially contributes to resource consumption and waste generation (Goessling & Peeters, 2015).

Technological innovations play a key role in enabling the effective application of circular economy principles. According to research, smart resource management systems and digital platforms for optimizing energy efficiency are among the main technologies contributing to reducing the negative ecological footprint (Bocken et al., 2016). The use of digital tools and applications for recycling and waste management allows for better resource control, while educating tourists through modern platforms can promote more responsible behavior (Dedehayir, Ortt, & Seppaenen, 2017).

Applying technological innovations based on the circular economy in tourism can bring multiple benefits. For instance, smart resource management systems in

hotels can reduce energy and water consumption, thereby lowering operational costs and increasing business sustainability (Hojnik & Ruzzier, 2016). Additionally, the introduction of electric vehicle charging stations contributes to sustainable tourism development and encourages the use of low-emission vehicles (Zeng et al., 2020). The implementation of ISO 14000 standards in the tourism industry has proven to be an effective way to reduce the negative environmental impact, as it enables businesses to adopt environmentally friendly practices (Melnyk, Sroufe, & Calantone, 2003).

Esposito et al. (2024) explore the use of social media for promoting the circular economy in the tourism sector, particularly in the post-pandemic context. The results show a high level of engagement on platforms such as Twitter, but emphasize the need for a more interactive approach to raise awareness about circular practices among users. This approach can play a crucial role in activating all stakeholders in the supply chain toward transitioning to a circular business model.

Some research suggests that innovations in tourism often rely on collaboration with suppliers and research institutions, which facilitates faster adoption of new technologies and environmentally sustainable practices (Shi et al., 2018). In the context of the Republic of Serbia, the application of circular principles is still in the developmental stage, but there are examples of good practices, especially in eco and ethno villages that use renewable energy sources and resource-saving technologies (Popovic et al., 2022).

A bibliometric analysis indicates a recent increase in publications exploring the link between circular practices and sustainability in tourism, highlighting the growing interest in this field. Kabil et al. (2023) analyze the scientific output related to the circular economy in tourism and identify key research areas such as waste management, resource optimization, and innovative business strategies.

Recent studies (Kabil et al., 2023; Esposito et al., 2024) confirm that the implementation of circular principles in tourism depends on the adoption of innovative technologies and that collaboration with research institutions is key to the success of these initiatives. Compared to earlier works, such as Bocken et al. (2016), more recent studies also emphasize the impact of global events, such as the COVID-19 pandemic, on accelerating the shift toward sustainable practices.

The conclusion of most studies is that technological innovations are one of the most important drivers in the transition toward sustainable tourism based on circular economy principles. Developing appropriate strategies for their broader application can contribute to the long-term economic, ecological, and social development of the tourism sector.

## 3. Research Methodology

This research focuses on the application of technological innovations based on circular economy principles in the tourism sector. The study was conducted through a survey questionnaire designed to assess the practices and attitudes of various stakeholders in the tourism industry regarding sustainable business and the circular economy. The survey included hotels, eco and ethno villages, as well as households implementing environmentally sustainable practices.

Respondents were selected based on criteria including the size of the establishment, type of services (hotel facilities, eco-villages), and geographical location. The study is dominated by regions with more developed tourist infrastructure, which may limit the generalization of findings to all tourism entities in the country.

### 3.1 Sampling and Distribution of the Questionnaire

The survey questionnaire was sent via email to over 80 addresses, with a total of 62 responses received, representing a response rate of 77.5%. The research was conducted from July 20 to August 25, 2024. The sample included subjects from various regions of Serbia, with the majority being from Sumadija and Western Serbia (53%), followed by Belgrade (28%), and Southern and Eastern Serbia (19%).

### 3.2 Research Instrument

The questionnaire contained 19 questions, divided into several thematic sections. The first group of questions addressed basic information about the application of circular economy principles, while the subsequent questions covered specific practices such as the use of renewable energy sources, automatic shut-off devices, electric vehicle charging stations, smart resource management systems, and the use of ecological products. Additionally, attitudes toward the use of ISO 14001 standards, wastewater management, and waste sorting were examined.

### 3.3 Data Analysis Methods

In this research, both quantitative and qualitative research methods were applied to provide a comprehensive insight into the application of circular practices in the tourism sector. **Quantitative analysis** was conducted through a factor analysis of the survey results in Table 1, using indicators such as the percentage of respondents, the significance rating of factors, the impact on ecological performance, and the average implementation rating. These indicators allowed for the quantification of the application of circular principles and the ranking of various sustainability factors. Additionally, Graph 1 presents the results on the implementation of circular practices in tourism.

At the same time, **qualitative analysis** was conducted, which included a deeper interpretation of the survey results. This analysis focused on identifying patterns, contextualizing findings in relation to existing literature, and considering the specific challenges and benefits of implementing sustainable practices in tourism. The combination of quantitative and qualitative methods enabled a deeper understanding of the situation and provided recommendations for the further development of the circular economy in the tourism industry.

### 3.4 Research Results

The factor analysis of the survey results is presented in Table 1. In addition to the listed factors, the covered questions and survey results include columns with the following indicators:

- Percentage of respondents (%) – shows the percentage of respondents applying specific practices.
- Importance rating of factors (1-5) – quantitatively assesses the significance of each factor for sustainability.
- Impact on ecological performance (1-5) – evaluates how much a specific factor contributes to reducing negative ecological impact.
- Average implementation score (1-5) – displays the average level of implementation among respondents.

*Table 1: Factor analysis of survey results*

| | Factor | Covered questions | Survey results | Percentage of respondents (%) | Evaluation of the importance of factors (1-5) | Impact on environmental performance (1-5) | Assessment of implementation grades (1-5) |
|---|---|---|---|---|---|---|---|
| 1 | Resource management | Use of renewable energy sources, smart management systems | Most respondents use renewable energy sources and smart management systems | 56 | 4,5 | 4,3 | 4,0 |
| 2 | Environmental standards and certification | Application of ISO 14001, ecological products | The vast majority apply ISO 14001 and use ecological products | 92 | 4,8 | 4,7 | 4,6 |
| 3 | Infrastructure for sustainability | Charging stations for electric vehicles, waste water management | There is room for improvement, especially in the infrastructure for electric vehicles | 37 | 3,7 | 3,8 | 3,5 |
| 4 | Waste management | Waste selection, wastewater treatment, storage of hazardous materials | Well-developed waste management and wastewater treatment | 79 | 4,6 | 4,5 | 4,3 |
| 5 | Training and awareness of employees | Employee education, application of ecological principles | High awareness of environmental education and the application of ecological principles | 98 | 4,9 | 4,9 | 4,7 |

Figure 1 shows the quantitative analysis of circular economy factors in tourism. The figure includes the percentage of respondents applying specific practices, the importance rating of factors, the impact on ecological performance, and the average implementation score for each factor.

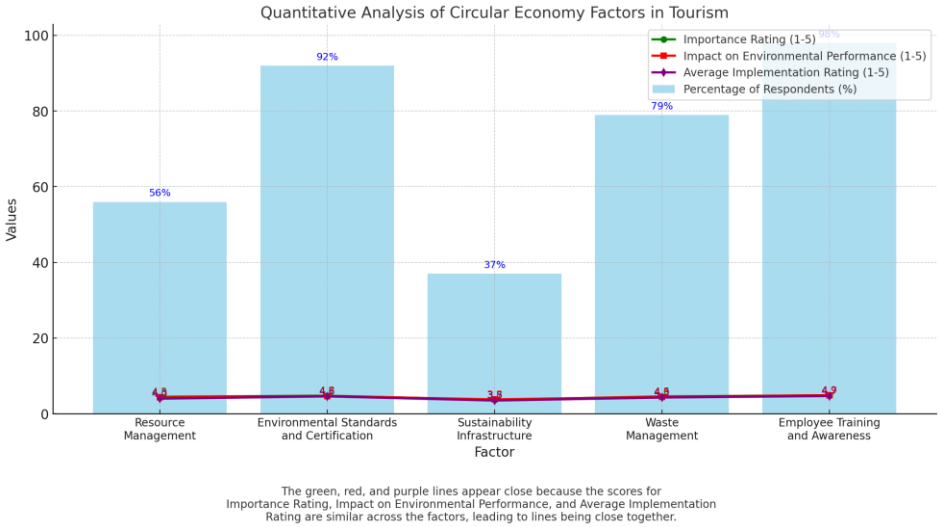


*Figure 1: Quantitative analysis of circular economy factors in tourism*

The survey results provide significant insight into the current state of circular economy implementation in the tourism industry in Serbia. The majority of respondents demonstrate awareness of the importance of environmentally sustainable practices, but there are significant differences in the level of implementation of certain circular principles.

**Resource Management and Use of Renewable Energy.** The use of renewable energy sources (56% of respondents) and smart resource management systems (53%) indicates a considerable level of awareness regarding the need for efficient resource management. However, this level of implementation may be linked to the availability of technology and financial resources for its implementation. The literature shows that the use of renewable energy sources depends on initial investments, which can be a barrier for smaller entities in the industry (Rodriguez et al., 2023). Introducing incentives or subsidies could increase interest in further implementation of these practices.

**Environmental Standards and Certification**. A high percentage of respondents (92%) applying the ISO 14001 standard indicates the prevalence of standardized practices in environmental management. This aligns with global trends in the tourism industry, where certification has become an important part of business strategy and a means of gaining competitive advantage (Esposito et al., 2024). However, certification alone does not guarantee complete implementation of all circular principles, highlighting the need for continuous improvement of standards and regular audits. Research findings show that the application of the ISO

14001 standard is most prevalent in environmentally oriented facilities. This practice also reveals regional specifics where the greatest challenges lie in infrastructural investments, especially for small establishments. Compared to similar studies, the results show similarities in the approach to sustainable tourism, but also differences in the level of support that facilities receive from local authorities.

**Sustainability Infrastructure.** The low representation of electric vehicle charging stations (37% of respondents) indicates challenges in implementing sustainable infrastructure. These results align with literature claims that investments in sustainable infrastructure in tourism are often insufficient due to high costs and a lack of support at the national or local level (Kabil et al., 2023). Improvements in this area could be achieved through public-private sector collaboration and directing funds from resources designated for the green transition.

**Waste and Resource Management**. Results indicate that waste management practices are well developed (79% segregate waste, 98% use treated wastewater). These data suggest a high awareness of the importance of waste reduction and recycling in the tourism industry.

**Employee Training and Awareness.** Nearly all respondents (98%) conduct training for employees on environmental principles, demonstrating that education is recognized as a key element for sustainable operations. The literature emphasizes that training and involving employees can significantly improve results in the implementation of circular practices, as it increases motivation and enables better innovation implementation (Esposito et al., 2024).

The survey results show that the tourism sector in Serbia is moving towards sustainable operations, but significant variations exist in the implementation of individual circular practices. The biggest barriers include a lack of investments in infrastructure and high implementation costs. Nonetheless, the existence of environmental standards and comprehensive employee training provides a solid foundation for the further development of sustainable practices. Linking with relevant sources in the literature and considering specific regional challenges enables a deeper understanding of the situation and offers guidance for enhancing the circular economy in tourism. This qualitative analysis highlights the importance of further improving environmental policies and supporting sustainable practices so that the tourism sector can effectively contribute to sustainable development.

## 4. Conclusions

The application of circular economy principles in the tourism industry is becoming increasingly significant as a response to ecological challenges and the need for sustainable development. Research conducted through quantitative and qualitative analysis shows that technological innovations play a key role in achieving sustainability goals, especially regarding efficient resource management, waste reduction, and optimization of energy efficiency. Technological solutions, such as smart resource management systems and renewable energy infrastructure,

enable the practical application of circular principles and promote sustainable growth.

The survey results indicate a high level of awareness among tourism entities regarding the importance of environmental standards, such as ISO 14001, and the implementation of sustainable practices, including technological innovations to increase energy efficiency and reduce negative environmental impacts. However, differences were observed in the level of implementation of specific circular practices, particularly concerning sustainability infrastructure, such as electric vehicle charging stations, where a lower level of application was recorded.

The quantitative analysis through factor analysis identified key factors contributing to the application of the circular economy, including resource management, standards and certification, infrastructure, waste management, and employee education. The qualitative analysis further highlighted the challenges faced by the tourism sector, such as high costs of implementing technological innovations and the need for additional infrastructural investments.

To accelerate the implementation of technological innovations in tourism based on the circular economy, it is recommended to introduce subsidies for investments in smart systems and renewable energy. Additional employee education through specialized training and greater collaboration with research centers can significantly enhance the efficiency of implementing sustainable practices.

Technological innovations based on circular economy principles represent a key driver of the transformation of tourism towards sustainable operations. Establishing more efficient strategies and incentive measures at the local and national levels can further accelerate the transition to sustainable tourism, reducing negative ecological consequences and enabling a better competitive position in the global market.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# WAYS TO AVOID BANKRUPTCIES: AVIATION INDUSTRY IN THE UNITED STATES

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***Abstract***

*Bankruptcy serves as a legal process for resolving debt issues among firms, individuals, and occasionally governments when they are unable to meet their financial obligations. This process can be initiated by either the debtor, seeking protection from creditors due to severe financial distress, or by the creditors, who may force bankruptcy proceedings if the debtor fails to comply with payment demands. While often viewed as a stigma, bankruptcy provides a structured way to manage debt and halt aggressive creditor actions, offering a path to financial recovery. The aviation industry has witnessed remarkable growth, with global passenger numbers escalating from 1.9 billion in 2004 to 4.5 billion in 2019. This expansion has significantly contributed to the global economy, employing 65.5 million people and generating $2.7 trillion in economic impact in 2018. The surge in demand has attracted numerous entrepreneurs and investors to establish or expand airlines. Despite this, the U.S. airline sector has experienced recurrent financial challenges, with 212 airlines filing for bankruptcy since 1978. This study investigates the factors influencing financial stability within the aviation industry through the lens of 14 participants. The research emphasizes the pivotal role of leadership in navigating financial instability. Key findings suggest that effective leadership strategies and financial management practices are crucial for mitigating bankruptcy risks. Future research should focus on applying these insights to refine financial practices and leadership approaches, potentially through targeted training programs aimed at improving financial risk management and enhancing organizational stability.*

***Key words:*** *aviation, bankruptcy, Strategy, External factors, United States*

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# 1. Introduction

Bankruptcy serves as a critical legal mechanism designed to help individuals and entities manage overwhelming debt by providing a structured approach to severe financial distress. This framework is especially significant in industries like aviation, where financial stability is crucial due to the sector's inherent volatility and scale. The U.S. aviation industry has faced recurrent bankruptcy challenges driven by internal and external factors, such as the cyclical nature of air travel demand, high fixed operational costs, fluctuating fuel prices, competitive pressure from low-cost carriers, and macroeconomic disruptions like terrorism, wars, and economic downturns.

The COVID-19 pandemic exposed the financial vulnerabilities of airlines, emphasizing their sensitivity to sudden external shocks. This review focuses on understanding the key factors behind airline bankruptcies in the U.S. aviation sector. It will explore how organizational structure, corporate culture, strategic partnerships, technology integration, and marketing strategies can help reduce bankruptcy risks and improve resilience. By examining these dynamics, the study offers a detailed analysis of the industry's financial challenges. Key themes such as market competition, financial management, leadership, and technological innovation will be discussed to provide insights into how airlines can navigate financial pressures and achieve long-term sustainability in a volatile economic landscape.

# 2. Literature Review

The aviation industry is highly sensitive to external factors compared to maritime, rail, and road transport. This sensitivity arises from its vulnerability to economic cycles, with air travel demand declining sharply during downturns due to its discretionary nature, unlike the more stable demand for rail and road transport (Doganis, 2010). Fuel costs, which can comprise up to 30% of airline expenses, further exacerbate this vulnerability (IATA, 2020). Additionally, aviation faces stringent safety, security, and environmental regulations, requiring substantial investment (ICAO, 2019). Technological advancements in aviation also demand rapid capital expenditure, unlike other transport modes (Bradley, 2015). Historical events such as the 9/11 attacks and the COVID-19 pandemic underscore aviation's extreme sensitivity, causing significant disruptions and financial strain (Blunk, Clark, & McGibany, 2006; Suau-Sanchez et al., 2020). These factors highlight the need for robust risk management and strategic planning.

Bankruptcy in various industries often stems from a mix of internal and external factors, but the aviation sector faces unique challenges. Common causes include financial mismanagement, adverse market conditions, and external shocks. The Z-score model (Altman, 1968) and financial ratios (Beaver, 1966) highlight key bankruptcy predictors, with high debt (Andrade & Kaplan, 1998) and economic downturns (Opler & Titman, 1994) being critical. In aviation, high operational costs and regulatory burdens compound these risks. External shocks, such as pandemics

(Bartik et al., 2020), add further strain. The industry's distinct challenges require specialized financial strategies and predictive models for effective bankruptcy risk management.

The COVID-19 pandemic exacerbated these issues (Maneenop & Kotcharin, 2020). Traditional bankruptcy prediction models, like the Altman Z-score (Altman, 1968), often fail to fully capture aviation's complexities (Barboza, Kimura, & Altman, 2017). Advances in data analytics, machine learning (ML), and artificial intelligence (AI) offer potential improvements, as demonstrated by studies by Kliestik, Misankova, and Valaskova (2018) and Tsai (2009). However, challenges related to data quality and model interpretability remain (Lipton, Berkowitz, & Elkan, 2015). Future research should integrate external factors and improve model transparency, guided by insights from Doshi-Velez and Kim (2017). The aviation industry's high operational costs, regulatory pressures, and economic volatility underscore the need for effective financial management and accurate bankruptcy prediction. Technological advancements and robust financial strategies are crucial for navigating economic challenges, optimizing costs, and maintaining stability.

## 3. Framework

The deregulation of the U.S. airline industry in 1978 brought lower fares and expanded services but also intensified competition, particularly affecting smaller airports and leading to price wars and capacity issues. As major carriers dominated the market through mergers, ticket prices rose, and competition decreased on certain routes. In addition to competitive pressures, financial mismanagement and leadership failures, as seen with Kingfisher Airlines and American Airlines, contributed significantly to airline bankruptcies. The rise of low-cost carriers and market saturation further strained traditional airlines, highlighting the need for strategic financial and operational planning to ensure long-term stability in the aviation industry.

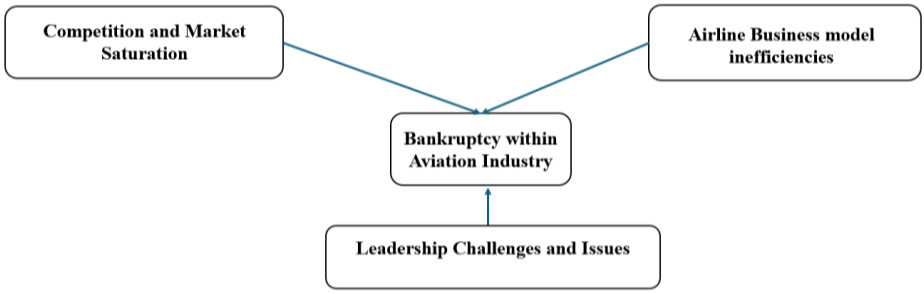


*Figure 1. Key factors of Bankruptcy within Aviation Industry*
*Source: Based primarily on Hecker (2001) and Dempsey (2011) authors made.*

# 4. Study Gap, Research Purpose, and Research Question

## 4.1 Study Gaps

While existing literature identifies factors contributing to bankruptcies and highlights the aviation industry's vulnerability, there remains a gap in understanding how these factors specifically impact airlines and lead to bankruptcy. Clear patterns among the causes of airline bankruptcies in the U.S. are lacking, which is the focus of this study. Further research is needed to analyze the factors influencing the bankruptcy of 212 defunct airlines and develop strategies based on these patterns to mitigate future risks.

## 4.2 Study Purpose

The literature review reveals several gaps in understanding the causes of airline failures, particularly in identifying clear patterns among the 212 defunct airlines in the United States. Our research aims to address these gaps by analyzing these patterns and developing strategies to mitigate future failures based on the findings.

## 4.3 Research Question

What are the key factors and mechanisms driving bankruptcy in the U.S. aviation industry?

# 5. Methodology

This study explores the multifaceted factors contributing to bankruptcy in the U.S. aviation industry using a qualitative methodology. Semi-structured interviews with e-leaders in the aviation sector were conducted to gain insights into the complex phenomena surrounding bankruptcy, as qualitative research focuses on understanding subjective experiences through interviews and observations (Creswell, 2013; Patton, 2015).

Purposive sampling was employed to select participants based on relevant criteria, specifically individuals in technology-driven leadership roles (Creswell & Poth, 2017). The target population included employees at various organizational levels working under e-leaders. Snowball sampling was used to access hard-to-reach e-leaders through referrals (Creswell & Poth, 2017). A sample size of 14 participants was chosen to balance the depth of exploration with practical data collection and analysis. Online interviews were conducted due to geographic constraints, and all sessions were recorded, transcribed, and prepared for analysis.

Thematic analysis was applied to analyze the interview data, identifying patterns and themes within the responses (Braun & Clarke, 2006). This flexible method can adapt to different theoretical frameworks, uncovering both explicit and implicit meanings in the data (Braun & Clarke, 2006; Guest et al., 2011). The approach combined deductive and inductive methods to allow themes to emerge

from the data. Ethical guidelines were followed, ensuring informed consent, participant anonymity, and secure data handling. Overall, this qualitative approach provided valuable insights into e-leadership and its impact on organizational performance, adhering to rigorous ethical standards.

## 6. Study Results

Table 1 represents the factors contributing to financial instability and bankruptcy in U.S. airlines, organizing the key factors and practices affecting the financial health of U.S. airlines and highlighting internal and external challenges as well as the role of management and strategic decisions. These challenges often arise from poor cash flow management, excessive debt, and underfunded pensions. Strategic missteps, such as over-expansion or misallocation of resources, further strain finances. Effective leadership is crucial in managing these risks, making sound financial decisions, and adapting to market changes, while weak leadership exacerbates financial difficulties.

Intense competition from low-cost carriers forces legacy airlines into aggressive pricing strategies that erode profit margins. External factors, such as volatile fuel prices, currency fluctuations, and economic downturns, also impact financial stability by increasing operational costs and reducing demand. Regulatory compliance, particularly regarding safety and environmental standards, adds to financial pressure. Additionally, High labor costs and limited access to capital can strain airlines' finances, while global events like pandemics and geopolitical tensions can drastically disrupt operations. These factors highlight the need for airlines to build strong financial resilience and adaptability to maintain stability amidst such challenges.

*Table 1: Factors Contributing to Bankruptcy*

| Category | Factors Contributing to Bankruptcy |
|---|---|
| **Financial Management** | Poor cash flow management, excessive debt, underfunded pensions, inadequate financial controls, lack of rigorous audits, and poor capital allocation. |
| **Strategic Decisions** | Over-expansion of routes, investment in wrong aircraft, ineffective fleet and route management, and misjudged market entry strategies. |
| **Leadership** | Importance of strong leadership in risk management, strategic planning, and crisis response; weak leadership exacerbates risks. |
| **Market Competition** | Intense competition from low-cost carriers leading to aggressive pricing, eroded profit margins, and unsustainable revenue models. |
| **Fuel Prices & Economics** | Volatility in fuel prices, adverse currency fluctuations, economic downturns affecting demand and financial stability. |
| **Regulatory Environment** | Compliance costs with safety, environmental standards, and taxation; impact of deregulation and government policies. |
| **Access to Capital** | Importance of credit access for operations and fleet upgrades; risks of tight credit conditions during economic downturns. |

| Category | Factors Contributing to Bankruptcy |
|---|---|
| **Customer Demand** | Impact of customer satisfaction and changing preferences on revenue; importance of loyalty programs and effective customer service. |
| **Technological Advancements** | Benefits of investing in technology for cost savings and operational efficiencies; risks of failing to innovate or delayed adoption. |
| **Mergers & Acquisitions** | Potential benefits from increased market share and economies of scale; challenges with integration and operational disruptions. |
| **Operational Inefficiencies** | Issues like outdated technology, poor route planning, and ineffective supply chain management leading to higher costs. |
| **Global Events** | Impacts of events like pandemics or geopolitical tensions on travel demand, operational costs, and investor confidence. |
| **Investor Pressure** | Short-term profit expectations leading to risky decisions, cost-cutting measures, and focus on immediate gains over long-term stability. |

*Source: Authors*

# 7. Discussion and Conclusion

## 7.1. Discussion

The study underscores the critical role of financial management and leadership in maintaining airlines' financial stability. Financial management theories must evolve to enhance internal practices like cash flow and debt control while responding to external economic pressures. Strategic leadership and effective risk management are vital for maintaining financial stability. This research adds to the theoretical understanding by showing that strong financial management and leadership can prevent bankruptcy and enhance stability.

The findings highlight that while operational efficiency in the U.S. airline industry has progressed steadily, profitability efficiency still requires enhancement. Addressing this gap may involve refining resource allocation strategies, optimizing revenue structures, managing costs more effectively, and expanding access to diverse funding options (Huang et al., 2021). Effective cash flow management, prudent debt practices, cost control, and strategic leadership are also vital for reducing bankruptcy risks and navigating economic uncertainties.

However, the study has limitations. Self-reported data on financial management and leadership may be biased, and focusing solely on the airline industry limits generalizability to other sectors. The small sample size also restricts the ability to establish strong statistical relationships, and broader economic conditions affecting financial stability were not considered. Further research is needed to address these gaps.

## 7.2. Conclusion

This study offers valuable insights into financial management and leadership within the airline industry, highlighting their significant impact on financial stability. By analyzing the influence of internal and external factors on financial health, it

provides a comprehensive understanding of bankruptcy risks. The findings on leadership's role in managing financial instability are particularly notable. Future efforts could focus on applying these insights to refine financial practices and leadership strategies, such as developing targeted training programs to improve financial risk management and stability. Adapting these practices in various contexts could enhance organizational performance and sustainability.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EXPLORING THE UTILITY OF BUSINESS INTELLIGENCE AND ARTIFICIAL INTELLIGENCE IMPLEMENTATION

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*Abstract*

*This study examines the role of Artificial Intelligence (AI) and Business Intelligence (BI) in transforming the business operations of the hospitality and airline sectors. The analysis focuses on the impact of these technologies on business transformation through business optimization, effective resource management, and service personalization. Data were collected through an anonymous survey conducted among employees in hotels and the airline company Air Serbia. The results of the SEM analysis confirm that BI and AI significantly contribute to operational efficiency, sustainability, and the enhancement of customer experience, with service personalization having the greatest impact on business transformation. The findings provide insights into the implementation of modern technologies and their role in shaping future business practices.*

***Key words:*** *business intelligence, artificial intelligence, hospitality, air transportation.*

## 1. Introduction

Business Intelligence (BI) and Artificial Intelligence (AI) have become pivotal in transforming the operational landscape of the hotel and transportation industries. In the hotel sector, BI provides valuable insights into customer behavior, operational efficiency, and market trends, enabling hoteliers to make informed decisions and tailor their services to guest preferences. AI further enhances guest experiences by enabling personalized recommendations, efficient booking systems, virtual assistants, and dynamic pricing models that optimize revenue while meeting

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customer needs. In the transportation industry, particularly in airlines, AI is widely used for predictive maintenance, route optimization, and enhancing passenger experiences through customized services and efficient communication systems. BI plays a critical role in analyzing real-time data, enabling airlines to forecast demand, manage capacities, and streamline their operations, which is particularly vital in a highly competitive market. The integration of BI and AI across these industries not only improves service quality and operational efficiency but also contributes to greater customer satisfaction and long-term competitiveness. These technologies empower organizations to adapt to changing market demands, enhance decision-making, and implement sustainable business practices, ensuring a future-ready approach in the service sector.

The aim of this study is to examine the role of Artificial Intelligence (AI) and Business Intelligence (BI) in transforming business operations in the hospitality and airline sectors. Specifically, the research seeks to identify the impact of these technologies on business optimization, effective resource management, and service personalization, and to assess their contribution to business transformation through improved operational efficiency, sustainability, and customer experience. Although there is substantial research on the implementation of AI and BI in tourism, several gaps remain unaddressed. There is limited quantitative research, particularly employing Structural Equation Modeling (SEM), to analyze the effects of these technologies in the hospitality and airline sectors. Additionally, few studies focus on employees' perceptions of how AI and BI influence critical business processes such as optimization, resource management, and personalization. Furthermore, the connection between AI and BI innovations and business sustainability remains underexplored. Empirical evidence from specific industries, such as hotels and airline companies like Air Serbia, is also scarce, leaving a gap in contextually relevant insights.

This study introduces several innovative contributions. It employs an integrative model to investigate the influence of AI and BI across three dimensions: business optimization, resource management, and service personalization. The research applies SEM analysis on empirical data collected from employees in hotels and the airline industry, providing a comprehensive understanding of their perceptions and attitudes. By focusing on the hospitality and airline sectors, where the adoption of AI and BI is rapidly growing but underexplored, the study offers critical insights into their application. Additionally, it addresses ethical and operational considerations, such as privacy protection and moral hazard, offering a holistic perspective on the challenges and benefits of adopting these technologies. The significance of this study is multifaceted. Theoretically, it contributes to the literature on AI and BI by providing novel insights into their application in specific sectors, expanding the understanding of their impact on business transformation. Practically, the findings serve as a guide for managers in the hospitality and airline industries, helping them recognize the potential of these technologies and strategically implement them to enhance business outcomes. From a sustainability perspective, the study highlights the ability of AI and BI to reduce operational costs, optimize resource use, and improve customer experiences, thereby supporting the

long-term development of these industries. By combining theoretical frameworks with practical implications, this study addresses existing research gaps and lays the foundation for future investigations into the transformative role of AI and BI in shaping modern business practices.

### 1.1 Literature review

The application of Artificial Intelligence (AI) and Business Intelligence (BI) in the hospitality and airline sectors is becoming essential for transforming operational processes, enhancing customer experience, and ensuring business sustainability. Mariani et al. (2018) emphasize the importance of BI and big data analysis in decision-making and improving operational efficiency, while Naumov (2019) highlights the role of AI in automating services, thereby increasing quality and personalization of customer experiences. Prentice et al. (2020) further confirm that such personalization directly impacts guest loyalty and satisfaction.

In the context of the airline industry, Andronie (2015) underscores the use of BI to analyze supply and demand, enabling airlines to optimally plan capacities and routes. Similarly, Bock et al. (2020) discusses the disruptive effects of AI, particularly through personalized recommendations and predictive algorithms that significantly enhance passenger experiences. These claims are supported by Bulchand-Gidumal et al. (2023), who analyze the role of AI in transforming tourism marketing by creating targeted campaigns based on user behavior analysis.

Cain et al. (2019) highlight the growing importance of automation in hospitality, where AI is used to manage reservations, automate front desk processes, and personalize offerings. Reis et al. (2020) examine the case of the Henn-Na Hotel in Japan, where robots have been integrated into operations, reducing costs and increasing efficiency. Bowen and Morosan (2018) further emphasize how robotics and AI are reshaping the fundamentals of hospitality, making it more adaptable to modern challenges.

Technologies like chatbots are becoming indispensable in customer support, as evidenced by Pillai and Sivathanu (2020), who show that AI-based chatbots significantly improve customer satisfaction while reducing operational costs. Mingotto et al. (2021) highlight the challenges of redesigning operations and jobs to integrate AI and robotics into hospitality services, reinforcing the need for organizational adjustments. Martínez-Martínez et al. (2019) point out that BI and AI contribute to sustainable business practices, particularly by enabling more efficient resource management and reducing environmental impact. Rosario and Dias (2022) emphasize that these technologies play a crucial role in transitioning to digital and sustainable business practices. Duan et al. (2019) further explains how AI aids decision-making in the era of big data, allowing organizations to respond more effectively to challenges. Buhalis (2020) underscores how BI and AI support the transition to smart destinations, while Casado Salguero et al. (2019) highlight their role in creating competitive advantages through intelligent data analysis. Ashaal et al. (2020) stress the importance of data management and privacy, especially within the framework of GDPR regulations, which directly influence the implementation of AI in the airline industry.

The integration of AI and BI in the hospitality and airline sectors has also been explored in studies that highlight how these technologies not only transform industries but also pose new challenges. Farrow (2019) discusses the evolution of AI through causal layered analysis, emphasizing that technologies like AI are not only tools for operational improvement but also means of enhancing human capacity. This directly relates to AI's ability to support managerial decision-making in sectors where speed and accuracy are crucial. Goel et al. (2022) analyze the adoption of AI and robotics among consumers in tourism and hospitality, highlighting factors such as user trust, data security, and ease of use. Their findings indicate that the successful implementation of AI technologies in these sectors often depends on companies' ability to alleviate concerns related to privacy and data security. This is particularly relevant in the context of Hu and Min (2023), who explore the dark sides of AI, such as privacy concerns and the "watching-eye effect" in service delivery. Their research underscores the need to balance the benefits of AI with its ethical implications. The COVID-19 pandemic, as noted by Gössling et al. (2020), has further accelerated the adoption of disruptive technologies in the tourism and hospitality sectors. They point out that the pandemic has not only altered travel patterns but also increased reliance on AI and BI for crisis management, demand forecasting, and operational adjustments to new market conditions. These findings align with the research by Iranmanesh et al. (2022), who emphasize that disruptive digital technologies, including AI, are redefining business processes in hospitality, from service personalization to resource optimization.

Based on the above findings, the following hypotheses were formulated:

**H1**: Business Optimization (BO) positively affects Business Transformation (BT).

**H2**: Effective Resource Management (ERM) positively affects Business Transformation (BT).

**H3**: Personalization of Services (PS) positively affects Business Transformation (BT).

## 2. Methodology

### 2.1 Data collection

For the purposes of this study, data were collected through an anonymous online survey conducted among employees in hotels and the Air Serbia company. The surveys were distributed between June and September of the previous year to ensure sufficient time for gathering a representative sample. A total of 258 respondents participated, with data collected through direct invitations, internal company networks, and emails obtained from publicly available sources. To ensure the reliability of the questionnaire, a pilot study was conducted prior to the main research with a sample of 30 employees. The objective of the pilot study was to identify potential issues in question formulation and ensure clarity and comprehensibility of the content. Based on feedback from the pilot study, minor adjustments were made to the questions to improve data quality. The survey was anonymous to minimize bias and encourage honest responses from participants. Ethical considerations were considered, with a particular focus on protecting

participants' privacy. Special permissions from companies were not required, as the data was collected exclusively through voluntary participation and publicly available information. Moral hazard was avoided by informing participants that their responses would not be used in a manner that could jeopardize their position or the reputation of the companies. The survey questions were designed to assess employees' perceptions of the impact of AI and BI on operational processes, sustainability, and customer experience. The sample of 258 respondents included employees with various levels of responsibility and years of work experience, ensuring the representativeness of the results and enabling a deeper analysis of diverse perspectives.

### 2.2 Sample and questionaire design

The data provides a comprehensive overview of the demographic, educational, and professional characteristics of individuals working in the airline and hotel industries. Gender distribution is relatively balanced, with a slight predominance of females (52.7%) over males (47.3%), indicating equitable representation. In terms of age, most respondents fall within the 26-45 age range (63%), reflecting a workforce predominantly composed of mid-career professionals. Younger employees aged 18-25 make up a smaller portion (12.5%), while those aged 46 and above account for 24.5%, highlighting limited representation from entry-level and nearing-retirement employees. Education levels demonstrate a strong emphasis on higher education, with most participants holding a bachelor's degree (42.1%) or a master's degree (31.5%). High school graduates represent 18.9%, and PhD holders account for a smaller but significant portion (7.5%), suggesting that educational qualifications are highly valued in these sectors. Regarding years of service, the workforce is predominantly experienced, with over half of the respondents having between 6 and 15 years of professional experience (52.5%). Meanwhile, a notable influx of newer professionals is evident, as 22.3% have fewer than five years of experience, while seasoned experts with over 20 years represent 9.0%. Sector distribution is nearly even, with a slight majority in the hotel industry (51.4%) compared to airlines (48.6%)(Table 1).

*Table 1: Sociodemographic characteristics*

| Characteristic | Categories | % |
|---|---|---|
| Gender | Male | 47.3% |
| | Female | 52.7% |
| Age | 18-25 | 12.5% |
| | 26-35 | 29.8% |
| | 36-45 | 33.2% |
| | 46-55 | 18.9% |
| | 56+ | 5.6% |
| Education Level | High School | 18.9% |
| | Bachelor | 42.1% |
| | Master | 31.5% |
| | PhD | 7.5% |
| Years of Service | 1-5 years | 22.3% |
| | 6-10 years | 28.4% |
| | 11-15 years | 24.1% |
| | 16-20 years | 16.2% |
| | 21+ years | 9.0% |
| Sector | Airlines | 48.6% |
| | Hotels | 51.4% |

### 2.3 Questinaire design

The questionnaire used in this study was designed to assess employees' perceptions of the impact of Artificial Intelligence (AI) and Business Intelligence (BI) on business optimization, resource management, and service personalization, as well as their influence on business transformation. The questions were adapted and modified from existing validated scales in prior research to ensure both reliability and contextual relevance to the hospitality and airline industries. Items related to business optimization were adapted from Mariani et al. (2018), focusing on BI's role in enhancing operational efficiency and decision-making. Questions addressing resource management were modified from Martínez-Martínez et al. (2019), highlighting the importance of AI and BI in optimizing resource use and supporting sustainability. For service personalization, the questionnaire drew from Prentice et al. (2020), which examined the effects of AI-driven personalization on customer satisfaction and loyalty. The questionnaire was structured into three sections: demographic information, perceptions of AI and BI, and the perceived impact on business transformation. A 5-point Likert scale ranging from "strongly disagree" to "strongly agree" was used to measure responses. To ensure clarity and relevance, a pilot test was conducted with 30 participants, and minor adjustments were made based on their feedback. This process ensured that the final instrument effectively captured the constructs under investigation and aligned with the study's objectives.

## 2.4 Data analysis

The heatmap provides a clear visual representation of the reliability and validity metrics (Alpha, rho_A, CR, and AVE) for each construct. Business Optimization and Personalization of Services exhibit consistently high values across all metrics, indicating strong reliability and validity. Business Transformation shows slightly lower AVE values, suggesting potential improvement in its convergent validity. Effectiveness of Resource Management demonstrates high rho_A and CR, reflecting solid internal consistency and composite reliability, though its AVE is moderate. Overall, the constructs show acceptable levels of reliability and validity, with minor variations that highlight areas for potential refinement (Figure 1).

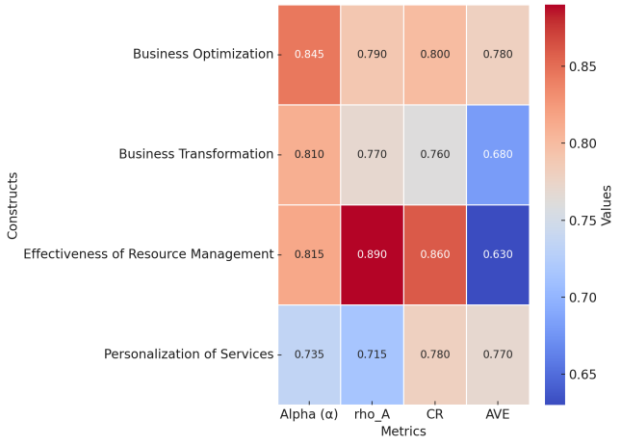


*Figure 1: Construct reliability and validity*
*Note: α – cronbach alpha, rho_A - reliability indicator of latent constructs, CR - composite reliability, AVE - average variance extracted*

Figure 2 combines the Fornell-Larcker criterion and HTMT (Heterotrait-Monotrait ratio) values to assess the discriminant validity of the constructs. The figure provides a visual representation of the relationships between constructs and their metrics, with the color intensity reflecting the strength of the values. Business Optimization demonstrates strong internal consistency, as indicated by its highest value (0.720), but shows weaker connections with other constructs, suggesting its relative independence.

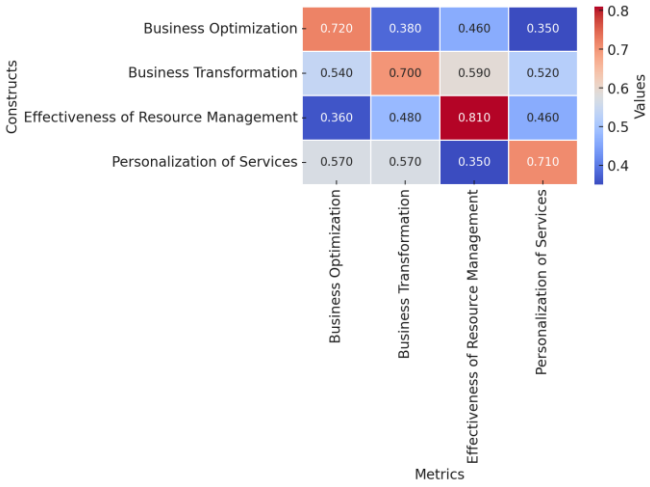


*Figure 2: Combined Fornell-Larcker criterion and HTMT (heterotrait monotrait ratio) values*

Business Transformation exhibits a solid relationship with itself (0.700) and moderate correlations with other constructs, indicating balanced reliability. The effectiveness of Resource Management stands out with the highest value in the heatmap (0.810), reflecting exceptional internal alignment, though its links to other constructs are less pronounced, emphasizing its specialized focus. Personalization of Services shows a good level of reliability (0.710), though its weaker correlations with other constructs highlight its unique and less integrated nature. Overall, the heatmap reveals that while all constructs demonstrate strong reliability, there are varying degrees of interrelation, pointing to opportunities for further exploration or refinement.

Figure 3 illustrates the updated values for the constructs Business Optimization (BO), Business Transformation (BT), Effectiveness of Resource Management (ERM), and Personalization of Services (PS). Each construct is represented by multiple items, with values ranging between 1.1 and 1.8. Business Optimization shows consistent performance across its items, with values falling within a steady range of 1.2 to 1.6. Business Transformation displays slightly higher variability, with values ranging from 1.1 to 1.7, indicating some items may require further refinement for consistency. The effectiveness of Resource Management stands out with the highest values, particularly ERM1 at 1.8, reflecting strong internal alignment and reliability. Personalization of Services demonstrates moderate values between 1.1 and 1.5, suggesting reliability but highlighting areas for potential improvement. Overall, the constructs exhibit acceptable reliability, with Effectiveness of Resource Management showing the strongest consistency, while Business Transformation may benefit from additional adjustments to ensure uniformity across its items.

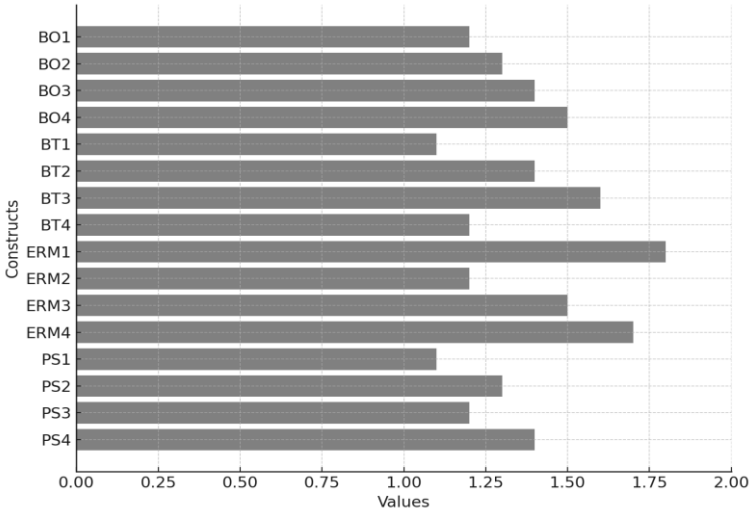


*Figure 3: Collinearity statistics (variance inflation factor—VIF < 3). Note: PS - personalization of services, ERM - effectiveness of resource management, BT - business transformation, BO - business optimization.*

## 3. Results

Exploratory factor analysis identified four key factors: Business optimization (BO), Personalization of services (PS), Effectiveness of resource management (ERM) and Business transformation (BT), each with four questions. All factors demonstrate high reliability ($\alpha > 0.85$ and CR > 0.90), confirming the internal consistency of the constructs. The AVE values for all factors exceed the recommended threshold of 0.50, indicating good convergent validity. While BO explains the highest variance, ERM shows the strongest reliability and consistency. The variability in responses (as shown by standard deviation) is relatively higher for ERM and BT, suggesting diverse perceptions among respondents. These results indicate a well-constructed and reliable model with areas of higher variability that may warrant further exploration (Table 3).

*Table 3: Descriptive values, reliability, and validity of the factors*

| Factor | IEV | %V | C% | EAE | %VAE | C%AE | EAR | m | sd | α | CR | AVE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BO | 4.732 | 29.853 | 29.853 | 4.732 | 29.853 | 29.853 | 4.203 | 2.41 | 1.012 | 0.861 | 0.913 | 0.720 |
| PS | 2.105 | 13.158 | 43.011 | 2.105 | 13.158 | 43.011 | 3.098 | 2.32 | 1.062 | 0.871 | 0.909 | 0.701 |
| ERM | 1.487 | 8.900 | 51.911 | 1.487 | 8.900 | 51.911 | 2.124 | 3.31 | 1.493 | 0.879 | 0.926 | 0.758 |
| BT | 1.192 | 7.450 | 59.361 | 1.192 | 7.450 | 59.361 | 1.457 | 3.19 | 1.744 | 0.892 | 0.920 | 0.743 |

*Note: IEV - initial eigenvalues, %V -, % of variance, C% - cumulative %, EAE - eigenvalues after extraction, %VAE -% of variance after extraction, C%AE - cumulative % after extraction, EAR - eigenvalues after rotation, m – arithmetic mean, sd – standard deviation, α - cronbach alpha, CR - composite reliability, AVE - average variance extracted*

The Table 4 provides an analysis of four key factors—Business Optimization (BO), Personalization of Services (PS), Effectiveness of Resource Management

(ERM), and Business Transformation (BT)—highlighting their mean values (m), standard deviations (sd), reliability (α), and factor loadings (FL).

*Table 4: Descriptive statistics of statements and factor loadings*

| Factor | Statements | m | sd | α | FL |
|---|---|---|---|---|---|
| **Business Optimization (BO)** | AI predicts flight delays using weather data. | 2.25 | 1.420 | 0.812 | 0.872 |
| | BI helps optimize supply and demand. | 2.70 | 1.460 | 0.790 | 0.830 |
| | AI automates guest check-in, reducing waiting time. | 2.33 | 1.430 | 0.808 | 0.890 |
| | BI optimizes room rates through occupancy analysis. | 2.60 | 1.480 | 0.806 | 0.840 |
| **Personalization of Services (PS)** | AI suggests personalized travel plans. | 2.15 | 1.400 | 0.790 | 0.830 |
| | BI creates tailored hotel marketing strategies. | 2.35 | 1.460 | 0.793 | 0.843 |
| | AI chatbots ensure 24/7 customer service. | 2.20 | 1.360 | 0.794 | 0.840 |
| | BI customizes services based on guest preferences. | 2.95 | 1.920 | 0.820 | 0.890 |
| **Effectiveness of Resource Management (ERM)** | AI optimizes fuel consumption to cut costs. | 2.85 | 2.050 | 0.815 | 0.870 |
| | BI tracks resource usage to enhance savings. | 3.95 | 2.350 | 0.830 | 0.860 |
| | AI predicts maintenance needs, minimizing downtime. | 3.40 | 2.140 | 0.780 | 0.860 |
| | BI monitors energy and water for cost efficiency. | 3.25 | 2.220 | 0.775 | 0.885 |
| **Business Transformation (BT)** | BI and AI improve efficiency and reduce costs. | 2.80 | 2.080 | 0.785 | 0.890 |
| | BI and AI boost customer satisfaction. | 3.30 | 2.200 | 0.790 | 0.810 |
| | BI and AI improve security measures. | 3.75 | 2.310 | 0.805 | 0.860 |
| | BI and AI drive sustainability and resource use. | 2.95 | 2.090 | 0.810 | 0.895 |

*Note: m – arithmetic mean, sd – standard deviation, α - cronbach alpha, FL – factor loading.*

Business Optimization (BO) focuses on the role of AI and BI in improving operational efficiency. The mean scores for BO statements range from 2.25 to 2.70, indicating moderate agreement among respondents, with a standard deviation between 1.42 and 1.48, reflecting some variability in responses. Reliability values (α = 0.790–0.812) and high factor loadings (FL = 0.830–0.890) suggest strong internal consistency and the importance of these technologies in predicting delays, optimizing supply-demand, and automating services. Personalization of Services (PS) emphasizes the use of AI and BI to deliver tailored customer experiences. With mean scores ranging from 2.15 to 2.95 and moderate standard deviations (1.36–1.92), respondents showed general agreement about the benefits of personalized recommendations, chatbots, and customized marketing campaigns. The reliability (α = 0.790–0.820) and factor loadings (FL = 0.830–0.890) indicate that AI and BI effectively enhance service personalization. Effectiveness of Resource Management

(ERM) highlights how AI and BI optimize resource use and reduce costs. Mean values for ERM range from 2.85 to 3.95, with higher standard deviations (2.05–2.35), suggesting greater variability in perceptions. Reliability values (α = 0.775–0.830) and strong factor loadings (FL = 0.860–0.885) confirm the role of these technologies in optimizing fuel usage, predicting maintenance, and monitoring resource consumption. Business Transformation (BT) explores the transformative impact of AI and BI on operational efficiency, customer satisfaction, and sustainability. Mean scores range from 2.80 to 3.75, with standard deviations between 2.08 and 2.31, indicating higher variability in responses. Reliability (α = 0.785–0.810) and factor loadings (FL = 0.810–0.895) demonstrate that these technologies are seen as critical for cost reduction, improved security, and sustainability efforts.

Table 5 presents the results of the SEM analysis and hypothesis testing, evaluating the relationships between Business Optimization (BO), Effectiveness of Resource Management (ERM), Personalization of Services (PS), and Business Transformation (BT). All three hypotheses were confirmed based on the statistical analysis

*Table 5: Results of SEM analysis and hypothesis testing*

| Hypothesis | Path | Estimate | m | sd | t | p | Confirmation |
|---|---|---|---|---|---|---|---|
| **H1** | BO → BT | 0.245 | 0.252 | 0.075 | 3.267 | 0.001 | Confirmed |
| **H2** | ERM → BT | 0.280 | 0.287 | 0.077 | 3.623 | 0.000 | Confirmed |
| **H3** | PS → BT | 0.305 | 0.298 | 0.081 | 3.712 | 0.000 | Confirmed |

*Note: BO - business optimization, PS - personalization of services, ERM - effectiveness of resource management, BT – business transformation, m – arithmetic mean, sd – standard deviation, t – t statistic, p – statistical significance*

For Hypothesis H1 (BO → BT), the path coefficient is 0.245, indicating a moderate positive relationship between Business Optimization and Business Transformation. The t-value of 3.267 and p-value of 0.001 confirm the statistical significance of this effect. These findings suggest that optimization practices, such as predictive analytics and operational improvements, play an essential role in supporting transformational processes.

Hypothesis H2 (ERM → BT) demonstrates a stronger relationship, with a path coefficient of 0.280, a t-value of 3.623, and a p-value of 0.000. This highlights that effective management of resources, such as energy, time, and costs, is a crucial factor in driving organizational transformation. The results underline the importance of strategies focused on efficiency and sustainability in achieving meaningful change. Hypothesis H3 (PS → BT) has the highest path coefficient of 0.305, reflecting a strong and positive influence of Personalization of Services on Business Transformation. The t-value of 3.712 and p-value of 0.000 further confirm this relationship as highly significant. This finding emphasizes that tailored approaches to customer engagement, powered by AI and BI technologies, are critical for advancing business transformation. The results confirm that all three factors significantly and positively contribute to Business Transformation, with Personalization of Services showing the most substantial impact. These findings validate the role of advanced

technologies in enhancing optimization, resource management, and service personalization to foster transformative outcomes in businesses.

## 4. Discussion

Given results highlight the importance of applying Artificial Intelligence (AI) and Business Intelligence (BI) in the hospitality and airline sectors, as confirmed by related studies from other authors. Our findings, which demonstrate that AI and BI significantly contribute to business transformation through business optimization, effective resource management, and service personalization, align with the results of Chi, Denton, and Gursoy (2020). They emphasize that the use of AI devices in service delivery directly impacts operational efficiency and customer satisfaction. Additionally, the study by Nocker and Sena (2019) highlights the growing importance of Big Data analytics in human resource management, which corresponds to our findings on the significance of BI in optimizing business processes. They point out that the application of advanced analytical tools can lead to more precise decision-making, a conclusion mirrored in our study through the identification of BI's positive influence on business transformation in hospitality and aviation. Our results are also complementary to the conclusions of Christou (2024), who underscores the potential overdependence on AI technologies in tourism while emphasizing the need for their responsible use to avoid negative effects. This balance is reflected in our study, which focuses on the positive aspects of AI application, such as service personalization, while also addressing ethical challenges, including privacy and moral hazard.

Chernyshev et al. (2023) examine the contribution of migration to population changes in urban agglomerations, emphasizing the role of technology in data modeling, which is relevant to BI and AI applications in sectors with complex operational demands. Their findings on the importance of analytical tools in strategic decision-making support our conclusions on the role of BI in resource optimization and business transformation. Furthermore, Custis (2012) highlights the historical concepts and future trends of business intelligence in hospitality, emphasizing that BI not only improves current operations but also enables strategic planning, which is a key element of our research. This synergy between the short-term and long-term benefits of BI is confirmed by our findings on its positive impact on business optimization and sustainability. In the domain of ethical and regulatory issues, Popay et al. (2006) provide guidance on narrative synthesis in systematic reviews, emphasizing the importance of transparency in research, which aligns with our approach to data collection and analysis. Their methodological recommendation for clarity and reliability of results reinforces the validity of our findings. Finally, the research by Ailia et al. (2022) on AI patents highlights the continuous growth and diversification of AI technologies, consistent with our conclusions about their increasing presence in the hospitality and aviation sectors. Their analysis of innovations confirms that AI not only transforms operations but also enables the development of competitive advantages, which is one of the key conclusions of our study. Based on these related findings, we can conclude that our results provide

additional empirical support to existing research, confirming the importance of AI and BI in improving operational processes, customer satisfaction, and sustainability in sectors with high demands for adaptation and innovation. This study thus contributes to the ongoing discussion on the optimal integration of modern technologies into business practices.

## 5. Concluding remarks

This study provides significant insights into the role of Artificial Intelligence (AI) and Business Intelligence (BI) in transforming the hospitality and airline sectors. The results indicate that AI and BI substantially contribute to business transformation through operational optimization, effective resource management, and service personalization, with service personalization showing the most pronounced impact. By combining empirical findings and theoretical frameworks, this research enhances the understanding of the potential of these technologies in modern business environments.

### 5.1 Theoretical implications

This study contributes to the existing literature by offering new insights into the application of AI and BI in specific sectors. The established links between business optimization, resource management, and service personalization with business transformation expand the understanding of how these technologies enable strategic changes. Furthermore, the findings confirm that the integration of AI and BI can serve as a tool for achieving sustainability, adding to the discussion on their role in developing sustainable business models.

### 5.2. Practical implications

The findings provide practical guidance for managers in the hospitality and airline sectors. AI and BI technologies can enhance operational performance, enable tailored customer experiences, and optimize resources, directly contributing to increased efficiency and competitiveness. Special attention should be given to the ethical aspects of applying these technologies, such as privacy protection and avoiding moral hazard, to ensure responsible implementation.

### 5.3 Limitations

While this study offers valuable insights, it has several limitations. First, the sample includes employees exclusively from the hospitality and airline sectors within a single region, which may limit the generalizability of the findings. Second, the research relies on self-reported data, which could introduce response bias. Finally, the study primarily uses quantitative methods, and future studies could incorporate qualitative approaches to gain deeper insights into the dynamics between AI, BI, and business transformation.

### 5.4 Directions for Future Research

Future research should expand the analysis to other industries to test the generalizability of the findings. Additionally, longitudinal designs are recommended to assess the long-term impact of AI and BI on business processes. Further research could also focus on specific challenges in implementing these technologies, including the integration of new systems, employee training, and adapting organizational culture. This study lays the groundwork for future research and provides guidance for the strategic application of AI and BI in industries with high demands for innovation and adaptation to modern challenges. By combining theoretical and practical implications, it contributes to the development of sustainable business practices and the enhancement of customer experience.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ESSENTIAL PROJECT MANAGEMENT SKILLS FOR SUCCESSFUL ENTREPRENEURIAL LEADERSHIP

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***Abstract***

*In today's business environment, which offers great opportunities for innovation, more individuals are looking to develop new business ideas and become entrepreneurs. The constant emergence of new trends, continuous monitoring, and adaptation to these trends are integral parts of conducting business. Managing those projects generally requires adherence to certain rules and guidelines. This is a complex whole, and it is important to start with understanding the basic concepts. This paper aims to highlight the importance of key project management skills and to examine whether they can be applied to leading an entrepreneurial venture. The study was conducted based on a sample of 46 entrepreneurs engaged in various activities. Based on the obtained and analyzed results, a significant correlation was established with the basic skills applied in both fields. The insights gained can contribute to the further education of entrepreneurs, enabling them to plan and conduct their business systematically to achieve better results.*

***Key words:*** *Entrepreneurship, Project management, Business*

## 1. Introduction

While not all project managers embody the characteristics of entrepreneurs, successful entrepreneurship inherently demands effective project management skills. Entrepreneurs must navigate complex processes, whether focused on product development, securing investment, or expanding market reach. Each process involves a structured sequence of activities that must be managed with the precision and methodology typical of formal project management practices. Managing entrepreneurial endeavours in a project-based framework becomes essential for

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business success, ensuring that objectives are met efficiently, optimised resources, and mitigated risks (Akhmetshin et al., 2019). This paper discusses the necessity for entrepreneurs to adopt project management principles in their operations to achieve sustainable growth and long-term viability in competitive markets

The examination involved a sample of 46 entrepreneurs operating in diverse business sectors. The results revealed a strong correlation between the foundational skills utilized in entrepreneurship and project management. However, a notable distinction emerged regarding applying fundamental project management tools and techniques.

## 2. Theoretical background: Project management and entrepreneurship

### 2.1. Comprehensive project management in modern business

Projects have been an integral part of human civilization since ancient times, dating back to several centuries before the Common Era. The construction of monumental achievements such as the Egyptian pyramids, ancient Greek temples, and the Great Wall of China exemplifies early project-based endeavors. These structures were not only feats of engineering but also required sophisticated project management knowledge in planning, organizing, and controlling resources and labor. While these early projects focused on monumental construction, the essence of project management remains crucial in the contemporary environment.

Today, projects range from large-scale initiatives impacting the global population to those tailored for specific user groups or internal organizational needs. Over the past few decades, the need for projects have surged, largely due to their pivotal role in achieving business objectives (Radaković & Morača, 2017). Despite variations in size and complexity, all projects follow a structured life cycle. According to the PMBOK Guide (2008), projects progress through four distinct phases, each contributing incremental value from initiation to completion. Each phase has its own defined start, end, and specific objectives and may be considered a project (Trish, 2007).

Key factors such as active participation, minimal interpersonal conflicts, and effective communication play a vital role in shaping the quality of an organization's project environment. These elements are crucial to fostering a productive atmosphere and ensuring project success (Dinsmore & Cabanis-Brewin, 2011). As project management continues to evolve, its principles remain as essential in modern business operations as they were in past projects.

### 2.2. Entrepreneurship in economic development

Peter Drucker (1985) emphasized that entrepreneurship is neither a science nor an art, but a practice. He posited that knowledge in entrepreneurship serves as a tool to achieve specific goals, implying that entrepreneurship is not an inherent personality trait. Rather, anyone capable of facing decision-making processes has the potential to act entrepreneurially. According to Drucker, entrepreneurship is

fundamentally the function of acquiring and utilizing resources. In a managerial role, resources are allocated to solve problems, while in an entrepreneurial role, resources are directed towards opportunities. Entrepreneurship, thus, becomes a process of seeking and responding to change, transforming it into an opportunity by applying innovation and creativity to identify or create resources and assign them economic value (Sharma, 2021).

Entrepreneurial activity plays a critical role in economic development, often regarded as one of the most significant contributors to the growth of a country or region. The number and competence of entrepreneurs are essential in determining the pace and direction of economic progress. Successful entrepreneurial ventures are largely determined by the quality of the entrepreneurial idea and the ability of the entrepreneur to effectively execute it.

In modern societies, entrepreneurship is actively promoted through various programs and initiatives led by both governmental and private institutions. However, fostering an environment that encourages entrepreneurial behavior and ensures the successful transfer of knowledge and technology to the market remains a significant challenge for organizations, especially those operating in dynamic and highly competitive business environments (Sharma, 2021).

### 2.3. Relationship between entrepreneurship and project management

In the context of entrepreneurial success, mastery of project management stands out as a key trait. Effective entrepreneurs must not only possess the ability to make swift decisions and multitask, but also manage projects and time efficiently. Central to this is a deep understanding of project management, which is structured around five fundamental phases: initiation, planning, execution, control, and closure. These phases provide a systematic framework that enables entrepreneurs to rapidly respond to competitive pressures and enhance their performance (Jovičić, 2017).

As businesses evolve, adherence to core project management principles becomes increasingly essential. By integrating these principles into the entrepreneurial process, individuals can exert greater control over their ventures, build confidence in achieving project milestones, and ultimately guide their businesses toward profitability and sustainability (Mehr, 1989). The structured approach offered by project management fosters not only strategic decision-making but also the agility needed to navigate the dynamic landscape of business development.

During the initiation and development of a business, the following similarities with project management arise: (Kemp, 2006):

- Market research and analysis;
- Careful planning, as success depends on it;
- Defining what makes the product or service unique and emphasizing it;
- Excellent customer service/providing high-quality products;
- Finding the right location;
- The entrepreneur's attention and time are required for what they do.

- Make clear and consistent hiring decisions;
- Find good people who want to advance and grow alongside the business;
- Training and retaining staff;
- The customer always comes first;
- Constant improvement and keeping up with trends.

One study was conducted on South African entrepreneurs with the main goal of determining the categories and subgroups of skills that entrepreneurs apply. The study identifies nine groups of skills: entrepreneurial spirit, business management skills, financial management skills, human resource management, marketing skills, technical skills, personal skills, leadership skills, and social and interpersonal skills.

It has been established that all these skills are in line with the existing literature, but they have been elaborated in more detail in this way, and new skills that were not identified in previous literature have been included (Kerrin et al., 2017). In the labor market, the most required skill is general knowledge of project management theory. This includes the ability to plan work, organize processes, set goals, and determine priorities (Akhmetshin et al., 2019).

## 3. Research methodology and results

The topic of this paper is to examine key project management skills applicable to entrepreneurship. A quantitative questionnaire was employed for the research. The study commenced in early September 2023 and the response collection phase took one month, during which 46 responses were gathered.

The questionnaires were distributed electronically via Google Forms. Before filling out the questionnaire, respondents were informed about the research objectives, and by completing the survey, they provided their contribution and consent to participate.

The target population for this study consisted of entrepreneurs from the territory of the Republic of Serbia to assess their knowledge and application of specific tools and techniques in their business operations. There were no restrictions on industry inclusion for this research, with all industries represented.

### 3.1. Respondent structure

Out of the total number of respondents, the majority were women (73.9%), with the largest age group being between 26 and 35 years old (43.5%), while only 4.3% were over 55 years old. Regarding education, half of the respondents had completed undergraduate studies (50%), and all had at least a secondary vocational education or higher. In terms of job positions, most respondents were in top management positions (65.2%).

*Table 1. Organization size and industry type*

| Variable | Category | Number | (%) |
|---|---|---|---|
| **Size** | Micro | 30 | 65,2 |
| | Small | 12 | 26,1 |
| | Medium | 2 | 4,3 |
| | Large | 2 | 4,3 |
| **Industry type** | Production | 22 | 47,8 |
| | Sale | 10 | 21,7 |
| | Education | 2 | 4,3 |
| | Media/entertainment/marketing | 2 | 4,3 |
| | Consulting services | 5 | 10,9 |
| | Health services | 1 | 2,2 |
| | Technology/software/IT | 1 | 2,2 |
| | Other | 3 | 6,5 |

In terms of organization size, the majority were micro-organizations (65.2%), followed by small organizations (26.1%), with medium and large organizations each accounting for 4.3%. Regarding the industry in which the organizations operate, the largest percentage was in manufacturing (47.8%), followed by sales (21.7%), while technology/software/IT and healthcare services had the smallest percentage (2.2%).

In response to the question of whether the organization is involved in projects, the highest percentage was for the answer 'often' (32.6%), while 23.9% answered that they are not involved in projects. Most organizations responded that they are involved in projects for new product development (34.8%).

### 3.2. Research results and discussion

The application of project management skills in entrepreneurship was examined and it was concluded that it is essential to have the ability to gather necessary information, work in a team, i.e., organize people, define problems, having negotiation skills, managing time, costs, quality, and dealing with uncertainty and risks. In the literature, all these skills are defined as important for increasing business growth and development, improving the business environment, and providing opportunities for the progress and development of employees themselves.

The second part of research included project management tools and techniques and to what extent they can be applied in entrepreneurship. For the purposes of the research, project management tools and techniques that were identified through a literature review as the most commonly used in this field were selected, such as WBS, Monte Carlo, Gantt Chart, Histogram, etc.

The participants evaluated the level of use of these tools in the development of their businesses, and the results are presented in Figure 1

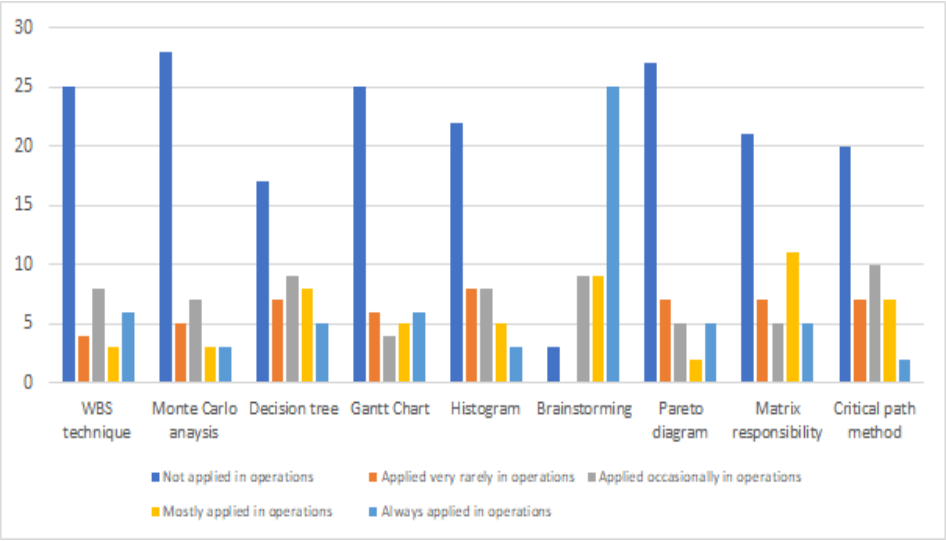


*Figure 1. Project management tools and techniques applied in entrepreneurship*

Unlike the set of questions related to project management skills, where respondents mostly gave high ratings (4 and 5) and were aware of their importance, when it came to project management techniques and tools, they predominantly gave low ratings (1 and 2). The least known terms identified were: Monte Carlo analysis (60%), Pareto diagram (59%), WBS, and Gantt chart (54% each). Among all the listed tools and techniques, only the brainstorming received a high rating, with 25 out of a total of 46 participants stating that they apply it in their business.

In the following part of the research, a matrix was provided consisting of basic functions in business and project management tools and techniques. The task for the participants was to mark all the tools and techniques they apply within the various functions (e.g. production, sales, research, etc.). The obtained results are presented in Figure 2.

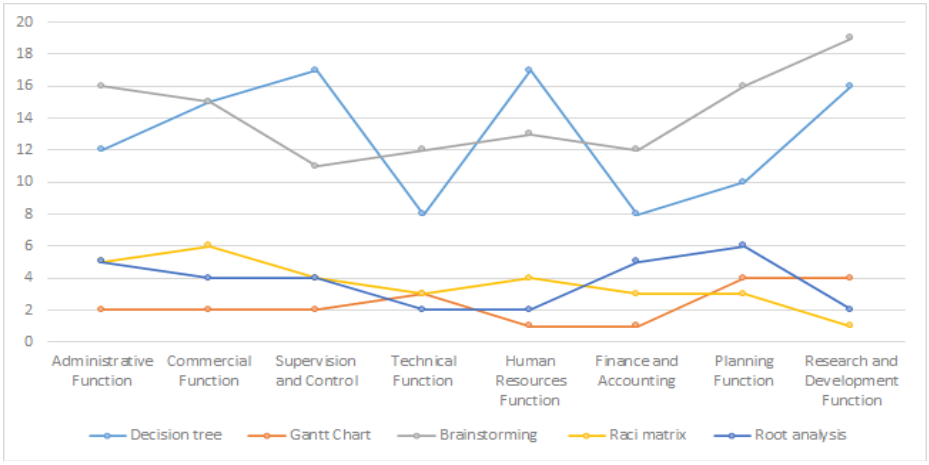


*Figure 2. The most commonly used project management tools and techniques represented by functions*

Decision trees and brainstorming are most commonly used for management and organization of work across various functions, particularly in research and development, control, and administrative functions. Other tools are used to a lesser extent but are equally applied across all functions of the organization.

Based on the overall results obtained, it can be observed that the entrepreneurs in Serbia do not have a high level of knowledge regarding these tools and techniques and small percentage of them is familiar with the significance of their application. This can be linked to the level of the position they currently hold, the type and level of education, as well as the involvement of their company in projects

## 5. Conclusion

This paper can contribute to further research on key project management skills that apply to leading entrepreneurial ventures. The frameworks and hypotheses presented can later be used for studies involving more respondents, through interviews or case studies. These findings could pave the way for new opportunities, fostering programs and additional training for entrepreneurs to grow their businesses and encourage potential collaborations between universities and the business sector.

At the start of their careers, entrepreneurs could benefit from guidance in choosing the most effective tools and techniques for their business by evaluating which ones are best suited to their industry, identifying the essential skills they need to acquire, and more

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE IMPACT OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES ON ORGANIZATIONAL STRUCTURE AND BUSINESS PROCESSES

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***Abstract***

*Artificial intelligence (AI) technologies are used in many forms throughout different organizations. These can include chatbots for customer interaction, recommendation services for business decisions, code or product design suggestions, detecting patterns of behavior or process flows, anomaly detection, and many other applications. Implementation of different AI technologies is related to companies process performance factors which have always the same goal of optimization under given constraints, and it brings novel ways in which companies may organize or reorganize jobs. Thus, AI technologies implementation have an impact on changing the existing business processes and impacting the positions and responsibilities of organizations employees. Since the AI technologies are increasingly present in today's business environment, this paper is focused on detecting the changes in organizational design, business processes and process management, due to AI technology implementation. The paper presents the analysis of how adoption of the AI technologies is changing organizations in these areas. Paper shows the discussion of recent published research papers on these topics, and highlights main implications.*

***Key words:*** *artificial intelligence, organizational structure, business processes.*

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# 1. Introduction

AI is revolutionizing traditional practices in management, marketing, customer service, and organizational processes. It is a major driver of innovation, facilitating the development of new products and services that address market needs (Melnyk et al., 2024). The integration of AI into the business sector has led to changes in organizational processes, impacting not only technological infrastructure but also organizational culture and business practices (Canbul Yaroğlu, 2024).

AI's capability to process and analyze large volumes of data has far-reaching effects on organizations. It has the potential to reshape organizational values, norms, and methods of operation, but it also poses challenges to maintaining a human-centered approach. By automating repetitive tasks, AI enhances worker efficiency, reduces errors, and increases service flexibility. In the face of a rapidly evolving business environment, digital transformation is crucial for maintaining competitiveness, necessitating adaptation to modern technologies and a cultural shift towards embracing change and innovation. Organizations must navigate novel challenges associated with embracing modern technologies to stay profitable and stable. Key issues include effectively leveraging technology, managing rising operational costs, addressing expertise gaps, ensuring security, and complying with customer data regulations (Füller et al., 2022). While most managers recognize the potential and requirements of AI-based innovation, they vary in their preferred methods for implementation. Many organizations report problems in implementing AI systems throughout the organization (Benbya et al., 2020) and much of the expected value remains unrealized (Tarafdar et al., 2020). Organizations must properly prepare themselves to drive AI implementation and unlock its full potential (Jöhnk et al., 2021). This preparation involves investing in specific organizational resources, such as specific human skills and roles, data, and IT assets. However, simply having these resources is not enough; it is crucial how organizations utilize, combine, and integrate them as capabilities to achieve desired outcomes and create value (Mikalef & Gupta, 2021). Capabilities emerge from the complex interplay of resources, along with organizational roles, structures, and processes (Peppard & Ward, 2004).

# 2. AI impact on organizational structure

To fully leverage the potential benefits of AI technologies, organizations must successfully implement and ultimately scale AI across the organizations (Makarius et al., 2020). Many companies lack the necessary guidance and frameworks to effectively manage the processes involved in implementing and scaling AI (Haefner et al., 2023), so leaders face challenges in establishing the right framework for integrating and scaling AI into their organizations.

The adoption of new technology requires not only changes in how the firm uses technology but also adjustments to its organizational structure and processes (Boothby et al., 2010). Haefner et al (2023) advise that firms must effectively organize to ensure that the AI system can autonomously contribute to value

creation, while also monitoring and maintaining these systems and their contributions to organizational processes. It is important that for to be prosperous in implementing the AI technology that the organizational structure must follow it. Therefore, in the following sections of this paper, we will dedicate our attention to this issue.

Haefner et al (2023) define AI organizational structure as the: "Organizational design of the AI team and its responsibilities within the firm".

Depending on the organization's vision and the stage of AI implementation and scaling, the AI structure will be different. Early phases may require more centralized AI structure where all AI-related activities are managed by a central team or department to ensure consistency and proper governance, while later stages, focused on scaling, might benefit from a decentralized AI structure where individual business units or departments independently manage AI initiatives based on their specific needs or hybrid AI structure to foster flexibility, innovation, and integration across various departments. Collaboration plays a crucial role in developing AI systems, especially due to the inherent complexity and opacity of AI, which widens the information gap between IT and other business functions in centralized AI structure. On one hand, IT departments need input from business units to design AI systems effectively, choose relevant features, and assess their performance (Lebovitz et al., 2021). On the other hand, business units need transparency and clear explanations from the IT team regarding the AI system's inner workings, performance, and limitations (Watson, 2017).

In centralized AI, central coordination helps prevent teams from duplicating efforts and promotes collaboration. For instance, if one team has effectively addressed a problem using AI, there should be a system in place that allows them to share their insights broadly across the organization. By centralizing efforts, leaders can develop a comprehensive AI strategy. This approach allows them to set a clear direction and prioritize the most critical AI projects. However, when organizations centralize AI responsibilities, they risk creating isolated teams of "tech experts" who may develop solutions that are disconnected from real business needs and lack practical value. As a result, the most successful AI initiatives strike a balance between centralized and decentralized efforts.

To overcome these obstacles, a hybrid AI organizational structure approach is often used, where a central AI team—often referred to as the Center of Excellence (CoE)—consolidates key functions and expertise while maintaining close connections with decentralized units and the wider organization. The AI CoE is supported by an integration team that ensures Proof of Concepts (PoCs) are successfully incorporated and scaled within the organization's structure.

Depending on the context, each CoE can operate effectively. However, it is generally advisable to position the AI CoE near key decision-makers to ensure alignment with strategic priorities (Shrestha et al., 2019).

In the literature, this type of structure supporting AI within an organization can be referred to as a "hub-and-spoke" model. In this structure, the 'hub' is responsible for setting standards, defining training strategies, ensuring ethical guidelines, and managing broader issues, while the 'spokes' focus on tasks more closely related to the practical application and use of AI Fountaine et al., 2019). Next, we will see how AI impacts business processes.

## 3. AI impact on organizational processes, and process management

The organizations are on a path to transforming their processes and process management approach to AI-assisted. Traditionally, the processes always follow a specific path when applying technologies as an improvement. Tracking process execution performances, such as process time, process costs, and quality of work, can reveal process performance over time or can show if the process executes within the given boundaries. Process time and costs are related, and process quality can impose repetition of process steps, which then brings us back to the dimensions of time and costs.

If performance degrades then the problem must be described and quantified. This enables priority-making in solving the existing problems which cause performance degradation or the inability of a process to reach organizational goals. The next step is to find the solutions and to decide if they are feasible and cost-effective. If the decision outcome on feasibility and cost-effectiveness is positive, then this solution or group of solutions is applied to the process, to some part of the process or just to process tasks. A solution type can be twofold. Solutions can express a way of task adjustment without introducing automation (reorganizing). But most often, solutions introduce some type of software. The previously described approach is called the Business Process Management methodology - BPM (Dumas et al., 2018). BPM methodology consists of several phases, guiding the organization from process discovery to process improvement. It has been often used when the business organization is motivated to do the digital transformation of its processes (Gabryelczyk et al., 2023). The BPM phases are intertwined with AI abilities when this technology is applied. Usually, the BPM digital solutions are in the form of wide-scope Business Process Management Systems (BPMS), which help in process flow automation and process performance tracking. With the introduction of AI, according to (Dumas et al., 2023), BPMS software will transform towards ABPMS – Augmented BPMS, helping processes become more adaptable and adding proactivity with respect to process time, costs, or quality. This type of software would represent not only the AI-empowered system, but also it would change the business process management approach where ABPMS would have interact with one or more human or digital agents, and execute the phases of BPM lifecycle autonomously (Dumas et al., 2023). The BPM conversational ability is also noted in (Rosemann et al., 2024), where different stakeholders such as process owners and process analysts can be able to send queries in natural language and get the desired response. So, the strictly transactional task execution nature will not be eliminated, but the AI's ability to process natural language would enable process management software with more a person-like behavior. The authors in (Rosemann et al., 2024) note that conversational and transactional integration is still at the beginning. Also the organizational processes would move from simplified to sophisticated (more customized to users' needs), and from automatized to autonomous (due to the machines being able to make autonomous decisions in the processes) (Rosemann et al., 2024).

If the company's automation decision goes into the process task automation direction, then the complexity of the task usually deters the automation type. The possibilities of task automation can vary from the automation scope. Task automation has been usually done with Robotic Process Automation (RPA) approach. These can be simple software bots for doing tasks like extracting information from an invoice document and copying it into the spreadsheet software, or consolidating multiple tables into one report which can be sent over email then, etc. Simple tasks are repetitive and time-consuming. Their automation does not require a complex bot. But, as task complexity grows, AI technology applications emerge. Technologies incorporating machine learning or deep learning, such as chatbots, exemplify adaptive solutions. Chatbots, which utilize natural language processing (NLP) and machine learning, have become integral in various aspects of consumer interactions, from shopping to healthcare (Enholm et al., 2022; Urbani et al., 2024). These software bots simulate human-like interactions, enhancing customer experiences, although they may lack deep contextual understanding and primarily generate optimized responses. We see the same attributes as in BPMS software, like conversation and customization, but on a process task level.

Lastly, Large Language Models (LLMs) are gaining popularity for the use of process management as seen in (Berti et al., 2024) and (Beheshti et al., 2023). In (Kampik et al., 2024), a Large Process Model (LPM) is proposed. LPM would merge AI approaches and process management knowledge, enabling understanding of the business processes management specifics to a wider audience, thus making the BPM projects more feasible in organizations (Kampik et al., 2024). In (Ziche & Apruzzese, 2024), a represented case study shows the implementation of LLM for the needs of business process modeling in an international company. In this case, the LLM does not replace but rather supports process modelers, having in mind process documentation used for models creation and organizational specifics. The natural language recognition is emphasized in all these papers, enabling process modeling, but the application is still in its beginning phase concerning the limitations, and specifics of each business process and the organizational system in which it lives.

## 4. Conclusions

We can see that the AI technology organizational implementation has started and that it brings competitive advantage, but also impacts the organizations to take different approach to work. To be able to integrate AI into everyday business, companies may need to adapt organizational structure to a balanced one between centralized and decentralized approach, and also have to be aware of ethical and other issues which can arise if not properly managed. As for the processes, the AI can be applied to a process as a whole, but from a managerial point of view it impacts mostly process modelling, analysis, and monitoring. When applied on to a single task, or group of tasks, then it impacts how the task is implemented. The strict process step-by-step approach would be looser with the conversational potentials of AI technology. Challenges for business process implementation lie in different procedures, policies, available information and knowledge. We conclude that AI will

definitely be more and more present in everyday organizational activities, and that will impact organizations more than any other technology, but surely this is only the beginning, and some adaptation of processes and organizational structure will be needed so that this technology can live to its potential.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# SUSTAINABLE INNOVATION AND TECHNOLOGY MANAGEMENT IN SERVICE COMPANIES. AN EXPLORATORY STUDY OF HAIRDRESSING BUSINESSES IN GERMANY.

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***Abstract***

*In an increasingly globally connected and digitalized world, companies are faced with a variety of complex problems that require them to rethink their business models and processes. Sustainable innovation and technology management is playing an increasingly important role, particularly in the service sector. This is not just about introducing new ideas and technologies, but above all about those that are environmentally friendly and socially friendly in the long term. Sustainable entrepreneurship plays a crucial role here by producing sustainable products and services through imaginative innovations. This study examines the meaning and implementation of sustainability in connection with innovations in service companies. The overall goal of the study is to analyze the current status, existing challenges, barriers and potential opportunities of sustainable innovation in service companies. In this context, the interaction between sustainability and innovation within these companies is examined. On the one hand, it examines which motives and motivations contribute to the development and implementation of sustainable innovations. On the other hand, the existing challenges and barriers are also highlighted. This enables a deeper understanding of the hurdles that stand in the way of successful implementation of sustainable innovations. The empirical data in this study were obtained using a written, partially standardized online survey among hairdressing businesses. The results of the study show that the topic of sustainability plays an important role for the hairdressing businesses surveyed. Above all, the interest in product, process and environmental innovations is emphasized.*

***Key words:*** *sustainable innovation, technology management, service companies, hairdresser.*

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# 1. Introduction

This study examines the significance and implementation of sustainability in connection with innovations in service companies. The overall aim of the study is to analyse the current status, existing challenges, barriers, and potential opportunities for sustainable innovation in service companies. On the one hand, the study investigates which motives and motivations contribute to the development and implementation of sustainable innovations. On the other hand, it also highlights the existing challenges and barriers. On the one hand, the study investigates which motives and motivations contribute to the development and implementation of sustainable innovations. On the other hand, it also highlights the existing challenges and barriers.

# 2. Literature Review

## 2.1. Focus and Method of the Literature Review

A comprehensive overview of the current state of research is provided (Snyder 2019), conducted on sustainable innovation and technology management to position the study within existing research. The literature review primarily examined publications from the past six years (2018-2023) that contained the keywords "sustainable innovation," "technology management," "service companies," and "hair salons" (Eco 2015). In addition to relevance, the citability of the sources was also considered. As a result, only publications from journals using a double-blind review process were included.

## 2.2. Sustainable Innovation and Technology Management in Hairdressing Businesses

Innovation and innovative activities play a key role in a company's success. Innovations can occur in different forms, depending on the organisations, areas, and processes they influence. The four most common types are product, process, marketing, and organizational innovations, with product and process innovations often regarded as the most dominant. Additionally, environmental, social, technological, business model, and service innovations are also distinguished (Turulja, Bajgoric 2018). Social innovations are changes designed to solve social problems and meet societal needs. They focus on changes in social practices, which in turn lead to broader changes in socio-technical systems. This means that social innovations not only target technological solutions but also consider non-technological aspects, such as societal norms, organizational structures, or models of cooperation (Edwards-Schachter 2018; Avelino et al. 2019). Innovation barriers hinder companies from adopting new initiatives or successfully developing innovations. Four main types of innovation barriers can be identified: financial, knowledge-based, market-related, and regulatory barriers (Valdés et al. 2021). In recent years, the concept of sustainability-oriented innovation has gained relevance. It provides a clear direction towards sustainability and encourages companies to

develop innovations that align economic, ecological, and social goals (Urbinati, Esfandabadi, Petruzzelli 2023). Given the unique characteristics of services, the existing literature argues that the IHIP attributes (intangibility, heterogeneity, inseparability, and perishability) are the fundamental features that distinguish services from products (Mishra, Anning-Dorson 2022; Wirtz, Holmqvist, Fritze 2020). The increasingly intense competition in service markets makes it more difficult for companies to attract and retain customers in the long term. As a result, there is a growing need to intensify customer loyalty measures (Vilkaite-Vaitone, Papsiene 2022). Continuous improvements in service delivery and the introduction of innovations are essential to achieving customer satisfaction (Mishra, Anning-Dorson 2022). In many service companies, the internal organization is poorly structured due to the small number of employees, which makes it difficult to access resources and knowledge to support innovation. Consequently, the opportunities to introduce innovations and implement necessary technology management processes are limited. Worldwide the hairdressing sector is represented by more than 3.5 million salons and the hairdressing sector mainly consists of SMEs. Annual numbers of visits in hair salons amount to over 800 million, resulting in six billion visits to hair salons, which demonstrates the market potential of this sector (López-Jáuregui, Martos-Partal and Labega 2019). It exists a total of around 80.000 hair salons throughout Germany. With less than 10 employees and a turnover of less than 2 million euros per year, hairdressing salons in Germany are also classified as micro-enterprises or small enterprises, depending on the number of employees and turnover. There is an average of around 1.6 employees per salon who are subject to social security contribution (Statista, 2020). Adams (2022) analyzed how hairdresser businesses can secure long-term success, highlighting the importance of marketing, cash management, and a solid business plan (Adams, 2022).

### 2.3. Research Gap and Research Questions

While some service sectors, such as hospitality (Han, 2021; Kim et al., 2017; Prud'homme and Raymond, 2013) and healthcare (Barrett et al., 2011; Reid et al., 2008; Corbin et al., 2021), have been thoroughly studied regarding innovation, hairdresser businesses have received limited attention.

Based on this, the following research questions (RQ1-RQ6) aim to address the research gap:

RQ1: What is the significance of different types of innovation in hairdresser businesses?

RQ2: What sustainability aspects are prioritised in hairdresser business innovations?

RQ3: What sustainable initiatives and innovations have already been implemented in hair-dresser businesses?

RQ4: What challenges and barriers do hairdresser businesses face in implementing sustainable innovations?

RQ5: Do hairdresser businesses plan to drive sustainability and innovation further in the future?

RQ6: What measures are necessary to support hairdresser businesses in implementing sustainable innovations?

## 3. Material and Methods

A quantitative highly structured explorative survey was conducted in to answer the six research questions (RQ1, RQ2, RQ3, RQ4, RQ5 and RQ6) (Möhring, Schlütz 2013). The survey was conducted via an online questionnaire (created with www.survio.com) (Wagner-Schelewski and Hering 2022). The data was collected in from 17th July to 31rst July 2023. The survey link was sent by email to 250 randomly selected hairdresser businesses. A total of 43 hairdresser businesses completed the survey, resulting in a response rate of 17.2%.

## 4. Results and Conclusions

The results of the investigation indicate an interest in product, process, and environmental innovations (RQ1). In addition to economic aspects such as cost reduction, personal beliefs and a sense of social responsibility play a significant role of motivations that drive salons to pursue sustainable innovations (RQ2). Challenges and barriers exist, particularly concerning costs and a lack of resources, such as personnel and time, for the development and implementation of sustainable innovations (RQ4). Funding and grants, along with sufficient resources, are seen as supportive measures to counteract these obstacles (RQ6). Hairdresser businesses particularly recognize promising potentials for sustainable innovations in the areas of recycling and products. It becomes clear that the overwhelming majority of surveyed salons intend to enhance their focus on sustainability and innovation in their operations moving forward (RQ3 & RQ5). Given the *limited sample size* of this study, it would be advisable for future investigations to aim for a broader data foundation. Different sectors within the service industry should also be considered to better understand the peculiarities and challenges in various contexts. *Future research* could increasingly focus on the potentials of recycling, particularly concerning water treatment and wastewater reuse, as well as sustainable products. A more detailed investigation of these areas could not only provide insights into potential innovations but also highlight approaches for effectively utilizing these potentials. From a *practical perspective* an intensified focus on the development and implementation of sustainable innovations in hairdresser businesses requires increased support in financial aspects and personnel resources. Additionally, improved knowledge transfer through training and informational offerings is necessary to empower businesses in their sustainability efforts (RQ6).

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ANALYSIS OF FACTORS INFLUENCING EMPLOYEE SATISFACTION AND STRATEGIES FOR IMPROVING IT IN THE TOP MANAGEMENT OF A TRADING COMPANY

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***Abstract***

*Employee satisfaction surveys within companies allow for the identification of the current situation among employees, potential issues, as well as improvement suggestions that enhance the efficiency and success of the company. This study uses comparative data from the annual employee satisfaction survey in top management in a commercial company for the years 2023 and 2024, to determine how improvement measures for certain satisfaction factors impact employees. The survey was conducted through questionnaires among directors. The research methods employed include the analysis of relevant literature, surveys, and interviews with directors. The collected data provides a basis for making important decisions regarding policies and practices that affect management. The study explores factors contributing to directors' satisfaction, including the work environment, opportunities for professional development and advancement, compensation and benefits, and decision-making autonomy. The aim of the paper is to highlight to HR leaders and general directors the factors influencing the satisfaction and engagement of employed directors, as well as the importance of conducting annual employee satisfaction surveys to achieve better company results. Additionally, the paper offers recommendations for improving this aspect. The results indicate a positive relationship between the mentioned factors and job satisfaction among employees. It concludes that organizations that pay attention to the satisfaction of their directors can expect improvements in their productivity, loyalty, and overall company success. This research contributes to a better understanding of the factors influencing employee satisfaction in top management, as well as practical examples for improving each of these factors.*

***Keywords:*** *employee job satisfaction, top management, factors of employee satisfaction, employee engagement*

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# 1. Introduction

Due to the increasingly demanding conditions in the labor market and the declining popularity of retail, companies in the trade industry are finding it increasingly difficult to retain employees. To gain a competitive advantage and adapt to rapid changes, they must increase efficiency by enhancing employee satisfaction (Parvin, 2011). Consequently, companies are investing significant efforts, financial resources, and time to retain their employees and achieve a competitive edge (Bartlett & Ghoshal, 2013). Modern equipment and a pleasant work environment improve employee satisfaction and service quality (Kumar et al., 2013). In practice, some companies consider the costs of improving working conditions and the environment unnecessary and do not invest significant resources in these aspects (Aghaji et al., 2021). According to research (HR Word Community, 2023), employee retention has decreased compared to previous years, and turnover in retail is on the rise. To increase employee commitment and efficiency, companies are willing to provide job security (Mahmood et al., 2019). Due to all of the above, companies are now placing greater emphasis on employee benefits and satisfaction. Directors have a significant impact on the company's operations, as their satisfaction directly affects the efficiency, motivation, and performance of the entire team, which will be demonstrated through this research. The paper is divided into several sections. The first part of the paper presents the methodological framework of the research, while the second part highlights the importance of employee satisfaction in top management and the factors influencing it. The third part of the paper presents the results of the annual employee satisfaction survey among top management at the trading company BB Trade LLC, with a focus on the impact of factors on satisfaction and changes compared to the previous year. The fourth part of the paper discusses the results, addressing the causes of changes in employee satisfaction, as well as providing recommendations and guidelines for improvements.

# 2. Methodological framework of the research

The methodological framework of the research employs a combination of basic (analytical and synthetic), general scientific, and specific methods (quantitative and qualitative). The research focuses on the retention and enhancement of employee satisfaction in top management within a dynamic business environment. The subject of the research is the factors that influence the satisfaction of directors in a trading company. The primary goal of the paper is to examine the satisfaction of employees in top management and assist HR leaders and general directors in understanding the factors that affect it. Additionally, the paper emphasizes the importance of annual employee satisfaction surveys for company performance and provides recommendations for improving this aspect.

This research is based on a primary hypothesis from which four additional hypotheses are derived, and will be tested:

*H0:* There is a positive relationship between investments in improving factors that influence employee satisfaction and the increase in job satisfaction among employees.
*H1*: There is a positive relationship between the work environment and the satisfaction of employees in top management.
*H2:* Opportunities for professional development and advancement directly impact the level of satisfaction among employees in top management.
*H3:* Compensation and benefits have a significant impact on the satisfaction of employees in top management.
*H4:* A high level of decision-making autonomy increases the satisfaction of employees in top management.

The following set of research methods was employed: (1) review of existing information; (2) employee satisfaction survey; (3) detailed analysis and processing of survey data; and (4) collection of data on employee satisfaction in top management from other available sources. The research methodology is designed to provide a comprehensive insight into the current situation and propose corrective measures for improving satisfaction at this management level through the analysis of relevant literature, surveys, and interviews with directors.

The research procedure is based on consecutive annual employee satisfaction surveys conducted among top management (which includes 12 directors) at the trading company BB Trade LLC - DTL PerSu markets (which employs over 1,350 people and operates 175 retail outlets) in June 2023 and 2024, using an anonymous survey created specifically for this research. The survey questions were divided into three sections. The first section consisted of questions requiring responses on a scale from 1 to 5 (where 1 – not satisfied at all, 2 – not satisfied, 3 – neutral, 4 – satisfied, 5 – very satisfied). The second section of the survey contained statements for which respondents had to rate their level of agreement on a scale from 1 to 5 (where 1 – strongly disagree, 2 – mostly disagree, 3 – neutral, 4 – mostly agree, 5 – strongly agree). The third section of the survey comprised open-ended questions where employees provided responses about what they were most satisfied with, what they were dissatisfied with, and what improvements they would like the company to implement.

## 3. Factors influencing the satisfaction of employees in top management

Some studies indicate that employee satisfaction plays a crucial role in achieving financial results (Koys, 2003). If a company cares for its employees, they will better serve customers, which increases productivity and efficiency. However, other studies suggest that there is a weak direct link between employee satisfaction and financial performance (Bernhardt & Donthu, 2000), while some point to a negative relationship (Tornow & Wiley, 1991). The factors that will be analyzed include the work environment, opportunities for professional development and advancement, compensation and benefits, and decision-making autonomy. The

work environment encompasses all physical, social, and psychological conditions that affect employees while performing their tasks. Studies show that a positive work environment enhances employee performance (Zhenjing et al., 2022) and significantly impacts their performance since employees spend a large portion of their day at work (Wang et al., 2021). However, many companies fail to recognize the importance of the work environment for job satisfaction, which can lead to difficulties (Raziqa & Maulabakhsha, 2015). Opportunities for professional development and advancement are crucial for highly educated employees when choosing an employer. Factors such as leadership style, career advancement opportunities, work environment, and organizational justice influence professional development (Firdinata & Hendriyani, 2018). Access to professional training, workshops, seminars, and programs for developing hard and soft skills, as well as a clearly defined path for advancement and career growth opportunities, play a key role in employee satisfaction. According to the annual regional HR survey, 80.4% of companies invest in the development of their employees (HR Word Community, 2023). With the shortening lifespan of skills, now lasting only two to three years, there is a need for constant renewal of skills. Lifelong learning and micro-learning are essential for keeping up with new technologies and building transferable skills (HR Word Community, 2023).

Compensation and benefits are crucial for employee satisfaction and are often the primary reason for leaving a job. A study with 95% confidence shows that fair and reasonable compensation directly influences higher performance and greater job satisfaction (Zulher et al., 2022). Surveys indicate that compensation and benefits are rated more favorably among top management than among workers in the trading company. Compensation for directors, which includes base salary, bonuses, and other financial rewards, provides material security and enhances satisfaction. Benefits for directors include additional perks such as private health insurance, paid vacations, flexible working hours, and other non-material benefits, which further contribute to their satisfaction. Autonomy in decision-making is crucial for the satisfaction of directors, as they are responsible for the company's success. Without this freedom, there is often a high level of dissatisfaction, given that they are expected to bear responsibility without corresponding authority. On the other hand, high autonomy allows employees to utilize their skills and knowledge to the fullest, which increases engagement and contribution to the organization. Job autonomy gives employees greater control over their work, improves their sense of competence, and reduces stress and dissatisfaction associated with micromanagement (Zychová et al., 2024).

## 4. Research results

In the following sections of the paper, we will review the survey results and examine the impact of the work environment, opportunities for professional development and advancement, compensation and benefits, and decision-making autonomy on the satisfaction of employed directors. In Figure 1, the comparative ratings of employed directors for the years 2024 and 2023 at the trading company

BB Trade LLC – DTL PerSu markets, who evaluated the work environment as a factor of satisfaction, are presented. The average rating in the survey on a scale from 1 to 5 for the work environment was 3.8 in 2023, while it significantly increased to 4.2 in 2024. When evaluating the work environment, specific questions were defined, which related to the following factors that influence the overall work environment: availability of resources, organization of the workspace, interpersonal relationships within the company, organizational culture, employee appreciation, stress levels, and the achieved balance between private and professional life.

*Figure 1. Rating of employee satisfaction in 2023 and 2024 caused by the work environment*

The improved rating of the work environment in 2024 compared to 2023 resulted from: 1. The renewal of IT resources, with a budget increase of 74%. 2. The renewal of the vehicle fleet and the allocation of twice as many funds for the purchase of new cars for directors. 3. The opening of new offices and new workspace in 2024. Organizational culture was examined through transparency and availability of information, equality and fairness among employees, as well as employee appreciation and the implemented values of the company. Transparency and awareness within top management were improved by involving directors in defining strategic goals and launching an internal communication and information portal. Additionally, teams were formed to address business challenges, including relevant directors and employees in establishing or redefining processes, which enhanced appreciation and the sense of being valued among employees. Interpersonal relationships were improved through better relationships with superiors and improved cross-departmental collaboration. By providing constructive and more frequent positive feedback from superiors, appreciating directors' suggestions, and more equitable performance evaluations, better relationships with superiors were achieved. Team spirit and cross-departmental collaboration were strengthened through joint teams for addressing business challenges, an increased number of joint activities, and team-building events. The level of stress in 2024 remained unchanged, with an average rating of 3.8 (on a scale from 1 to 5). The work environment, which allows for a balance between private and professional life, received an average rating of 3 in 2024, which is a decline compared to the 3.2 rating in 2023. Based on the presented results, it can be concluded that four factors had higher average ratings for 2024 compared to 2023. The factor of stress level remained unchanged, while the factor representing the balance between private and professional life saw a slight decrease in rating. These

two factors are heavily influenced by the company's development and the rapidly growing retail market, where the high frequency of changes and the expected flexibility from employees and the company play a key role. When considering the overall satisfaction across all seven factors, it can be concluded that the average rating is positive, thereby confirming the first hypothesis: "There is a positive relationship between the work environment and the satisfaction of employees in top management."

The opportunity for professional development and advancement was rated with an average score of 4 in 2023, while in 2024, this score increased to 4.4, as shown in Figure 2.

*Figure 2. Rating of employee satisfaction in 2023 and 2024 caused by opportunities for professional development and advancement*

The improved rating for the opportunity for professional development and advancement in top management in 2024 compared to 2023 resulted from: 1. Allocating 45% more financial resources for external training. 2. Increasing the number of internal training sessions at the PerSu Academy, covering both soft and hard skills, with the number of training sessions tripled. 3. Launching an online platform for digital learning in 2024. 4. Increasing the number of seminar and conference attendances by 50% compared to 2023. 5. Establishing and implementing a performance management and improvement process for employees in 2024, which includes employee development plans. This segment, which affects employee satisfaction, has been recognized by the Company as an opportunity to respond to a competitive market and a chance to achieve better financial results by investing in employee knowledge and development. The results of the seven factors that constitute satisfaction with opportunities for professional development and advancement for 2024 are higher compared to 2023, and therefore, it can be said that the second hypothesis is confirmed: "Opportunities for professional development and advancement directly impact the level of satisfaction among employees in top management."

Compensation and benefits were rated with an average score of 2.7 in 2023, compared to 3.9 in 2024, as shown in Figure 3.

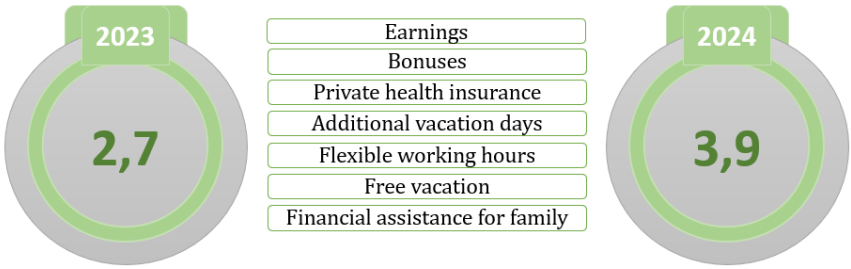


*Figure 3. Employee satisfaction rating in 2023 and 2024 caused by compensation and benefits*

The improved rating for compensation and benefits in 2024 resulted from: 1. Higher salaries across the entire company, including employees in top management, with an average increase of 25% compared to 2023. 2. Key Performance Indicators (KPIs) were defined for 85% of the company's employees and for directors who lead those sectors, increasing the number of sectors included in the company's bonus and reward process. The bonus budget increased by 32%. 3. Additional benefits were introduced, such as private health insurance and extra vacation days for employees in top management (from 20 working days to 22-24 working days, depending on the level of education, years of service, and social conditions). 4. The number of other accompanying non-material benefits increased. Free fit passes, theater tickets, and access to swimming pools were introduced for management employees. Other benefits remained unchanged, such as: anniversary awards for 10 and 20 years of service, free fruit snacks, financial assistance upon the birth of a child, free vacations at Tara and Zlatibor for five days with family, free health check-ups for employees, and holiday packages for employees' children. All these changes in 2024 contributed to increased employee satisfaction with compensation and benefits. Employees expressed that they consider their benefits package to be more competitive compared to 2023 and that the financial compensation is more adequate relative to the work they perform. The results across all seven factors indicate the confirmation of the third hypothesis: "Compensation and benefits have a significant impact on the satisfaction of employees in top management."

Autonomy in decision-making is extremely important for employees in top management, as it is closely tied to their responsibility for the results of the sectors they manage. In the employee satisfaction survey, this segment was rated with an average score of 4 in 2023, while it increased to 4.5 in 2024. Responsibility is one of the core values of this company, which includes and emphasizes accountability for results, and decision-making autonomy is crucial for taking responsibility for the decisions made by directors.

*Figure 4. Rating of employee satisfaction in 2023 and 2024 caused by decision-making autonomy*

In 2024, the following measures were implemented to further increase decision-making autonomy for top management employees: 1. Flexible working hours were introduced for top management employees. 2. The option to work from home one day per week was introduced. 3. The level of decentralization in decision-making within top management was increased. 4. A greater number of directors' proposals were approved by the General director. The analyzed results of the seven factors that constitute satisfaction with the level of decision-making autonomy show noticeable satisfaction across all factors, confirming the fourth hypothesis: "A high level of decision-making autonomy increases the satisfaction of employed directors." Through the analysis of all the steps taken to improve employee satisfaction, we can conclude that by directly influencing the aforementioned factors and introducing additional benefits for employees, we can positively impact their satisfaction.

The overall results of this study support the hypotheses, which suggest the existence of a relationship between the work environment, opportunities for professional development and advancement, compensation and benefits, and decision-making autonomy, and job satisfaction among top management employees. The research results confirmed the auxiliary hypotheses and indicated that if companies directly influence the improvement of employee satisfaction factors by investing in their enhancement, employees will be more satisfied with their jobs. This directly confirms the primary hypothesis: "There is a positive relationship between investments in improving factors that influence employee satisfaction and the increase in job satisfaction among employees."

## 5. Discussion

The importance of conducting annual employee satisfaction surveys is evident in the example of BB Trade LLC – DTL PerSu markets, which implements improvement suggestions after each satisfaction survey. Since 2022, when the employee satisfaction survey was first conducted, the results have significantly improved in all segments, as reflected in the ratings obtained in this survey. Additionally, the turnover rate in BB Trade LLC before 2022 was 45% in top

management, while in 2024, it decreased to 15%. The increase in employee satisfaction across all these segments has also led to improved employee retention. Furthermore, the company has experienced stable revenue growth over the past period. Since 2022, it has achieved an average annual growth rate (CAGR) of 10%, with revenue growth of 17% in 2023 alone.

The following studies support the first hypothesis: "There is a positive relationship between the work environment and the satisfaction of employees in top management." The results of a study that examined the model of multimedial mediation and the impact of the work environment on employee performance showed that a positive work environment improves employee performance (Zhenjing et al., 2022). According to Urie Bronfenbrenner's ecological systems theory, work environments are interconnected and influence workplace activities in terms of context, time, and processes (Ferschmann et al., 2022). Social exchange theory explains how a favorable work environment motivates employees to perform better, providing a basis for understanding the effect on employee performance (Christensen et al., 2021). In return, employees give their best to achieve the goals set by their organizations and perform better in a favorable work environment. Social exchange theory also explains how a favorable work environment increases employee commitment. When employees feel supported by management, they develop trust in the organization. This trust motivates them and increases their commitment, resulting in a better attitude towards work and improved performance (Casper & Thaichon, 2021). Employees spend most of their time at work, and the integrated work environment significantly affects their performance (Wang et al., 2022). Poor working conditions prevent employees from showcasing their abilities and reaching their full potential. Therefore, it is imperative for companies to understand the importance of a good work environment (Abdul & Maulabakhsh, 2015). Supporting the proposed H1 hypothesis are also the results of a study on work environment variables and employee performance, which show that the work environment has a significant positive impact on employee performance (Simbolona, 2017). Kusmaningtyas's research indicates that the work environment has a significant impact on employee satisfaction and performance, in addition to the influence of organizational culture (Kusmaningtyas, 2014).

The following studies support the second hypothesis: "Opportunities for professional development and advancement directly impact the level of satisfaction among employees in top management." These studies have examined the significance of professional development and career advancement. One of the company's activities to enhance the capabilities of its employees and increase their satisfaction is career development. Research on the effects of work motivation, the work environment, and career development has shown that these factors influence employee satisfaction (Prayud & Komariyah, 2023). The results of Oduma's research (Oduma & Were, 2014) indicate that career development affects employee performance. Additionally, career development impacts job satisfaction (Ahmed et al., 2010). Willis Shattuck and colleagues, through a review of databases, found that the second factor (after inadequate financial compensation) for leaving a job is dissatisfaction with professional development (Willis et al., 2008).

The following research supports the confirmed third hypothesis: "Compensation and benefits have a significant impact on the satisfaction of employees in top management." According to a 2012 study conducted by SHRM (Society for Human Resource Management), 64% of employees believe that compensation and benefits are very important for their overall job satisfaction. Competitive salaries and attractive benefits packages are key to retaining and motivating good workers. Gallup's research shows that employees who feel well compensated are more engaged and productive. A study in the Harvard Business Review reveals that companies with strong compensation and benefits programs have a 50% lower employee turnover rate. Odunlade found that there is a link between compensation and job satisfaction (Odunlade, 2012), and Souza observed that compensation is a predictor of job satisfaction (Sousa, 2020).

The confirmation of the fourth hypothesis: "A high level of decision-making autonomy increases the satisfaction of employees in top management" is in line with the following research. Employees with a high degree of autonomy feel more satisfied with their jobs because it gives them greater control over their work. This leads to a better ability to shape the work environment according to their preferences and advantages (Zychová et al., 2024). Job satisfaction and motivation are positively associated with autonomy in work scheduling, decision-making at work, and work methods (Hackman & Oldham, 1976). Research among staff members of the International Bank of Afghanistan found that employee involvement in decision-making positively impacts job satisfaction (Mohsen & Sharif, 2020). All these findings support the validity of hypothesis H4, that a high level of decision-making autonomy increases the satisfaction of employed directors.

Therefore, the recommendations and guidelines for increasing employee job satisfaction include effective management through a positive work environment, setting realistic goals, monitoring and recognizing work, caring for employees, and providing frequent feedback. Key elements are communication, feedback, transparency, and consistency, which are essential for building trust and a positive environment. Regularly measuring employee engagement is crucial, as is fostering a culture of experimentation and innovation. Additionally, the integration of automation and digitalization can significantly improve operational efficiency and satisfaction by streamlining processes and providing employees with the tools they need to work independently and innovatively. The overall results of this research support the findings of previous studies and the confirmed hypotheses, which suggest the existence of a relationship between the analyzed factors and job satisfaction among employees in top management. Through the analysis of all the steps taken to improve employee satisfaction, it can be concluded that directly influencing the aforementioned factors and introducing additional benefits for employees positively impacts their satisfaction.

## 6. Conclusion

Companies often attempt to quickly respond to increased employee turnover, but sometimes they implement the wrong measures. This research has enhanced the understanding of factors that influence job satisfaction among top management employees and provided examples of how to improve each of these factors. Companies should structure and encourage opportunities to enhance these factors in order to improve employee satisfaction, which will directly impact their retention and engagement. Additionally, these results suggest that companies should focus on creating attractive compensation packages and fostering an environment where employees feel comfortable working independently and have the freedom to make decisions, while also being focused on their development opportunities and advancement. By conducting employee satisfaction surveys, companies demonstrate their concern for employees' opinions and satisfaction, while simultaneously gaining insights into job satisfaction levels, identifying gaps, and learning what needs to be addressed in the future to maximize their potential. Employee satisfaction surveys should not be just a formal exercise of filling out questionnaires, generating numbers, and presenting results without actionable plans. HR leaders are aware that investing in a strategy to improve employee engagement and satisfaction is crucial in today's challenging labor market.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# HOW TO ELEVATE THE PRIVATE JET CHARTER EXPERIENCE?

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***Abstract***

*The private jet charter business has seen major growth because it appeals to individuals who want luxury, flexibility and privacy. There is the need for charter brokers to react decisively, effectively, and without prior thought, in order to provide clients with value as the industry becomes more competitive.*

*This article enhances our theoretical understanding of luxury consumer behavior by delving into the complex preferences and decision-making processes of affluent passengers in the private aviation charter market. On an organizational level, it emphasizes the importance of service customization in increasing customer happiness and loyalty, arguing that businesses should prioritize specialized solutions to match the sophisticated needs of high-net-worth clientele. Furthermore, the study emphasizes the importance of increasing efficiency in safety measures, training programs, and regulatory compliance as a crucial strategy for creating a competitive edge through consistent delivery of trustworthy services.*

*The article investigates the impact of real-time price prediction systems, mobile itinerary apps, and personalized in-flight amenities on the customer experiences and emphasizes the importance of cultivating a culture of continual improvement and adaptation through openness to client feedback, awareness of industry trends, and competitive benchmarking of satisfaction levels in private jet charters. It studies focuses on customization of services, enhancing technology, in-flight services, maintaining safeness while on air, ensuring the environment is not compromised during the flight operations.*

***Key words:*** *Luxury Consumer Behavior, Service Customization, Client Satisfaction, Private Aviation, Safety and Efficiency.*

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# 1. Introduction

In the realm of luxury travel, the private jet charter experience stands out as the epitome of exclusivity and comfort. As discerning travelers seek unparalleled levels of service and convenience, the question arises: How can one elevate the private jet charter experience to new heights of sophistication and opulence? This article delves into various strategies to enhance every aspect of the private jet charter journey, from personalized services and luxurious amenities to exceptional customer service and safety measures.

Private jet charters are in high demand as they are very convenient, comfortable and flexible and attract different range of clients including wealthy individuals, celebrities, dignitaries and top executives among others (Private jet traveler, 2022). As consumer needs change so do the services offered by companies such as renting a private jet. To make the experience of hiring a private jet more appealing, a combination of personalized services, modern technology, luxurious onboard services, highest safety standards, and an unwavering commitment to environmental conservation is needed. By exploring these key elements, the article aims to provide insights into creating a truly unforgettable and bespoke travel experience for those who demand nothing but the best. Join us on this journey as we uncover the secrets to elevating the private jet charter experience to a level beyond imagination.

## 1.1 Literature reviews

Previous research has focused on the experience of chartering a private jet, emphasizing the motivators for UHNWIs such as time efficiency, control, and safety perception.

Behaviors and decision-making processes of Ultra-High Net-Worth Individuals are driven by time, as it is their most valued asset. Key findings show that UHNWIs suggest consistency in their behaviors, overcoming cultural distinctions, notably in the luxury industry. Time management is crucial to their luxury experiences, shifting the definition of luxury in comparison to the general population sector (Park & Tarquini-Poli, 2021). UHNWIs value experiences above owning luxurious material possessions. Key elements influencing their behavior involve managing expectations, developing personal ties with brands, and freeing up time for meaningful interactions with loved ones. UHNWIs value memorable luxury experiences, indicating that luxury brands should prioritize experience-driven marketing. Time savings and flexibility in service delivery are critical. (Klaus, 2022).

## 1.2 Methods

A mixed-methods approach was employed to investigate consumer behavior in the private aviation charter sector. It combines qualitative methodologies, such as in-depth interviews and observations, with quantitative surveys to evaluate cost, time efficiency, convenience, safety, and service quality.

This study's central research question is: “What are the determinants shaping consumer preferences and decision-making processes when opting for private jet charter services?". In order to answer this question, the interviews were divided into specific thematic:

**General Information:**

- Could you describe your experience with private aviation charter services?
- How often do you use private aviation services?
- Can you explain why you typically use private aircraft services? (For example, business, leisure, and events.)

**Decision-Making Process:**

- When selecting a service, how important are issues such as safety, convenience, cost, and flexibility to you?
- Can you comment on any specific situations where a specific characteristic of a private jet broker influenced your decision-making process?
- Service Experience:
- How crucial is customized service, customer support, and rapidity from the service provider to you?
- What specific services or amenities do you value the most while using private aircraft services?

**Comparative Analysis:**

- How do private aviation services differ from commercial airline experiences in your opinion?
- Could you outline the process you go through when evaluating and eventually selecting a charter broker?
- What sources of information do you use to evaluate a private aviation broker's reputation and reliability?
- Have you compared the offerings of various brokers? If yes, what were the significant differences between them?
- What distinguishes a certain broker from others in the industry?
- Could you tell me about a time when a broker exceeded your expectations? What factors led to this pleasant experience?
- Conversely, have you had any issues or disappointments with a broker's service? What elements influenced this experience?

**Future Preferences:**

- What improvements or new features would you like to see in future private aviation services?

The surveys investigate consumers' perceived value of charter services, while price elasticity studies investigate demand sensitivity to price changes. A modified SERVQUAL model and brand perception surveys were used to measure gaps between consumer expectations and experiences, as well as brand loyalty via Net Promoter Score as in figure 1 below.

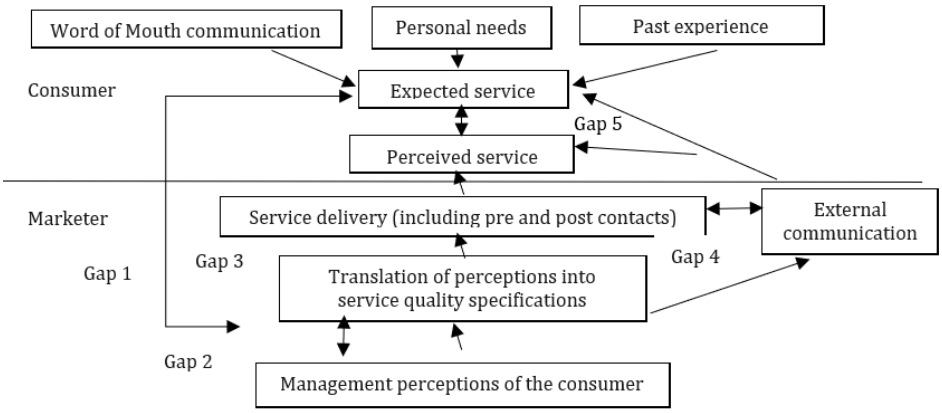


*Figure 1: Parasuraman et al., (1985)*

Forty people have been interviewed. The respondents chartered a private jet at least once in their lives in order to come at a comfortable response to the issue. All of these people are over 21 and come from different parts of the world. HNWI, royal families, and celebrities are included in this sample. These people travel on a personal or professional level.

Gathering data allows us to collect and analyze customer feedback, including satisfaction levels, complaints, suggestions, and preferences, which can inform strategies for enhancing the private jet charter experience. Thematic coding and statistical analysis will help discover crucial patterns, while triangulation boost trust by cross-checking data from many sources. This enables the study to evaluate the performance of private jet charter services, including on-time performance, safety records, customer service quality, and overall customer experience.

## 2. Results

The results, which have been structured using the five key themes analysis, provide significant insight into consumer preferences for private aviation charter services.

### 2.1 General Information

Respondents submitted information about their motivations and satisfaction levels, which ranged from personal convenience to company efficiency. Some people enjoyed the exclusivity and flexibility of private planes, particularly when traveling with children or pets or visiting determined airports. Others preferred typical business or first-class commercial flights, citing convenience and familiarity. Common themes included the advantages of privacy, time efficiency, and individualized service, with some inconsistencies identified.

### 2.2 Decision Making Process

The elements that influence the decision-making process are safety, convenience, affordability, and flexibility. The majority of responders identified safety as their top priority, underlining the importance of tight safety protocols. Convenience, such as easy booking and smooth service, was also highly desired, however the importance of cost varied. Flexibility, while less highlighted, appeals to individuals who require control over their travel itineraries. The involvement of private jet brokers was essential, with respondents citing customized service, timeliness, transparency, and affordable price as key elements in building confidence and influencing their selections.

### 2.3 Service Experience

The essential components of a positive travel experience are emphasized by the value of personalized attention, customer care, and promptness from private jet consultants. This allows to build trust and confidence. Some people place a higher value on the in-flight experience and others understand that relationships are formed through post-flight activities. Sustaining an excellent client-broker relationship aims to learn about personal preferences in order to anticipate eventual needs. Finally, respondents identified specific amenities and services that could improve their private jet experience: enhanced cabin cleanliness, comfort, pet-friendly accommodations, high-quality catering, and elegant furniture. Understanding and addressing these preferences brings to client happiness, promote loyalty, and stand out in a competitive market.

### 2.4 Comparative Analysis

Compared to commercial airlines, private aviation offers personalized service, flexibility, and privacy, with customizable schedules and fewer crowds, enhancing comfort and efficiency. On the other hand, in the competitive charter market, a broker stands out by offering proactive problem-solving, consistent service, and by building strong client relationships. Clients prioritize rapid responses, personalized service, and trust, often guided by recommendations, online reviews, and personal experiences.

### 2.5 Future Preferences

As the private aircraft sector evolves, clients are requesting certain essential improvements. They seek more competitive pricing and better convenience, pointing out faster access to major airports and the usage of smaller, less congested ones. Improved service quality is critical, particularly in terms of cabin maintenance and comfort, while remaining affordable. Safety remains a primary focus, with calls for increased safety precautions and fleet updates. Furthermore, there is a need for higher-quality meals and top-notch amenities.

# 3. Discussion

## 3.1 Personalized Services

Personalization is very important in luxury travel. Charter operators can improve the customer experience by giving special tours depending on each individual's tastes and requirements. This could mean customized timing, personal routes, and in-flight services tailored for a person (NBAA, 2021).

The concierge services contribute to deliver a high-end experience through arranging everything including ground transportation up to VIP access to events, hotels booking and dining reservations. The personal concierge can anticipate customer requirements and ensure perfect travel.

Private jets users expect a high degree of customization from private jet advisors. Customizable cabin configurations are what operators can offer to help them choose interior decor, seating arrangement and facilities in line with their own desires and needs. Individual dietary requirements as well as gourmet dishes prepared by top chefs create the essence of specialized menu for each customer on-board airplanes.

## 3.2 Technological Advancements

Integrating cutting-edge technological solutions into booking systems may lead to great improvement of end user experience. It is essential to have user-friendly interfaces which enable customers access information, compare different choices and make reservations in a simpler way. To hasten the booking process, there is need for real-time update on availability status, quick changes of costs and safe payment options.

## 3.3 Safety and Security

Safety is number one priority among the clients in the private jet charter industry. Airplanes must be maintained regularly and adherence to strict safety rules is a must, too. Operators needs to recruit very knowledge-driven pilots who have been in that field for quite some time or experienced flight all their lives; they should also invest in modern safety devices like real-time monitoring devices or auto servo zephyrs waves signals interception technology (NBAA, 2021).

The major concern for those who use private jets is privacy and safety. Having high standards of security procedures makes travelers to have a stress-free experience, for example the whole crew must undergo thorough background checks, the boarding should be done in a secure manner and sensitive data must be managed without any noise or show.

## 3.4 Sustainability

Sustainable procedures are becoming more and more important in the private jet charter industry as environmental issues evolve. To lessen their negative

influence on the environment, operators should turn to fuel-efficient planes, sustainable aviation fuel (SAF), and carbon offsetting (IATA, 2022).

To build trust with clients, companies can provide green certifications and transparent sustainability reports containing related information. Demonstrates responsibility towards the environment thus building credibility only if accredited by the right organizations such as International Air Transport Association (IATA). Regular release of sustainability updates goes a long way in informing passengers/guests about ongoing projects aimed at cutting down on private jet emissions.

### 3.5 Enhancing Customer Satisfaction

It is crucial for one to gather and act on feedback from customers in order to maintain service improvement. The crew who fills out post-flight surveys after every flight, as well as private jet advisors who communicate directly with passengers themselves over the phone may spot out ways for improving service provision. The long-term loyalty of customers can be built by responding to comments positively and showing readiness to improve (NBAA, 2021).

When you commit yourself to staff learning and growth, it implies that they can really serve your clients well. When the professionals are given ongoing trainings aimed at enhancing their skills in handling clients together with issues of culturally sensitive nature plus up to date industry developments, this indeed enables them not only to fulfill customer expectations but also go beyond them.

## 4. Conclusions

To create a better private jet charter experience, companies need to take into account personalized services provided by advisors and crew, technological improvement, alongside a detail-oriented service with stringent security measures and eco-friendly actions necessary for its operation. Private jet advisors can drive a competitive market edge by relentlessly coming up with new ideas as well as meeting evolving clients' requirements leading to high-end flying experience that meets safety and comfort. Hence, the journey towards elevating the private jet charter experience is not just about reaching new heights of opulence and luxury but about creating lasting memories and unforgettable experiences that leave a lasting impact on those who embark on this exclusive mode of travel.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE INFLUENCE OF INDUSTRY 4.0 ON HUMAN RESOURCES MANAGEMENT

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***Abstract***
*Although the term industry 4.0 is represented worldwide, till today there is no generic and common understanding in terms of assessing the Industry 4.0 readiness for organization. It is a new concept, e.g. new reality of the modern economy, because innovation and technological development play crucial roles in each organization. Industry 4.0 significantly changes product and production systems, concerning the design, processes, operations and services. The purpose of this paper is to identify its influence on human resource management and is based on secondary data, because the implementation of this concept has further consequences for management and future jobs through creating new business models.*

***Key words:*** *industry 4.0, digital transformation, human resource management*

## 1. Introduction

The fourth industrial revolution differs from the previous ones with the fact that it relates to all fields of life (Slusarczyk, 2018). Industry 4.0 includes many technologies, which include Internet of Things (IoT), Internet of Service (IoS), cloud-based manufacturing, radio frequency identification (RFID), enterprise resource planning (ERP) and social product development (Fonseca, 2018; Georgakopoulos et al., 2016; Kube & Rinn, 2014; Lasi et al., 2014; Lin et al., 2016; Lom et al., 2016; Lu, 2017; Singer, 2015). In order to be productive and to meet the ever-changing customers' demands, manufacturers have to be innovative, agile, efficient, responsive and also cost effective by continuously reducing the operational costs. This is usually achieved by the higher level of digitization and automation within and external to the organization's supply chain. Transforming an organization to digitalization means changing the strategy of the overall organization, which is a big decision to undertake (Sony & Naik, 2020). Digital transformation has

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revolutionized the way companies relate to their customers, how companies run their operations, how they conceive of their business model and how they organize themselves (Fenech et al., 2019). It is about integrating digital technologies, such as social, mobile, analytics and cloud, in the service of transforming how businesses work (Kane et al., 2018). The integration of digital technology into business processes has become very important for the survival and competitive advantage of contemporary organizations (Bharadwaj, 2000).

The aim of this research is to clarify the state of opinion, expectation, and preparedness about how Industry 4.0 affects the processes of human resources. Investing in technology has become the most important condition of sustainable competitive power and advantage. By examining existing research, this study seeks to provide a comprehensive understanding of the benefits and challenges associated with these topic.

## 2. Industry 4.0

The concept of Industry 4.0, identified as the fourth Industrial Revolution, was initially introduced in Germany in 2011 (e.g. Lu, 2017; Sanders et al., 2016) referring to the integration of physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries, meant to form a system in which all processes are integrated and share information in real time frame (Hozdić, 2015). The basic principles of Industry 4.0 are therefore the connection of machines, work pieces and systems, and businesses are creating intelligent networks along the entire value chain that can control each other autonomously (Basl, 2017). Besides it, the concept of Industry 4.0 assumes blurring the differences between the work of people and the work of machines. Like the first industrial revolution improved the operation of factories, the second one introduced electricity into the industry and the third one automated the uniform tasks of line workers, the fourth one improves information management and decision-making.

According to Lasi et al. (2014) "Industry 4.0 describes the increasing digitization and automation of the manufacturing environment, as well as the creation of digital value chains to enable communication between products, their environment and business partners". Hermann et al. (2016) define Industry 4.0 as "a collective term for technologies and concepts of value chain organization". Based on the papers in this research category, Lu (2017) claims that "Industry 4.0 can be summarized as an integrated, adapted, optimized, service-oriented, and interoperable manufacturing process which correlates with algorithms, big data, and high technologies". In addition to the definitions proposed by scientists, being so important for understanding the concept of Industry 4.0, it is also interesting to find out how this phenomenon is understood by manufacturers, who the industrial revolution will apply to. Table 1 shows their opinions.

*Table 1: Manufacturers' Understanding the 4th Industrial Revolution (The 4th Industrial Revolution…, EEF The Manufacturers Organisation) (Slusarczyk, 2018)*

| |
|---|
| "Not just about tech but how you join up the tech to work better – more productive, efficient, more insights and information" |
| "Communication and data analysis" |
| "Optimization for efficiency gains – smarter ways of working" |
| "Use data to provide answers more quickly" |
| "Next step in optimization and efficiency" |
| "Will become essential for competitive manufacturing" |
| "Real time data availability and information" |
| "Provide better solutions for customers" |
| "Information management from data – data on its own isn't helpful" |
| "Information flow and exchange" |
| "Help to integrate service and product" |
| "Connecting up 'buckets' of work areas – information flow" |
| "Managing data and systems to improve competitive edge" |
| "Product/process/supply chain – joining up and smarter ways of working between areas" |
| "Enhancing service provision" |
| "Information to help to optimize products" |
| "An enabler of ultimate ambition and goals" |

The 4th Industrial Revolution is associated with three phenomena (Paprocki, 2016):

1. Common digitization and ensuring constant communication between people themselves, people and devices and between devices themselves,
2. More and more frequently implemented disruptive innovations, which allow for a stepwise increase in efficiency and effectiveness of the operation of the socioeconomic system,
3. The achievement of such development of machines is that they gain the ability for autonomous behavior through the use of artificial intelligence in the process of their control.

## 3. Digital Transformation and Human Resource Management

The enlarging digitalization of economies has focused attention on the importance of digital transformation and how it can help businesses stay competitive in the market. Rapid and continuous changes occur not only at the company level; they also have environmental, societal, and institutional implications. This is the reason why for the time of the past two decades the research on digital transformation has received growing attention, with a wide range of topics investigated in the literature (Kraus et al., 2021).

At a human resource level, Industry 4.0 propagates the idea of workers that increasingly will focus on creative, innovative and communicative activities (Erol et al., 2016). Indeed, all the challenges that I4.0 poses require continuous innovation and learning, which is dependent on people capabilities (Shamim et al., 2016). Therefore, the role of employees during Industrial Revolutions is very important (Sirotek & Firlus, 2016) and Industry 4.0 requires a labour force with high skill

levels. This includes developing and establishing training and workshops for the employees, with the focus on new core tasks such as how to manage and control digitized systems. Therefore training and continued professional development of employees are of major importance to succeed in early stages of the transition towards digitalization (Kagermann, 2013). The areas of skill requirements will be IT infrastructure, automation technology, data analytics, data security/communications security, development or application of assistance systems, collaboration software, non-technical skills such as systems thinking or process understanding (Benešová & Tupa, 2017; Lichtblau et al., 2015). Employee performance in the workplace was characterized as a single global indicator reflecting the characteristics of professional success or meeting the set of objectives (Charbonnier-Voirin & Roussel, 2012). In their research the authors Zhang and Chen (2024) emphasize that digital human resource management processes refer to the implementation of selection, training and development, and assessment functions leveraging state-of-the-art digital technologies.

Beyond skills, individuals are embedded in a social context, which requires the ability to communicate, cooperate and to establish social connections and structures with other individuals and groups. The full digital integration and automation of whole manufacturing processes in the vertical and horizontal dimensions imply that workers will be responsible for a broader process scope and will need the ability to understand relations between processes, the information flows, and to cooperate ad-hoc in finding appropriate solutions for particular problems (Erol et al., 2016).

The possibility for employees to benefit from more responsibility and personal development thanks to the implementation of Industry 4.0 needs to be stimulated by managers. Managers must be able to build or act as mediators that enable social processes and decision processes. Therefore, managers' support to employees, which reduces distance between the workers and the managers of the plant through the reduction of hierarchical levels, higher autonomy of teams and workers, wider distribution of decision authority can facilitate organizational learning and innovations by increasing employee participation (Agostini & Filippini, 2019). The following Table 2 shows common characteristics of the human resource management in the digital transformation.

*Table 2: Common characteristics of the human resource management in the digital*

| Characteristics | Reference |
|---|---|
| creative activities<br>innovative activities<br>communicative activities | Erol et al., 2016 |
| continuous innovation<br>learning | Shamim et al., 2016 |
| high skill levels | Sirotek and Firlus, 2016 |
| training<br>continuous professional development of employees | Kagermann, 2013 |

When talking about digitalization and human resources, organizations should focus on (Agostini, & Filippini, 2019):

1. Employee skills (possibility to develop innovations, skilled for digital technologies, widely considered as the best in industry),
2. Training for employees (trainings and development are received on regular basis, continual training and upgrading of employee skills is important, trainings are received to improve skills),
3. Internal social capital (skilled for collaboration with each other to diagnose and solve problems, skilled for sharing information and receiving knowledge from one another, skilled for interaction and exchange of the ideas with people from different areas of the company),
4. Organizational support (skilled to devote considerable effort to developing subordinates, skilled for pushing decisions down to the lowest appropriate level, skilled for issuing creative challenges to their people instead of narrowly defining tasks).

## 4. Conclusions

Staying behind the global economy will make competition almost impossible. The country, the companies, the machines, and the employees have to increase their capabilities in line with Industry 4.0. Industry 4.0 will change the relationships between organization and environment, organization and communities, organization and value chains, organization and humans. Therefore, future studies can be directed as to what components of organizational strategy must be designed for considering these changing relationship**s.** On the other hand, Industry 5.0, the next big step, is still in development. It is expected to focus on collaboration between humans and machines to empower people to fully utilize their skills and make work safer, more efficient, and more meaningful. Regarding this, future research should include qualitative comparative analysis of Industry 4.0 and Industry 5.0 and their impact on human resource management.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EXAMINING THE IMPACT OF DISRUPTIVE ATTRIBUTES OF THE INTERNET ECONOMY ON THE SUCCESS OF SMALL AND MEDIUM-SIZED ENTERPRISES IN THE REPUBLIC OF SERBIA

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***Abstract***

*The work examines the impact of the most significant disruptive attributes of the Internet economy on the success of small and medium-sized enterprises. The aim of the study is to identify and quantify the influences of key disruptive attributes of the Internet economy on the success of small and medium-sized enterprises operating in the Republic of Serbia. The research was conducted on a sample of 116 small and medium-sized enterprises from various sectors, noting that service sector enterprises dominate. Data was collected using a structured questionnaire developed specifically for this research through exploratory factor analysis. Structural Equation Modeling (SEM) was utilized in the study.*

***Key words****: Small and medium-sized enterprises, disruptive attributes, Internet, Republic of Serbia.*

## 1. Introduction

Internet has changed the lifestyle. It has entrenched itself in every walk of life, be it sharing thoughts, social networking, playing online games, marketing and even buying and selling (Peprah et al., 2024). In today's digital era, the Internet has emerged as a pivotal force shaping the business landscape, bringing with it numerous disruptive innovations that significantly influence how businesses operate (Sugiharto, 2024). Small and medium-sized enterprises (SMEs), which form the backbone of the global economy, are increasingly confronted with constant changes driven by technological advancements and evolving business models (Macca et al., 2024). These changes are fundamental and strategic and go beyond the traditional boundaries of the organization (Radivojevic et al., 2022a).

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Successful involvement in e-business flows, above all, requires an understanding of the nature and ways of capitalizing on the "disruptive" attributes of the Internet. The Internet helps companies to create and maintain conditions for making profits in new ways, adding value to products/services or providing the basis for a new product/service. Therefore, if a company fails to take advantage of the nature of Internet attributes, its earning capacity and survival will be questioned. The company's ability to successfully compete with its competitors in the future will depend on its ability to exploit the following "disruptive" attributes of the Internet economy. Studying the disruptive attributes of the Internet enables a deeper understanding of how new digital tools, platforms, and technologies can transform business processes, optimize operations, and unlock new market opportunities.

Therefore, the goal of this paper is to examine the impact of disruptive attributes of the Internet on the success of small and medium-sized enterprises in the Republic of Serbia. These disruptive innovations often introduce radical changes in how businesses interact with customers, manage resources, and create value. Understanding these attributes can help SMEs identify growth opportunities, mitigate risks, and effectively adapt to a dynamic market. Additionally, analyzing the impact of the Internet on the success of SMEs provides valuable insights into strategies that can enhance competitiveness and ensure long-term sustainability (Radivojevic et al., 2022a). As digital transformation accelerates, it is crucial for SMEs to stay abreast of the latest trends and technologies. This research underscores the importance of examining the disruptive attributes of the Internet, highlighting the need for continuous monitoring and adaptation of business strategies to achieve success in an increasingly complex and competitive business environment.

## 2. Disruptive attributes of internet economy

As already pointed out, the disruptive attributes of the Internet represent those characteristics of digital business that affect the way of organizing and running a business, which are different from organizing and running a business in the physical economy, and which at the same time enable companies to take advantage of certain advantages of doing business via the Internet (Zhang et al., 2024). Therefore, the success of the company's business depends on the ability of the company to use these attributes for its business. It is possible to identify 9 such attributes that shape business over the Internet in relation to business in the physical world (Radivojevic et al., 2009; Melnyk et al., 2019): the network effect, open platform, connectivity and digitalization, exchange of information; digital assets as an input in the process of business transformation, transparency of costs speed and frequency of changes, virtual store, industry boundary.

1. The network effect is also present in the industrial economy (eg regular telephone services), but it is much more significant in the IT economy. A phenomenon by which the value of a thing or phenomenon increases the more people use it. By combining the effects of economy of scale and

economy of breadth on the demand side, the network effect is strengthened. Building a sustainable critical mass of installed customer base (scale effect) is valuable, because with each increase in volume, the number of potential customers for cross-buying (breadth effect) increases, thus creating the conditions for an even greater increase in the customer base. Therefore, securing a critical mass of consumers is crucial.
2. Open platform - the Internet provides a platform for communication, cooperation and free exchange of information;
3. Connectivity and digitalization - thanks to connectivity and digitalization, bits do not remain isolated in products or product systems, but exchange takes place in real time;
4. Exchange of information - transmission and exchange of information without waste, the so-called. without "deaf phone effects;
5. Digital assets as an input in the process of business transformation - in the digital economy, information is a source of income;
6. Transparency of costs - the Internet enables customers to easily compare all offers from the price-quality aspect;
7. Speed and frequency of changes - in the digital economy, changes are frequent and fast. In all industries, companies must learn how to quickly adapt to changes in business and the economy;
8. Virtual store - enables the display of a large number of different products, without investing in physical facilities (warehouses, warehouses, windows) and without physical presence;
9. Industry boundary - The company, business ecosystem or "Business web" must provide a unique offer that is completely individualized. It is about the so-called costumization (customized - make up an offer that fully meets individual needs and requirements.

Of course, it is difficult for one company to fully utilize all these attributes. Not all of these attributes are equally important for every type of business via Internet, but without using these attributes better and more efficiently than competitors, companies will not be able to survive on the market. Bearing in mind the above, it is important to understand which of these attributes has the greatest impact on the success of small and medium-sized enterprises in the Republic of Serbia, taking into account the specifics of digital marketing in the Republic of Serbia, as and consumer habits.

## Data and research methodology

The study was conducted on a sample of 116 small and medium-sized enterprises and various sectors, noting that companies from the service sector dominate, operating in the Republic of Serbia. The research period spans during 2024. The sample size was determined considering the population size, desired level of confidence, and allowable sampling error. All questionnaires were validly completed. The data were collected based on a structured questionnaire, which was composed based on relevant statements proposed in the scientific literature (Evans

& Wurster, 1997; Kaplan, 2000; Radivojevic et al., 2009). More precisely, the questionnaire contains ten sub-scales for measuring the nine disruptive attributes of Internet, as well as a sub-scale for measuring business performance. Therefore, the questionnaire contains a total of 30 items: 3 items for each disruptive attribute of the Internet and three items for business performance. The items are presented in Table 1 in Appendix.

The validity of the questionnaire was tested using Exploratory Factor Analysis. Participants evaluated the questionnaire statements on a five-point Likert scale ranging from (1) 'strongly disagree' to (5) 'strongly agree'. Sample adequacy was tested using the Kaiser-Meyer-Olkin test of sample adequacy (test value = 0.883). Additionally, a Bartlett's test of sphericity was conducted ($\chi 2(435) = 1692.8$). The results of the questionnaire validity test are presented in Table 1, indicating the use of Promax rotation. The results suggest that the questions are grouped as expected. Factor loadings are all greater than 0.3. Furthermore, the collected data were processed using the statistical software JASP for Structural Equation Modeling (SEM). A various goodness-of-fit indices have been used. Results for the overall model are presented in Table 2.

*Table 2. Results for the overall model fit*

| **Goodness Fit Index name** | **p-value** |
|---|---|
| Parsimony Normed Fit Index (PNFI) | 0.557 |
| Bollen's Incremental Fit Index (IFI) | 0.911 |
| Relative Noncentrality Index (RNI) | 0.901 |
| Standardized Root Mean Square Residual (SRMS) | 0.033 |

*Source: Authors*

All indices show satisfactory values of a good model, like as suggested by literature (Rather, 2020). The quality of survey instruments was examined through reliability and validity analyzes (Hollebeek and Rather, 2019). Convergent and discriminant validity of the constructs were calculated. Reliability was assessed by using composite reliability. The average extracted variance (AVE) for each sub-scale is greater than 0.5, indicating convergent validity of the questionnaire (Alavi et al., 2020). Also, the reliability coefficients are greater than 0.7, indicating questionnaire reliability (Hollebeek and Rather, 2019, Cavic et al., 2024). Results are shown in Table 3. All items have factor loadings above than 0.5.

*Table 3. Results of Confirmatory factor analysis*

| | | | | | | CR | AVE |
|---|---|---|---|---|---|---|---|
| **Factor** | **Item** | **Estimate** | **Std. Error** | **z-value** | **P-value** | | |
| ND | X1 | 0.205 | 0.012 | 17.083 | 0.000 | 0.876 | 0.702 |
| | X2 | 0.333 | 0.016 | 20.813 | 0.000 | | |
| | X3 | 0.334 | 0.021 | 15.905 | 0.000 | | |
| OP | X4 | 0.293 | 0.042 | 6.976 | 0.000 | 0.894 | 0.739 |
| | X5 | 0.34 | 0.015 | 22.667 | 0.000 | | |
| | X6 | 0.814 | 0.043 | 18.930 | 0.000 | | |
| CD | X7 | 0.079 | 0.021 | 3.762 | 0.000 | 0.876 | 0.703 |
| | X8 | 0.034 | 0.009 | 3.778 | 0.000 | | |
| | X9 | 0.902 | 0.023 | 39.217 | 0.000 | | |
| EI | X10 | 0.293 | 0.069 | 4.246 | 0.000 | 0.843 | 0.642 |
| | X11 | 0.391 | 0.034 | 11.500 | 0.000 | | |
| | X12 | 0.112 | 0.022 | 5.091 | 0.000 | | |
| DA | X13 | 0.38 | 0.034 | 11.176 | 0.000 | 0.887 | 0.725 |
| | X14 | 0.291 | 0.056 | 5.196 | 0.000 | | |
| | X15 | 0.321 | 0.086 | 3.733 | 0.000 | | |
| TC | X16 | 0.402 | 0.069 | 5.826 | 0.000 | 0.858 | 0.669 |
| | X17 | 0.077 | 0.011 | 7.000 | 0.000 | | |
| | X18 | 0.112 | 0.041 | 2.732 | 0.003 | | |
| SFC | X19 | 0.299 | 0.034 | 8.794 | 0.000 | 0.800 | 0.572 |
| | X20 | 0.121 | 0.033 | 3.667 | 0.000 | | |
| | X21 | 0.112 | 0.041 | 2.732 | 0.003 | | |
| VS | X22 | 0.128 | 0.029 | 4.414 | 0.000 | 0.878 | 0.706 |
| | X23 | 0.329 | 0.065 | 5.062 | 0.000 | | |
| | X24 | 0.222 | 0.031 | 7.161 | 0.000 | | |
| IB | X25 | 0.289 | 0.069 | 4.188 | 0.000 | 0.821 | 0.604 |
| | X26 | 0.098 | 0.017 | 5.765 | 0.000 | | |
| | X27 | 0.312 | 0.082 | 3.805 | 0.000 | | |
| BP | X28 | 0.348 | 0.066 | 5.273 | 0.000 | 0.874 | 0.699 |
| | X29 | 0.083 | 0.032 | 2.594 | 0.005 | | |
| | X30 | 0.101 | 0.033 | 3.061 | 0.001 | | |

*Source: Authors*

The discriminant validity of the scales was tested based on the Fornell-Larcker criterion. The square root of AVE per construct was compared with correlation between the constructs. The results supported the discriminant validity since the correlations between the construct with other constructs are lower compared to square root of its AVE (table 4).

*Table 4. Results of the discriminant valid*

| | NE | OP | CD | EI | DA | TC | SFC | VS | IB | BP |
|---|---|---|---|---|---|---|---|---|---|---|
| **NE** | 0.838 | | | | | | | | | |
| **OP** | 0.342 | 0.859 | | | | | | | | |
| **CD** | 0.332 | 0.321 | 0.839 | | | | | | | |
| **EI** | 0.412 | 0.337 | 0.372 | 0.801 | | | | | | |
| **DA** | 0.121 | 0.462 | 0.229 | 0.335 | 0.851 | | | | | |
| **TC** | 0.098 | 0.276 | 0.341 | 0.385 | 0.338 | 0.818 | | | | |
| **SFC** | 0.043 | 0.289 | 0.552 | 0.471 | 0.391 | 0.410 | 0.756 | | | |
| **VS** | 0.521 | 0.381 | 0.281 | 0.228 | 0.391 | 0.371 | 0.387 | 0.840 | | |
| **IB** | 0.321 | 0.413 | 0.173 | 0.478 | 0.479 | 0.112 | 0.381 | 0.238 | 0.777 | |
| **BP** | 0.223 | 0.223 | 0.195 | 0.421 | 0.440 | 0.241 | 0.199 | 0.361 | 0.393 | 0.836 |

*Source: Authors*

Structural equation modelling (SEM) was used to test structural relationships between variables. The results are presented in Table 5. The various Goodness-of-fit indices reveal an acceptable fit of the model.

*Table 5. Results of Structural equation modelling*

| Factor | Factor | Estimate | Std. Error | z-value | p |
|---|---|---|---|---|---|
| **NE** | BP | 0.141 | 0.013 | 10.846 | 0.000 |
| **OP** | BP | 0.344 | 0.008 | 43.000 | 0.000 |
| **CD** | BP | 0.066 | 0.035 | 1.886 | 0.030 |
| **EI** | BP | 0.077 | 0.038 | 2.026 | 0.021 |
| **DA** | BP | 0.019 | 0.002 | 9.500 | 0.000 |
| **TC** | BP | 0.083 | 0.004 | 20.750 | 0.000 |
| **SFC** | BP | 0.072 | 0.027 | 2.667 | 0.004 |
| **VS** | BP | 0.376 | 0.027 | 13.926 | 0.000 |
| **IB** | BP | 0.207 | 0.013 | 15.923 | 0.000 |
| Goodness-of-fit indices: PNFI = 0.567, IFI = 0.902, RNI =0.902, SRMS = 0.032 | | | | | |

*Source: Authors*

## 4. Discussion

As based on the results shown in Table 5, all disruptive attributes of the Internet are statistically significant, which means that they all have a direct and positive impact on the performance of businesses undertaken in e-business. This finding is expected. The results show that the virtual store has the greatest influence, followed by open platforms and industry boundaries. Namely, the virtual store allows customers to make purchases from anywhere and at any time, which indicates that the flexibility and accessibility provided by online sales significantly contribute to the competitiveness and success of the company. In addition to being available 24 hours a day, seven days a week, the virtual store does not require significant costs of maintaining and equipping a physical store, as well as labor costs. Hence, it is understandable that this attribute has the greatest impact on the performance of the company in e-business. The second most important attribute is

the open platform. Open platforms allow different users and companies to connect, share resources and innovate. Identifying an open platform as a significant factor in business success implies that the ability for a company operating over the Internet to integrate with others is a very important factor in business. this is also understandable, first of all, from the aspect of exploitation of intellectual capital, i.e. organizational capital related to the establishment of relations with external stakeholders. This conclusion is in accordance with the research findings of Radivojević et al., (2022b, 2023) and Invanović et al. (2021).

The third most important attribute is industry boundaries. This refers to the ability of a business to expand its business beyond traditional industry boundaries using online tools and strategies. SEM results show that industry boundaries have a significant impact, as businesses that use the Internet to explore new markets and expand their offerings have a greater chance of success. In other words, they easily reach other markets, not only to offer their products, but also to procurement markets, thus overcoming traditional patterns of business. This not only affects the reduction of acquisition costs and acquisition of new customers, but also adds to the effect of economies of scale. Therefore, this factor should not be considered without the influence of the economy of scale, which has a known influence in the physical, traditional economy.

Digital assets have the most external impact. Of course, there are several reasons for that. Namely, although digital assets can improve business, their inherent value can be limited if they are not fully integrated into business processes, and therefore do not contribute to the company's competitiveness. In addition, Digital Assets often require additional implementation and integration into existing business processes. If a business fails to adequately integrate these assets into its strategy or operations, their impact on success will be less. In contrast, attributes such as a virtual store or open platforms can provide more direct and tangible benefits to the business. Furthermore, consumers and users may more quickly accept and value attributes such as virtual stores due to their immediate utility and accessibility. Digital assets may not offer such obvious or immediate benefits, which can reduce their immediate impact on business success. Disruptive attributes such as open platforms often enable faster innovation and adaptation to market changes, which can have a more significant impact on business success. Digital assets, while useful, may not offer the same levels of innovation and adaptability, which may reduce its relative impact.

The influence of other factors ranges between digital assets and the above-mentioned attributes. Although at the end of the analysis, it should be pointed out that the observation and interpretation of individual influences has a number of limitations, the biggest of which is that the synergistic effects of the mutual influence of these attributes are neglected. Therefore, it is more important to determine whether some fail to contribute to business success than to analyze their individual impacts.

## 5. Conclusion

The research was conducted for a sample of 116 small and medium-sized enterprises and various sectors, noting that companies from the service sector dominate, operating in the Republic of Serbia. The aim of the research was to examine the influence of various factors of the disruptive attributes of the Internet on the performance of business operations. The findings indicate that the virtual store is the most important factor. Then comes open platforms and industry boundaries. On the other hand, digital assets have the least impact. The influence and importance of other factors ranges between these first three and digital assets, and their influence is approximately equal. The importance of this research is reflected in the fact that there are no similar studies, and that the findings of this research indicate which factors companies operating through the Internet in the Republic of Serbia should focus on.

Of course, like any research, this has a number of limitations that must be taken into account when accepting its findings. In addition to the aforementioned limitation of the research, a limitation worth mentioning is the fact that the sample consisted of companies from different sectors, with the fact that the cause was dominated by companies from the service sector. So the obtained data are definitely influenced by this fact. This is especially important when it is taken into account that different sectors have their own specificities that affect the way and the need to exploit certain disruptive attributes of the Internet. Therefore, it is recommended that future researchers, in addition to applying achievements in the field of ICT in order to validate these findings, perform sector segregation and examine the impact of each attribute on a specific industry sector.

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## Appendix

*Table 1. Results of Exploratory Factor Analysis*

| | | | Factor loads | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Items | NE | OP | CD | EI | DA | TC | SFC | VS | IB | BP |
| Disruptive attribut | The network effect (NE) | The network effect enhances user experience in social media platforms. | 0.468 | | | | | | | | | |
| | | Companies can leverage the network effect to increase their market share. | 0.403 | | | | | | | | | |
| | | There are potential downsides of the network effect for new entrants in a saturated market. | 0.322 | | | | | | | | | |
| | Open platform (OP) | An open platform provides advantages for developers and third-party applications. | | 0.452 | | | | | | | | |
| | | Open platforms promote innovation and collaboration in technology. | | 0.435 | | | | | | | | |

| | | | Factor loads | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Items | NE | OP | CD | EI | DA | TC | SFC | VS | IB | BP |
| es | | Companies face challenges when transitioning from a closed to an open platform model. | | 0.393 | | | | | | | | |
| | Connectivity and digitalization (CD) | Increased connectivity significantly impacts the way businesses operate in a digital marketplace. | | | 0.378 | | | | | | | |
| | | Digitalization plays a crucial role in improving customer engagement and satisfaction. | | | 0.462 | | | | | | | |
| | | Improved connectivity drives economic growth in underserved regions. | | | 0.355 | | | | | | | |
| | Exchange of information (EI) | Rapid information exchange has implications for decision-making processes in organizations. | | | | 0.380 | | | | | | |
| | | The exchange of information contributes to transparency and accountability in businesses. | | | | 0.471 | | | | | | |
| | | Security challenges arise from the increasing exchange of information online. | | | | 0.350 | | | | | | |
| | Digital assets (DA) | Digital assets like cryptocurrencies challenge traditional financial systems. | | | | | 0.491 | | | | | |
| | | Key legal considerations surround the ownership of digital assets. | | | | | 0.391 | | | | | |
| | | Businesses can effectively monetize their digital assets. | | | | | 0.389 | | | | | |
| | Transparency of costs (TC) | Transparency in costs affects consumer trust and purchasing decisions. | | | | | | 0.563 | | | | |
| | | Technologies can enhance cost transparency across supply chains. | | | | | | 0.609 | | | | |
| | | Companies must balance the need for cost transparency with protecting proprietary information. | | | | | | 0.471 | | | | |
| | Speed and frequency of changes (SFC) | Rapid changes in technology influence business strategy and operations. | | | | | | | 0.591 | | | |
| | | Organizations can effectively adapt to the speed and frequency of changes in their industries. | | | | | | | 0.498 | | | |
| | | Some industries have been significantly transformed by rapid technological changes. | | | | | | | 0.453 | | | |

| | | | Factor loads | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Items | NE | OP | CD | EI | DA | TC | SFC | VS | IB | BP |
| | Virtual store (vs) | Virtual stores enhance the shopping experience for customers compared to traditional retail. | | | | | | | | 0.448 | | |
| | | Key technologies enable the operation of successful virtual stores. | | | | | | | | 0.351 | | |
| | | Businesses can drive traffic to their virtual stores in a competitive market. | | | | | | | | 0.487 | | |
| | Industry boundary (IB) | Traditional industry boundaries are becoming blurred by digital transformation. | | | | | | | | | 0.537 | |
| | | The dissolution of industry boundaries has implications for regulatory frameworks. | | | | | | | | | 0.551 | |
| | | Companies can innovate by crossing traditional industry boundaries. | | | | | | | | | 0.503 | |
| | **Business Performance (BP)** | Business performance metrics directly impact decision-making processes within organizations. | | | | | | | | | | 0.507 |
| | | Effective use of data analytics significantly enhances the assessment of business performance. | | | | | | | | | | 0.565 |
| | | Employee engagement and motivation are crucial factors influencing overall business performance. | | | | | | | | | | 0.529 |

*Source: Authors*

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# SELECTION OF CRITERIA FOR EVALUATING INNOVATIVE PROJECTS

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***Abstract***

*Market conditions determine the impossibility not only of development but also of the simple survival of organizations without innovations that create new business opportunities. Innovation projects have experienced exponential growth, leading to an open challenge of identifying the best project solutions. Due to limited resources, effective methods are needed to select profitable projects and innovative ideas. An important success factor for project selection is defining appropriate evaluation criteria. The paper focuses on the presentation and selection of criteria for the evaluation of innovative projects. The list of criteria was defined based on the conducted research in which evaluators and providers of grants for financing innovation projects participated. Criteria defined in this way can support funding agencies to improve their decision-making strategies, as well as to make better funding decisions based on expert evaluations.*

***Key words****: innovative projects, evaluation, criteria for evaluation*

## 1. Introduction

Companies operating in today's market face significant challenges due to globalization, rapid market changes, digitization, new regulations, as well as increased demand for product customization. To remain competitive, companies should be oriented towards thinking about new products, processes and ways of working. That's how they get new ideas, improve existing ones or create new businesses. Innovations represent the bearer of new ideas and new types of business. In addition, innovation in manufacturing, especially the adoption of new technologies and processes, has been identified as a key driver of the success of the

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transformation process brought about by Industry 5.0, which represents the latest technological and social transformation of the manufacturing industry.

The understanding and definitions of innovation presented in the literature differ from each other. The concepts of innovation and invention were distinguished by Schumpeter as original combinations of new or existing knowledge, resources, equipment and other factors. A real innovation is not only an invention or an idea, but the definition implies the development of something that is successfully used in the production process (Gärtner et al., 2023). The Oslo Manual 2018 defines an innovation as: a new or improved product or process (or a combination thereof) that is significantly different from the unit's previous products or processes and that is made available to potential users (product) or put into use by the unit (process) (Galindo-Rueda, F., 2019). Some authors in addition to new and better quality products, including process innovation, organizational innovation, administrative innovation, marketing innovation and business model innovation.

Companies strive to implement revolutionary technologies by implementing innovative projects. The resources and funds of any organization are not enough for trial and error implementation of all proposed projects, therefore organizations require effective methods for selecting profitable projects and innovative ideas. The basic project evaluation and selection process usually involves six steps, namely, proposal submission, form review, project evaluation peer review, review result aggregation, panel evaluation, and final decision (Tian et al., 2005). It is a complex decision-making process that includes multiple evaluation criteria and multiple decision-makers (Liu et al., 2010). One of the current issues is how to evaluate an innovative project, taking into account its specificities. There is no consensus on how to evaluate innovative project ideas. Decisions on the selection of ideas within the innovation process are usually based on a set of criteria that innovation projects must fulfil (Eisenreich et al., 2021). It is especially important to include more indicators in the groups of criteria for evaluation, as well as to make recommendations for selecting projects for financing based on the final evaluation of criteria from a clearly defined list of criteria.

Traditional evaluation methods are focused on economic criteria, while feasibility and social aspects are neglected. The risks are not sufficiently treated, as well as the contribution of the project from the point of view of green economy, digitization and fulfilment of Sustainable development goals (SDGSs).

The aim of this paper is to propose criteria for the evaluation of innovative projects, which will speed up the process of selecting the most effective innovative projects for implementation.

After introductory considerations on the importance of work research, a literature review was conducted to identify existing approaches and to identify relevant criteria for evaluating innovative projects. Then a list of criteria for evaluating innovative projects was proposed, after which the selection of criteria was explained in the discussion. Finally, concluding remarks are given.

## 2. Literature Review

It is obvious that any innovation should be new and practically implemented, to bring economic or other benefits. An effective project is necessary to implement the innovation process. The innovation project is the rationale for introducing the innovation and the very process of implementing the innovation through investment. An innovative project is a form of creating an innovative activity of a company in a certain period of time, with certain activities and resources aimed at concrete results. Therefore, the innovation process requires significant resources, encounters obstacles for its effective. completion and includes changes that inherently represent uncertain outcomes. The potential economic utility does not in itself provide a basis for a detailed analysis of the various innovative project proposals to be evaluated. For this reason, a holistic perspective is necessary in the evaluation of innovations (Grekul et al., 2019).

Project selection in innovation management is usually based on criteria used to evaluate projects (Eisenreich et al., 2021; Dziallas & Blind, 2019). Determining a set of evaluation criteria is another critical step in selecting innovative project ideas (Cubukcu et al., 2024). Various academic studies have investigated sets of evaluation criteria. As the choice of criteria largely depends on the context of the project, the literature does not provide a unique list of criteria. The way in which evaluation criteria are applied and who evaluates innovative projects varies greatly (Eisenreich et al., 2021). When evaluating grant applications, three criteria were applied in paper (Gudkov et al., 2021): novelty and effectiveness of the proposed solutions, feasibility of the planned results of the innovation project, prospects of implementation and commercial realization of the product being created. Some authors recommend the use of a combined variant of the list of criteria method in solving the problem of efficiency assessment, where five groups of criteria can be distinguished: Social criteria; Economic criteria; Market criteria; Investment efficiency criteria; Scientific and technical criteria (Eisenreich et al., 2021). To select the most attractive innovative project, technoparks evaluate their production, financial and economic capabilities (Petryna et al., 2020). When evaluating grant applications, the following three criteria were applied: the novelty and effectiveness of the proposed solutions, the feasibility of the planned results of the innovation project, and the prospects for the implementation and commercial realization of the product being created (Gudkov et al., 2021). Many papers deal with the evaluation of innovative projects at the enterprise level. Such criteria can deal with different aspects of strategy, market, resources, technology and risk (Martinsuo & Poskela, 2011). It can be said that economic analysis is the most common criterion used in the project selection process (Khalili-Damghani & Tavana, 2014). Due to the fact that project results have short-term and long-term effects on social, economic and environmental aspects, some authors introduce the third generation of new criteria for the evaluation of projects related to sustainable development ( Akhavein et al., 2021; Hesampour et al., 2016).

It can be concluded that it is necessary to create a list of criteria that, in addition to financial criteria, would also integrate innovation, feasibility, and social

criteria. Practically no examples can be found in the literature where criteria related to job creation, inclusion of vulnerable categories, impact on the green economy, digitization, fulfilment of the SDGs are integrated with the financial and feasibility criteria.

## 3. Criteria for evaluation of innovative projects

Innovations represent the main factors in the creation of a competitive market for new products, technologies and services, and they also have a significant impact on economic growth. The development of innovative companies is an important part of the innovation policy of every country (Gudkov et al., 2021). That is why the project-based approach is one of the most widespread approaches for the promotion of innovation. It is necessary to really assess the potential of the innovative project, because it has a significant impact on the processes aimed at the development of regional and national innovation policy, the selection of national priorities for the development of the innovative system. Therefore, in order to promote innovation, there are a large number of competitions for the financing of innovative projects, both from the government and ministries, as well as from various agencies and funds.

Support for these projects is provided on the basis of a grant. As a result, the task of project evaluation is highly professional. Expert evaluation is especially important, followed by the selection of the most promising projects for further financing and implementation. When evaluating grant applications, decision makers apply different criteria. The criteria are necessary to manage and control the multitude of innovative ideas and concepts that are submitted to the providers of funds. The choice of criteria is very important for the evaluation process itself in order to choose an adequate project for implementation. If many criteria are considered, the cost of analysis and solutions becomes very high and difficult to understand. If very few criteria are considered, important criteria may not be taken into account, and therefore the best project solutions may not be selected, and profitable innovative projects may be rejected. In many cases, evaluators must determine the values of the quality of the project in use, based on subjective criteria, not allowing an objective assessment of essential characteristics such as functionality or usability. Typically, between three and five criteria are used for evaluation. According to the literature, this number of criteria is common when evaluating numerous ideas (Eisenreich et al., 2021).

### 3.1 Selection of criteria for the evaluation of innovation projects

In this paper, the criteria were identified through an interview and a survey. Respondents were asked to describe their evaluation process and criteria for selecting innovative projects. Respondents represent members of commissions and decision-makers for project evaluation in institutions that award grants for financing innovation projects. Fifty respondents from Bosnia and Herzegovina participated in the research. After the obtained results, four groups of criteria were identified. Each criterion is divided into several sub-criteria (Table 1). In addition to

the financial criteria, criteria related to the innovativeness of the project idea, feasibility and criteria for social responsibility and inclusiveness were also defined.

*Table 1: Criteria for evaluating innovative projects*

| ID | CRITERIA | SUB-CRITERIA |
|---|---|---|
| **K1** | **FINANCIAL CRITERIA** | • current financial and economic state of business, dynamics of its development, availability of outside investors<br>• liquidity of company's investment to implement the project<br>• investment return period from project implementation<br>• profit from project implementation |
| **K2** | **INNOVATIVE PROJECT IDEA** | • the project's novelty rate<br>• analysis of scientific and technical, technological novelty of the innovation<br>• relevance of the project to the industry sector/market<br>• stakeholder participation in the project<br>• advantage of project competitiveness |
| **K3** | **PROJECT FEASIBILITY** | • feasibility in aspect of market demand, costs, and time<br>• technical and human capacities for implementation of proposed project<br>• total project duration<br>• indicative plan of activities during project implementation<br>• expected project results<br>• commercial risk, technology risk, and project risk in case of project implementation, during and after the project implementation<br>• fluctuations in a relevant market segment, feasibility of the sales plan<br>• sustainability of the project |
| **K4** | **SOCIAL RESPONSIBILITY AND INCLUSIVENESS** | • creating new working places<br>• influence on women economic empowerment<br>• include vulnerable categories<br>• contribution to the development of the green economy<br>• contribution to the digital transformation of the applicant's business<br>• contribution of the project to the achievement of sustainable development goals (SDGs) |

## 4. Discussion

The literature on the evaluation of innovative projects showed that in most cases the authors try to use different criteria of the economic efficiency of innovations for the evaluation of innovations (Alexandrova et al., 2018). In practice, innovative projects are characterized by a wider range of criteria that should not be considered in the decision-making process. Accordingly, a list of criteria was defined, which includes, in addition to financial criteria, criteria for evaluating

innovation, feasibility and social responsibility and inclusiveness of vulnerable categories.

Financial criteria usually refer to profitability and revenue metrics (Eisenreich et al., 2021; Dziallas & Blind, 2019). Some authors mainly focus on profitability measures such as return on investment (Dziallas & Blind, 2019). In the proposed list of criteria, in addition to the return on investment, criteria related to the current financial and economic state of the business, the dynamics of its development, the availability of external investors, the liquidity of the company's investment for the implementation of the project, as well as the expected profit from the implementation of the project are defined. As part of the criteria related to the innovativeness of the project idea, the level of innovativeness of the project, the analysis of the scientific and technical, technological novelty of the innovation, the relevance of the project to the industrial sector/market, the participation of interested parties in the project (suppliers, distributors, customers, partner organizations) are considered, as and the competitive advantage of the project.

Based on the feasibility of the project from the point of view of market requirements, costs and time, criteria related to technical capacities and human resources necessary for project implementation, activity plan, project duration and expected results, market analysis, sustainability of the project and risk analysis were defined.

Innovation projects are characterized by high risk and uncertainty during the entire cycle, therefore special attention must be paid to the identification and risk determination procedures in all stages of development, production and implementation of an innovative project (Alexandrova et al., 2018).

In the context of Industry 5.0, presented by the European Union, it is also important to consider innovations that increase prosperity for people and organizations within the assessment. The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015, recognizing that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability. All three dimensions of sustainability in projects should integrate economic, social and environmental benefits. Assessment and evaluation of projects that are successful in sustainability can determine policies and procedures of the organization to achieve the final goals in the future of the organization (Hesampour et al., 2016).

Project selection is a typical problem of group decision-making based on multiple criteria, and its main goal is to select appropriate projects through the assessment of multiple experts from a given group of research projects characterized by multiple criteria (Liu et al., 2010; Cubukcu et al., 2024; Akhavein et al., 2021). As a rule, experts evaluate five to ten applications, which gives them the opportunity to analyse and compare different projects before choosing the most promising one. In addition to their knowledge and expertise, evaluators should research, and study significant amounts of additional information related to the proposed innovation (Gudkov et al., 2021). To increase the objectivity of the independent examination, it is suggested that at least three independent experts be involved in the assessment process.

Considering the complexity of the project evaluation, the list of criteria can also be used when applying the multi-criteria decision-making method (MCDM) when choosing the best project solutions. Also, the defined criteria do not have to have the same weight in the evaluation. The weights of the criteria can be evaluated at each new project evaluation.

## 5. Conclusions

In this paper, an analysis was performed and the significance of the criteria used in the evaluation of innovative projects was presented. Based on the research, a list of criteria was defined. Four groups of criteria have been defined, namely financial criteria, criteria for evaluating innovation, feasibility, and social responsibility and inclusiveness. For each group, corresponding sub-criteria are defined.

Innovative projects should satisfy not only economic, but a whole series of criteria, which are summarized in the proposed list. Using the proposed list of criteria can help formalize the evaluation and decision-making process for selecting an innovative project for implementation. The mentioned criteria will enable a more reasoned choice of financing variations in favor of a specific innovative project. Improving the innovation evaluation process can also help investors finance new ventures. The criteria defined in this way can also be used to award grants for innovations by the government, where priorities would be given to criteria such as social responsibility or technological feasibility.

The advisability of investing in the development of innovation through innovation projects is necessary to ensure the sustainable development of the economy. Market conditions determine the impossibility not only of development, but also of the simple survival of an organization without innovations that create new business opportunities.

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# PROJECT MANAGEMENT AND ETHICS

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# BENEFITS OF WORK-LIFE BALANCE POLICIES FOR EMPLOYEES AND ORGANIZATIONS

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***Abstract***

*This study explores the pivotal role of work-life balance in modern corporate environments, reflecting a company's ethical responsibility and social impact. The objective of this paper is to investigate how promoting work-life balance influences employee well-being and organizational outcomes. The methodology includes a literature review of research on work-life balance practices and their ethical and social implications, complemented by case studies of companies with strong policies. Key findings indicate that organizations that prioritize work-life balance exhibit high levels of corporate responsibility and ethics. This leads to increased employee satisfaction, reduced stress, and enhanced well-being. Family-friendly policies notably improve the work climate, reduce burnout risk, and boost productivity. These findings contribute to understanding how such policies not only improve the immediate work environment but also foster positive social change. Employees with a good work-life balance show higher job satisfaction, which can reduce stress-related medical needs and absenteeism. Companies that prioritize work-life balance and family-friendly policies create a positive and sustainable work environment. This commitment enhances internal processes, boosts employee well-being, and positively impacts the broader community.*

***Key words****: work-life balance, well-being, family-friendly policies.*

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# 1. Introduction

The concept of work-life balance has evolved significantly, reflecting changes in work environments and societal expectations (Bakker & Demerouti, 2018). Initially focused on flexible hours and part-time options for working mothers (Bello & Garba ibrahim, 2020), work-life balance now includes telecommuting, job-sharing, extended parental leave, and wellness programs (Agerström et al., 2023; Kim et al., 2023). This broader approach aims to support a harmonious integration of professional and personal commitments, crucial for maintaining employee well-being (Bakker & Demerouti, 2018).

The growing recognition of work-life balance as a fundamental aspect of employee well-being has led many organizations to develop and implement policies designed to support this balance (Barbar et al., 2024). Initially driven by legal requirements or societal pressures, contemporary work-life balance policies are increasingly viewed as strategic assets (Barbar et al., 2024). Organizations now recognize that fostering a supportive work environment through these policies can enhance employee engagement, increase retention rates, and improve productivity (Kim et al., 2023). Despite these advancements, there remain gaps in understanding and implementing effective work-life balance policies (Barbar et al., 2024). For instance, more empirical evidence is needed on the long-term impacts of these policies on employee health (Gragnano et al., 2020), and organizational outcomes (Kaya & Karatepe, 2020). Additionally, the effectiveness of work-life balance initiatives can vary across different cultural and organizational contexts, indicating a need for more nuanced studies.

This paper aims to investigate how promoting work-life balance within corporate settings influences employee well-being and organizational outcomes. By examining existing research and analyzing case studies of companies renowned for their effective work-life balance policies, this study seeks to provide a comprehensive understanding of the benefits and challenges associated with these practices. The findings will address existing research gaps and offer practical insights for organizations looking to enhance their work-life balance strategies.

# 2. Methodology

This study evaluates work-life balance practices through a literature review and case studies. The literature review analyzed research on work-life balance policies from 2010 to 2023, sourced from academic databases including JSTOR, PubMed, Scopus, and Google Scholar. Key terms included "work-life balance", "flexible working arrangements", and "family-friendly policies". Selection criteria focused on relevance, academic rigor, and recency, with studies reviewed thematically to identify policy types, ethical considerations, and impacts on employees and organizations (Vaziri et al., 2022).

Case studies of companies renowned for effective work-life balance, such as Google, Microsoft, and Patagonia, were also examined. Data from company reports, interviews, and media articles were used to assess specific policies like flexible

working hours, remote work, and parental leave, and their effects on employee satisfaction and organizational performance.

The synthesis of literature and case studies provided a comprehensive evaluation of work-life balance benefits and identified areas for further research.

## 3. Results

The findings from the literature review provide an extensive analysis of work-life balance policies and their impact on employees and organizations. The review highlights a variety of approaches adopted by different organizations, examines the ethical and social implications of these policies, and includes case studies from companies recognized for their exemplary practices. The results emphasize how work-life balance initiatives not only enhance employee satisfaction and boost organizational performance but also contribute to broader social change by promoting equitable and supportive work environments.

### 3.1 Work-life balance policies

Work-life balance policies encompass a wide range of initiatives designed to help employees manage their professional and personal lives more effectively. Flexible working arrangements include telecommuting, flexible hours, and compressed workweeks (Bontrager et al., 2021). Telecommuting allows employees to work from home or other locations, which helps them manage personal responsibilities while maintaining productivity. Flexible hours enable employees to choose their work hours within certain limits, accommodating personal needs such as medical appointments or childcare (Chung & van der Lippe, 2020). Compressed workweeks, where employees work longer hours on fewer days, provide extended time off, supporting personal commitments and reducing stress (Bontrager et al., 2021).

Family-friendly policies are specifically aimed at supporting employees with family responsibilities (Barbar et al., 2024). Paid parental leave allows parents to spend the initial months with their newborns without financial pressure, while childcare support, including on-site facilities or financial subsidies, helps manage childcare needs (Agerström et al., 2023). Family health benefits ensure that employees' families receive necessary medical care, further enhancing work-life balance and fostering a supportive work environment (Kim et al., 2023).

Employee wellness programs focus on promoting both physical and mental health (Kim et al., 2023). On-site gyms and fitness classes encourage a healthy lifestyle, while mental health resources, including counseling and stress management workshops, support emotional well-being. Wellness days, designated for employees to focus on their health, help prevent burnout and maintain long-term productivity (Kim et al., 2023).

Additional policies such as job-sharing and sabbaticals offer unique flexibility by allowing employees to share responsibilities or take extended breaks for personal development (Schabram et al., 2022). Remote work flexibility, which includes working from various locations, and unlimited or flexible vacation policies

provide employees with greater autonomy over their schedules (Bontrager et al., 2021). Phased return-to-work programs assist employees in gradually resuming full-time work after extended leave (Kim et al., 2023). Shift-swapping policies and on-site childcare support help manage unexpected personal commitments and childcare needs (Schabram et al., 2022). Elder care assistance programs support employees in managing responsibilities for aging relatives (Yadav & Sharma, 2021). Paid volunteer time off and mental health days are becoming increasingly recognized as essential components of work-life balance, supporting both personal well-being and corporate social responsibility (Borowiec & Drygas, 2023).

### 3.2 Ethical and Social Implications

The ethical and social implications of work-life balance policies are profound and multifaceted. Implementing these policies demonstrates a company's commitment to the well-being of its employees and reflects a broader corporate social responsibility (Kim et al., 2023). By prioritizing work-life balance, companies contribute to a healthier and more equitable society, positively impacting the community beyond the workplace (Gragnano et al., 2020).

Work-life balance policies play a critical role in advancing gender equality (Barbar et al., 2024). Flexible working arrangements, parental leave, and family-friendly policies enable both men and women to share family responsibilities more equitably (Kim et al., 2023). This support helps to break down traditional gender roles and promote a fair distribution of domestic duties, fostering a more inclusive work environment (Agerström et al., 2023).

Effective work-life balance policies significantly enhance employee well-being by reducing stress and preventing burnout (Vaziri et al., 2022; Li & Zhang, 2023). Employees who feel supported in balancing their personal and professional lives are generally more satisfied and loyal to their employers (Li & Zhang, 2023). This increased job satisfaction contributes to lower turnover rates, reducing costs related to recruitment and training, and maintaining a stable and experienced workforce (Vaziri et al., 2022; Li & Zhang, 2023).

A favorable work-life balance leads to increased productivity. Employees who can effectively manage their personal and professional lives are more focused and efficient at work (Li & Zhang, 2023). This improved productivity benefits the organization by enhancing overall performance and reputation, creating a positive feedback loop where satisfied employees contribute to the company's success.

### 3.3 Work-life balance Case studies

Examining case studies of companies known for their effective work-life balance practices provides valuable insights into successful implementation and benefits. Google is renowned for its flexible working options, including remote work, flexible hours, and on-site amenities such as gyms and nap pods. This approach supports employee well-being and job satisfaction, contributing to its reputation as an employer of choice and enhancing retention (*Google's Approach to Remote Work Policy - Esevel*, n.d.).

Microsoft has championed flexibility, allowing employees to adjust their schedules and work environments. During the COVID-19 pandemic, the company expanded its remote work options to include permanent work-from-home arrangements. This flexibility, combined with strong mental health support, has led to increased employee happiness, innovation, and engagement (*The Microsoft Approach to Remote Work Policy - Esevel*, n.d.).

Patagonia's commitment to environmental and social responsibility extends to its work-life balance policies. The company offers extensive parental leave, on-site childcare, and flexible hours. These practices contribute to high employee loyalty, low turnover rates, and alignment with its mission, enhancing its brand identity and attracting like-minded talent (*Corporate & Social Responsibility History - Patagonia*, n.d.).

In Serbia, Manpower's pilot program for a four-day workweek aims to improve work-life balance by reducing work hours while maintaining full-time pay. Initial results indicate increased job satisfaction and productivity, although challenges remain in adapting this model across different sectors and cultural norms. This initiative reflects a global trend towards flexible work arrangements and could serve as a model for broader implementation (*Manpower Srbija*, n.d.).

These case studies illustrate that successful work-life balance policies involve flexibility, alignment with company values, and comprehensive support systems. By adopting such practices, companies can create supportive environments that enhance employee satisfaction and organizational performance.

## 4. Discussion

This review of the literature highlights the substantial benefits of work-life balance policies for both employees and organizations. Such policies, encompassing flexible working arrangements, family-friendly initiatives, and employee wellness programs, are shown to significantly enhance employee satisfaction, reduce stress, and prevent burnout. Companies that prioritize these policies not only demonstrate a strong commitment to corporate social responsibility but also achieve improved organizational outcomes, including increased productivity, higher employee retention, and a more positive work environment.

Despite these advantages, implementing work-life balance policies effectively presents notable challenges. One major issue is the gap between policy and practice (Kim et al., 2023). Organizations may offer flexible working options, but employees often face pressure to prioritize work over personal life (Kim et al., 2023). This pressure can stem from managers expecting availability beyond standard hours or from a workplace culture that discourages the use of flexible policies. Consequently, employees may hesitate to fully utilize these options, fearing negative impacts on their career advancement or perceptions of a lack of commitment (Li & Zhang, 2023).

Cultural barriers further undermine the effectiveness of work-life balance policies. In some organizational cultures, using flexible arrangements such as telecommuting or parental leave can be stigmatized (Yadav & Sharma, 2021).

Employees who utilize these benefits might be perceived as less committed or ambitious compared to those adhering to traditional work schedules. This stigma can discourage employees from taking advantage of work-life balance policies, leading to their underutilization (Ferdous et al., 2020). Additionally, in sectors where long hours are normalized or celebrated, employees may feel compelled to work excessive hours to demonstrate dedication, despite the presence of supportive policies (Ferdous et al., 2020).

For work-life balance policies to be effective, they must be accompanied by a shift in organizational culture (Li & Zhang, 2023). This includes redefining what it means to be a dedicated and successful employee, and moving away from the notion that long hours equate to productivity or commitment. Without this cultural shift, even well-designed policies may fall short of their intended goals (Li & Zhang, 2023). Addressing these challenges requires creating a supportive culture that genuinely values work-life balance and ensures that employees can fully utilize available resources without fear of adverse consequences (Vaziri et al., 2022; Li & Zhang, 2023).

This review acknowledges several limitations. The scope of the literature may not encompass all relevant studies, potentially omitting important findings. Additionally, the case studies presented are from a limited number of companies, which may not fully represent the diversity of industry practices. The review primarily focuses on short-term benefits, and the long-term impacts of work-life balance policies on employee health and career progression remain underexplored.

Future research should investigate the long-term effects of work-life balance policies on employee health and career trajectories to provide a more comprehensive understanding of their effectiveness. Additionally, exploring the impact of work-life balance policies across different cultural contexts could offer insights into how varying cultural attitudes towards work and family influence the success of these initiatives. Expanding research to include a broader range of industries and company sizes would also enhance the generalizability of findings and contribute to developing more effective work-life balance strategies.

## 5. Conclusions

This study underscores the significant benefits of work-life balance policies while emphasizing the need to address challenges related to organizational culture and the genuine support of these policies. Effective implementation requires overcoming barriers and cultural stigmas that may hinder utilization. By adopting best practices from leading organizations and creating a supportive, inclusive environment, companies can enhance their work-life balance initiatives. Such improvements are crucial for boosting employee well-being, job satisfaction, and overall organizational performance. In summary, refining and expanding work-life balance policies is essential for fostering sustainable, supportive work environments, meeting employee needs, and advancing broader social well-being.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DETERMINATION OF THE MAIN RISK FACTORS INFLUENCING THE PROJECT SUCCESS: A SYSTEMATIC LITERATURE REVIEW

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***Abstract***

*A substantial body of literature emphasizes the importance of understanding the risks associated with projects. These risks, inherent in every endeavor, can significantly impact project success.*

*Therefore, this paper aims to determine which factors play the biggest role in finishing the projects successfully and without delay. We used a systematic literature review method PRISMA to identify more than 90 articles. Considering the continuous and fast-paced changes in the industry, only the latest state-of-the-art articles, published in the last three years, have been taken into consideration, to provide a novel insight into noteworthy elements determining projects' success in the recent period. Multiple factors, such as the type of industry and research methodology were taken into consideration. The research has shown that the construction industry has the lead in researching risk factors influencing project success. Two major topics were identified as most studied in determining the risk associated with project success – determining the relationship between multiple factors during the project delivery and modeling systems to determine potential risks. The results given in this review paper can help future project managers consider some additional factors when making decisions and setting deadlines. Additionally, more research should be done to determine the potential factors that can increase the chances of project success in the future.*

***Keywords****: risk factors, project success, project management, management strategies.*

## 1. Introduction

Understanding the risks associated with projects is crucial for ensuring their success, as these risks can significantly affect outcomes. The efficient and timely project delivery is one of the main requirements for project leaders and managers.

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In order to achieve this, it is necessary to determine key risk factors and to utilize this knowledge to prevent delays.

The need for constant improvement in project management processes requires constant research and developing new strategies, given the fact that different industries or project types require different management paths.

The question is, what are the main strategies when determining potential risks while planning projects, and how are these risks identified and quantified.

Based on this, we identified strategies for project management (PM) risk assessment and listed potential methodologies for improving the project success.

### 1.1 Methods

Using the PRISMA systematic literature review method, we analysed over 60 articles published in the past three years to ensure a focus on the latest research (see PRISMA Checklist in Figure 1).

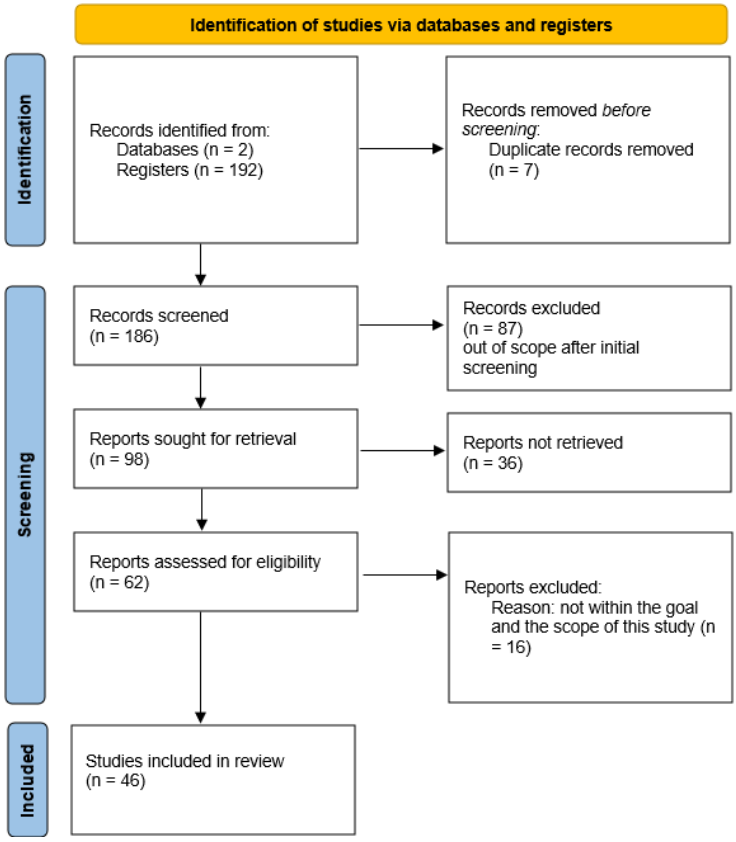


*Figure 1: PRISMA flowchart*

After determining the PRISMA methodology to be the one to go for this research, we have conducted the following steps:

**Step 1. Identifying and defining research goals:**

Our goal is to determine main risk factors in project management and proposed strategies for their discovery, and well as the proposed methodologies to alleviate the impact of these factors on project success.

**Step 2. Literature search:**

In this step, we initiated a rigorous search of the literature. To find relevant published articles we used keywords "project management" AND "risk management" AND "resilience". Two major databases were searched, Scopus and Web of Science (WOS). We limited the search to "Articles" and" English only"; Additionally, time frame was set to last 3 years (2022-2024). The research was condusted in May 2024, so it only includes articles up to this date. The search yielded 192 articles related to our research topic – 182 from Scopus and 10 from WOS (see details in Figure 1).

**Step 3. Inclusion and exclusion criteria:**

Initially, we checked the data for duplicates, thus discarding seven articles. Later, we screened each (of the remaining 185 articles) article's title and abstract to check its relevance according to our inclusion/exclusion criteria (i.e., related to the study's objectives, publication year between 2022-2024, and academic articles written in the English language). This process resulted in the identification of 98 relevant articles, as 87 articles were found irrelevant as they did not meet study objectives. After discarding these articles, we sought for retrieval of 98 articles, of which we were able to fully retrieve 62 (36 were not retrieved in full version).

We further assessed the quality of the remaining 62 relevant articles and also conducted further checks to determine if the core findings fall within our agenda. After detailed evaluation, an additional 16 articles were excluded, and 46 remained for final analysis.

**Step 4. Extraction of data and analysis:**

Lastly, we thoroughly studied these 46 articles to identify the risks and strategies to alleviate it that have been discussed in the literature. A detailed discussion of this analysis is given in the discussion section.

## 2. Discussion

Out of the 46, 42 (91%) were research articles, and 4 were a systematic literature review (9%).

We find that 39% (18) of articles were published in the year 2022, 41% (19) in 2023, and 20% (9) in 2024. Articles were very diverse when it comes to the country of origin (note that, for the articles with affiliations from multiple countries, only the first authors' country was taken into consideration), and there were 8 articles from China (17%), 6 (13%) from Australia, 4 (9%) from each - USA, Iran and

Turkey, 3 (6%) from France, 2 (4%) From UK, and 1 form each - Brazil, Cyprus, Czech Republic, Denmark, India, Indonesia, Malaysia, Pakistan, Portugal, Romania, Saudi Arabia, Serbia, Sweden, Switzerland and Uganda. In (Table 1) we can clearly see that Australia and China are taking a lead in investigating this topic in recent years.

*Table 1: Countries that studied risk factors and project improvement within the last 3 years*

| Number of studies | Countries |
|---|---|
| **5-10** | Australia, China |
| **3-5** | France, Iran, Turkey, USA |
| **1-2** | Brazil, Cyprus, Czech Republic, Denmark, India, Indonesia, Malaysia, Pakistan, Portugal, Romania, Saudi Arabia, Serbia, Swede, Switzerland, Uganda, UK |

Furthermore, 18 of these articles were published in 2022 (39%), 19 in 2023 (41%) and 9 in 2024 – 9 (20%). Most of them (7, 15%) were published in the International Journal of Project Management, then 5 (11%) in Sustainability, and the other were published in various other journals. The distribution of articles published in open access journals (24) and traditional ones (22) was very similar, as can be seen in the Figure 2.

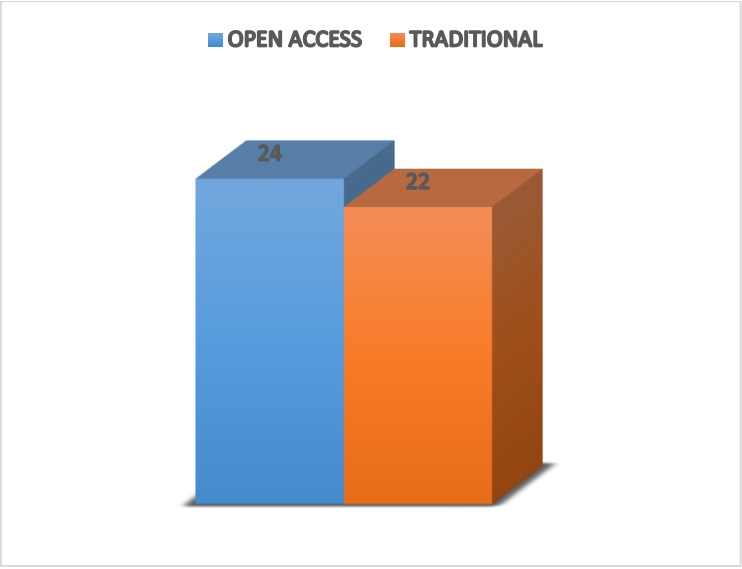


*Figure 2. Distribution of open access versus traditional journals*

Keyword analysis revealed that most repeated kewords were project; management; resilience; project management and construction. The table 2 summarizes the frequency of the 15 most-used keywords in reviewed articles, and the Figure 3 shows visualization of overall keyword frequency.

*Table 2. Most common keywords*

| Keyword | Number of uses | Keyword | Number of uses |
|---|---|---|---|
| project | 43 | analysis | 7 |
| management | 30 | complexity | 7 |
| resilience | 18 | theory | 6 |
| project management | 17 | success | 6 |
| construction | 10 | project success | 5 |
| performance | 10 | network | 5 |
| projects | 9 | construction projects | 4 |
| risk | 9 | | |

*Figure 3. Visualised distribution of keywords*

After content analysis of the selected articles, it has been concluded that their main research topics could be divided into three groups:

1. Research that proposed models for project risk management or PM efficacy improvement
2. Research on the relationship of factors in project management
3. Research on various other factors

The majority (22/46) of the papers (e.g. Wang et al. (2022), Jiang et al. (2024), Zarghami (2024), Hamdani et al. (2024), Nunes et al. (2022) etc.) deal with proposing different models for increasing project resilience or choose best strategies for project management, using mainly surveys based on questionnaires and interviews, and some of them testing the model in a case study.

Nine out of forty-six studies (such as Safapour et al. (2023), Al-aloosy et al. (2024), Franke et al. (2022) etc.) focused on finding relationships between project factors or participants to the success of the project.

Besides modelling of the processes and determining the corelation between different factors on PM success, additional studies researched topics such as project

success decreasing due to the unforeseen events (Mollajan et al., 2023), crisis events like Covid (Omotayo et al., 2024) or external disruptions (Iao-Jörgensen, 2023) etc.

Based on methodology that is used in these research, it is notable that the predominant choice is a survey (a questionnaire and/or interview was conducted in 24/46 studies) or a case study (a method used in 15/46 studies), which is usually used to test the proposed models in research papers.

## 3. Conclusions

A numerous study that are included in this literature review reveal several key findings on project risk management and factors influencing project success. Multiple studies propose models to enhance project resilience and management effectiveness, utilizing mainly methods like surveys, interviews, and case studies, while others research different influence of external factors to the project success, or merely analyze data to obtain better understanding and knowledge of different strategies or factors. Among the methods used, besides the three mentioned, were, in a lesser occurrence, the methods like data analysis, quantitative analysis and cluster analysis.

The main methods used are shown to be a survey (a questionnaire and/or interview was conducted in 24/46 studies) and models are usually verified by conducting a case study (method used in 15/46 studies).

It should be concluded that many of the studies used specific case studies for their research and that all aspects of project management should be analyzed according to the specific project and apply the appropriate measures accordingly.

The proposed studies can serve as a lead in determining the best strategies when planning projects and determining the best practices. This research gives a theoretical base on the key points to be considered while planning projects and the main methodologies for their determination identified in this study can be used for application in industry/company practices.

Additionally, given that the majority of these studies was conducted in a construction industry, further research should be conducted in other areas in order to compare results and provide insight into effects of different industries to applying same methods and models.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE HUMAN DIMENSION OF PROJECT SUCCESS: EXPLORING THE ROLE OF HIGH-PERFORMANCE WORK PRACTICES, TRUST, AND TEAM VOICE

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***Abstract***

*This study explores the human dimension of project success by examining the roles of high-performance work practices, project team members trust and voice. By combining a literature review of key concepts with bibliometric thematic mapping analysis of project success within the time span of 2019-2024, the introductory study provides a theoretical foundation and highlights the need for further investigation into the mediating roles of project team members trust and voice in the relationship between high-performance work practices and project success. Our work bridges literatures on project success, leadership, human resource management and behavioral science.*

***Key words****: Project Success, High-Performance Work Practices, Leadership, Trust, Voices*

## 1. Introduction

### 1.1 Justification & Study Objective

In the realm of general management literature, the impact of leadership traits and competencies on team performance is widely recognized (Castro et al., 2023). However, within the field of project management, the influence of a project team's trust and voices (among team members, towards the project manager, project outcomes, or the organization) remains underexplored (Castro et al., 2023; Zhu et al., 2019). While it is acknowledged that trust among project team members (PMTs) is essential for successful collaboration and task execution, the significance of trust itself presents a notable gap in existing studies.

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Transformational leadership (TFL) has emerged as one of the most extensively studied leadership theories, demonstrating a strong connection with anticipated outcomes for individuals and teams (Fareed et al., 2022). Studies have consistently shown that TFL positively affects project success (PS), work outcomes, and overall organizational performance (Iqbal et al., 2019). Nonetheless, some studies emphasize the complex interactions between leadership, high-performance work systems (HPWS), and employees' emotional well-being, underscoring the necessity of integrating these elements to cultivate a sustainable work environment (Ehrnrooth et al., 2023). Furthermore, findings indicate a close relationship between the motivational and inspirational behaviors associated with TFL and PS.

Recent studies highlight that the integrated and synergistic nature of high-performance work practices (HPWPs), as part of the HPWS, can lead to an increased occurrence of viable and PS (Savković et al., 2023; Zaman, Khan, et al., 2022). Despite these insights, a significant lack of longitudinal studies tracking the effects of these practices over time has been identified, alongside limited research at the industry level (Zaman, Khan, et al., 2022). For instance, the authors of the paper "Fall Seven Times, Stand Up Eight: Linking Project Management Innovation, Project Governance, and High-Performance Work Practices to Project Success" suggest that future studies should explore the roles of PMTs voice and silence in achieving PS (Zaman, Khan, et al., 2022).

Trust is recognized as a crucial psychological factor, often identified as an antecedent to silence in teams (Fareed et al., 2022; Zhu et al., 2019). The Tuckman Ladder Theory illustrates that trust plays a vital role in the transition from the norming to the performing stages of team development. PMTs need time to learn how to communicate effectively and collaborate productively; the 'storming' phase is essential in this process, during which initial conflicts and disagreements may arise. For example, in the Agile "Scrum" framework, it is anticipated that the initial sprints may not proceed smoothly, which is acceptable as relationships develop over time. Thus, PMs must acknowledge that their teams consist of individuals who need time to build trust and cohesion.

TFL exhibited by PMs has been shown to reduce silence behaviors among PTMs by fostering a sense of trust (Wang et al., 2019). Additionally, TFL has been demonstrated to positively impact employee voice (Zhu et al., 2019).

This discussion highlights a critical loop: Specifically, TFL enhances HPWPs and PS while also positively influencing PTMs voices. Furthermore, HPWPs contribute positively to PS. However, an important question arises: What are the roles of PTMs trust and voices mediate the relationship between HPWPs and PS?

This introductory study offers insights into the complex nature of collective behavior, advocating for a re-examination of existing models for assessing project success. The study aims to provide a theoretical foundation and highlight the need for further investigation and testing of the roles of PMs trust and voices in the relationship between HPWPs and PS.

Lastly, it can be concluded that TFL serves as the underpinning theory of this study, effectively bridging the discussed concepts.

Based on the provided rationale, the authors propose the following research question:

- RQ: How does PMTs trust and voice influence the relationship between HPWPs and PS?

This study is organized as follows: (1) The introductory part describes the need, objectives, study question, and methodology; (2) The second section presents the state of the art; (3) The discussion answers the RQ; and (4) The study concludes with key findings, implications and limitations.

### 1.2 Methodology

The research design in this study combines two primary approaches: a literature review of key concepts— HPWPs, PS, and the dynamics of voice and trust within PMTs—as well as thematic mapping of PS through bibliometric analysis.

The literature review aimed to identify relevant studies published within the last six years (including 2024). Articles were sourced through the Google Scholar search engine, using specific keywords related to the aforementioned concepts.

The bibliometric analysis followed the standard workflow (Zupic & Čater, 2015). The initial step involved the formulation of a study scheme, defining the research questions and identifying the tools and techniques necessary for conducting the bibliometric analysis, as detailed in the introductory section.

Next, data collection was performed by retrieving a dataset from the Web of Science (WoS) core collection for the period 2019–2024. The search was limited to articles in English within the WoS Business and Management categories. Filtering ensured that only documents containing the specified search terms in the title, abstract, keywords, and keyword plus (i.e. Topic) were included, with a focus solely on journal articles.

Query link:
https://www.webofscience.com/wos/woscc/summary/9fbf1246-aaef-44c6-ab37-937e1597eecd-010ea4a7d3/relevance/1

The bibliometric analysis, conducted using the "bibliometrix" R package, provided a comprehensive review of the literature. This analysis helped identify knowledge gaps, generate new research ideas, and highlight contributions to the field. A thematic mapping was also conducted at this stage.

In the next step, visualization techniques were applied using VOSviewer software, which allowed for the graphical representation of bibliographic data (van Eck & Waltman, 2010).

The final step, interpretation, focused on analyzing the findings from the bibliometric analysis and providing insights into emerging research trends and the study's contributions to the field.

# 2. The State of Art

## 2.1 Project Success: Thematic Mapping and Its Implications

In thematic analysis, density and centrality are crucial attributes. Density measures theme cohesiveness, while centrality reflects topic relevance. The thematic map is divided into four quadrants: driving themes (upper right), basic themes (lower right), niche themes (upper left), and emerging themes (lower left) (Dores et al., 2021).

**Figure 1** illustrates thematic analysis from 2019-2024, revealing seven clusters within PS:

- **Cluster 1 (red)**: *Information*—includes terms "information", "implementation", "trust", "strategies", "integration", "R&D", etc.
- **Cluster 2 (blue)**: *Complexity*—covers terms "construction projects", "costs", "time", "failure", "decision-making", "risk management", etc.
- **Cluster 3 (green)**: *Product*—focuses on terms "product development", "supply chain management", "collaborative product development", etc.
- **Cluster 4 (violet)**: *Transformational Leadership*—addresses terms "emotional intelligence", "creativity", "job satisfaction", "work behavior", "team performance", etc.
- **Cluster 5 (orange)**: *Performance*—highlights terms "project success", "innovation", "knowledge management", "organizational culture", etc.
- **Cluster 6 (brown)**: *Allocation*—emphasizes terms "resource allocation", "delivery in project management", etc.
- **Cluster 7 (light violet)**: *Post-Truth Era*—discusses terms "misinformation", "decision-making processes", etc.

Clusters 1, 4, and 5 emerge as the largest, underscoring the importance of information integration, leadership, and performance metrics. Clusters 3 and 6, which pertain to product development and resource allocation, represent niche themes, suggesting that while these areas are relevant, they may not dominate current discussions in project management. Cluster 2 reflects challenges in decision-making and risk management. Lastly, Cluster 7, centered on the "post-truth era," highlights an emerging theme, addressing the growing concern about misinformation and its implications for decision-making processes. This indicates a need for increased awareness and strategies to mitigate the effects of misinformation in project management contexts.

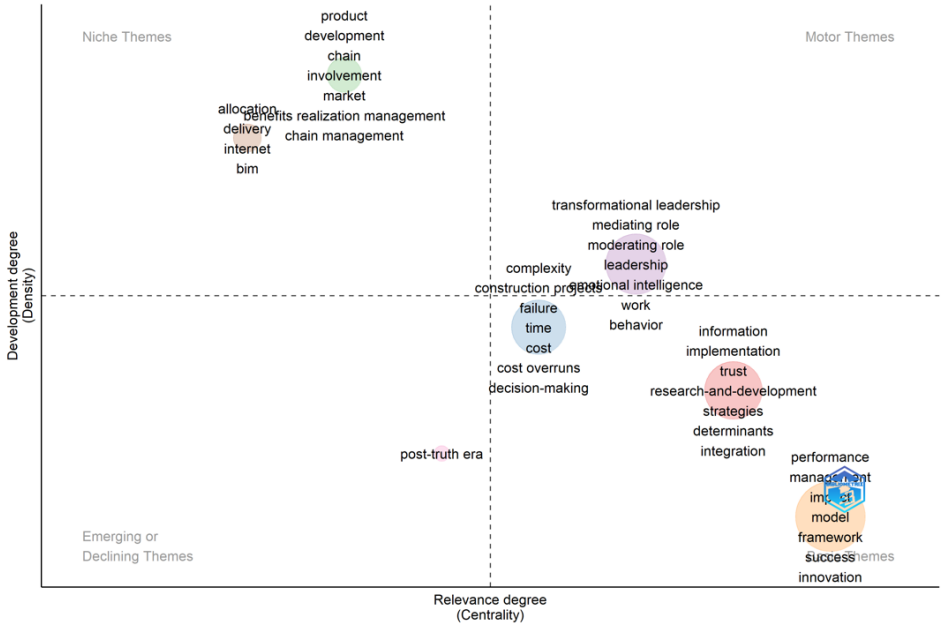


*Figure 1: Thematic Map*

## 2.2 High-Perfrmance Work Practices: Literature Review

Recognized as integrated bundles of human resource practices, HPWPs are identified as key drivers of employee motivation, job quality, and meaningful work (Mansour et al., 2023). The theoretical foundations of HPWPs have been linked to principles of high involvement and high commitment, demonstrating applicability across diverse industries (Zaman, Khan, et al., 2022). Furthermore, the triad framework of ability, motivation, and opportunity (AMO) has been proposed as a critical basis for achieving desired organizational outcomes by enhancing the capabilities and decision-making skills of team members (Mansour et al., 2023; Zaman, Khan, et al., 2022). Collectively, these practices are understood to create a synergistic effect that amplifies employee commitment, skills, and knowledge, resulting in outcomes that surpass their contributions (Dasí et al., 2021). Despite their acknowledged significance, HPWPs remain in the process of being firmly established as definitive determinants of PS; however, they are viewed as essential for cultivating a supportive work environment that encourages continuous improvement among project team members (Zaman, Khan, et al., 2022). In this regard, the lack of HPWPs can give rise to detrimental consequences such as organizational politics, conflict, and project failure (Hussein, 2019). Therefore, it is clear that HPWPs play a crucial role in facilitating both innovation and sustainable success within organizations. (Jalali et al., 2021) These work practices are typically classified based on their impact on employees' involvement, skills, motivation, and task structuring abilities.

### 2.3 Project Team Members Trust and Voices: Literature Review

Trust is defined as a general tendency to depend on others with a personal decision. Trust in management is regarded as a critical practice and tool that facilitates organizations in promoting enhanced employee productivity within a supportive environment (Jalali et al., 2021).

Employee voice is defined as the informal and voluntary expression of ideas, suggestions, concerns, problems, or opinions related to work issues, aimed at fostering improvement or change (Morrison, 2022). Organizational policies and practices serve to define the appropriate beliefs, values, and behaviors within a given environment, thereby shaping collective perceptions regarding whether expressing voice is deemed acceptable and encouraged within the organization(Knoll et al., 2021). Furthermore, managers play a key role in interpreting and implementing these policies (Milenkovic et al., 2023; Savkovic et al., 2024), influencing team members' perceptions by fostering a culture of openness, modeling vocal behavior through their own actions, and providing opportunities for team members to develop confidence in voicing their opinions (Zaman, Florez-Perez, et al., 2022).

## 3. Discussion

Recent project management literature consistently highlights the pivotal role of behavioral factors—such as leadership styles, communication, project management expertise, commitment, and teamwork quality—in project success (PS) (Zaman, Florez-Perez, et al., 2022b). HPWPs are increasingly recognized as a critical solution to enhance team performance by fostering collaboration and commitment, both essential for PS (Savković et al., 2023; Zaman, Khan, et al., 2022).

Implementing HPWPs for all PTMs, including PMs, addresses several challenges, while trust among PTMs, trust in the PM, and the concept of PTMs' voice are critical influences on project outcomes (Bjelica et al., 2023; Savković et al., 2024). Trust enhances communication, reduces conflicts, and fosters collaboration, while voice encourages PTMs to contribute ideas, driving innovation and improving performance (Fareed et al., 2022; Morrison, 2022; Zhu et al., 2019).

Although TFL has been shown to enhance HPWPs by promoting trust and encouraging PTMs to voice their opinions, the roles of trust and voice between HPWPs and PS remain underexplored, requiring further investigation (Wang et al., 2019). Trust and a culture that supports open communication may unlock the full potential of HPWPs, contributing significantly to PS.

Thematic analysis has underscored the importance of these interactions, identifying gaps, such as the "post-truth era" theme, which highlights diminished trust in projects. This gap further accentuates the comprehensive role of trust in PS. Future research should focus on a deeper analysis of trust, voice, and the factors influencing their development to fully understand how they impact project outcomes.

Additionally, HPWS, which encompass HPWPs, have been shown to reduce job demands and lower emotional exhaustion, with some studies suggesting that

prioritizing HPWS development over TFL might better improve employee well-being (Ehrnrooth et al., 2023). Previous research supports the idea that trust directly impacts individual, team, and project performance, while HPWPs, through training and skill enhancement, improve trust and provide the motivation for creativity and innovation (Jalali et al., 2021).

These findings underscore the necessity of rethinking how we measure project success (PS) today by integrating a "human dimension" that accounts for PMTs trust and voice. This adjustment emphasizes that fostering these behavioral factors is critical to fully unlocking the potential of HPWPs and ensuring more sustainable and impactful project outcomes.

## 4. Conclusion

This study investigates the relationship between PS, HPVPs, and project PMTs' voices and trust, positioning this inquiry within the umbrella of the TLF as an overarching management theory that integrates these concepts. The findings indicate the need for further studies that will form a theoretical framework and develop hypotheses. Based on the literature review and bibliometric thematic mapping, the authors anticipate the mediating role of PMTs' trust and voices in the relationship between HPVPs and PS. In the long term, the authors anticipate extending existing models for measuring project success by incorporating a new human dimension.

The study has limitations, including its reliance on literature from last six years, which may constrain the understanding of long-term trends.

## Acknowledgments

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# USING INTERPRETATIVE STRUCTURAL MODELING FOR ANALYZING KEY PROJECT MANAGERS' AND PROJECT TEAM MEMBERS' SKILLS, CRITICAL FOR PROJECT SUCCESS

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***Abstract***

*Project management is one of the most challenging jobs in any organization, as it requires a broad understanding of the various areas that must be coordinated. Over the past few decades, a number of studies have emerged on the correlation between project managers' and project teams members' competencies and project success. To improve project success, the organizations have to consider various skills such as communication (internal and external), effective control and monitoring, effective planning, ability to manage risk, etc, and their significance and the role in the project success. The aim of this paper is to use Interpretative Structural Modelling (ISM) and MICMAC analysis in order to analyze contextual interrelationships among the identified skills, divided into clusters, to develop structural relationship among these skills and to classify factors based on their driver and dependence power and their mutual relationships.*

***Key words:*** *competences, project manager, project team members, project success, structural modelling.*

## 1. Introduction

Realizing the importance of people management skills, Turner reformulated his definition of a "project" to recognize its human aspects. He defines a project as: "An effort in which human, financial, and material resources are organized in a new way to undertake a unique scope of work, given specifications, within cost and time

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constraints, to achieve beneficial change defined by quantitative and qualitative objectives (Turner, 1999).

The role of the project manager has evolved from a project administrator to a much higher managerial and leadership position, and to fulfilling organizational strategic needs. The project manager manages the project through the identification of project requirements; establishment of clear and achievable goals; balancing competing demands for quality, scope, time and cost; by adapting plans and approaches to different interests and expectations of different stakeholders; and project management in response to uncertainty. The role of a project manager is one of the most challenging jobs in any organization, as it requires a broad understanding of the various areas that must be coordinated. In addition, it requires strong interpersonal skills (Ahsan et al., 2013).

On the other hand, although it is clear that the success of the project largely depends on the project manager and related factors, the literature indicates that it also depends on the members of the project team. Successful project teams consist of individuals who share common goals and operate in the same way (Waweru, 2018).

In this regard, critical project factors depend on the skills and competencies of the project team and the leadership skills of the project manager to get the best out of his team (Mwinzi & Moronge, 2018). Project success is determined by project team effectiveness, project scope management, project time management, project costs, and project quality, which positively and significantly affect sustainability. Although extensive research has been conducted on the critical competencies of project managers and team members, there is a lack of structured analysis of the interrelationship between these competencies. This study aims to bridge this gap by employing Interpretative Structural Modeling (ISM) and MICMAC analysis to systematically examine the mutual dependence and driving power of these competencies. This will provide project managers with a clear hierarchical framework for prioritizing skill development.

## 2. Project and project seccuss

Considering that the field of project management is increasingly complex and diverse, a deeper understanding of the factors that contribute to project success is required. When we talk about project management, different project managers have different definitions of success, depending on their experience, knowledge, and the context in which they work. Some consider the number of projects completed on time and within the available budget to be the key factors of projects, which results in customer satisfaction, while others consider effective communication, successful cooperation, and the involvement of interested parties as success criteria.

All projects depend on some critical and key factors that represent the factors that determine the success of the project (Gupta et al., 2013). In this regard, they are those inputs into the management system that directly or indirectly lead to the project's goal (Murphy & Ledwith, 2007; Cooke-Davies, 2002).

Success is a subjective term and different people perceive it differently, but it is generally considered that a successful project is one that meets the requirements of the client/project orderer and other interested parties, especially the quality dimension.

Despite the well-developed body of knowledge in the field of project management, no comprehensive and unique agreement, i.e. consensus among authors, has been reached on the definition and method of measuring project success that would be appropriate for all projects (Ahimbisibwe et al., 2015, Savkovic et al., 2023), taking into account different human, budgetary and technical variables of each project. Criteria for measuring project success have evolved from simply measurable iron triangle criteria (time, scope and cost) to multidimensional frameworks that have a long-term perspective and relate to efficiency and organizational impact.

### 2.1 Key project managers' and project team members' competences

Factors based on the project manager are grouped into 4 clusters, namely: communication skills, technical knowledge, management skills and management-leadership style, where each cluster represents a set of skills needed for successful project implementation. The "communication skills" group assesses the importance of the project manager's communication skills to the success of the project. The "technical knowledge" cluster analyzes the importance of the project manager's technical ability for the successful completion of the project. The "management skills" and "management-leadership style" clusters assess the importance of the managerial ability and leadership style of the project manager for the success of the project (Jokanović Đajić et al., 2024).

Unlike project success factors based on the project manager, which are distributed in 4 clusters, factors based on project team members can be divided into input and process (Liu & Cross, 2016). Input factors include the characteristics of the internal environment in which the team operates and the characteristics of the team members, as well as the work on the project, e.g. leadership, management support, rewards, team diversity, clear goals, management skills and ability to use tools and techniques. On the other hand, process factors describe the internal interaction between team members and the external interaction between team members and other stakeholders, i.e. project stakeholders and include: cooperation, communication, learning activities, cohesion, commitment, conflict resolution, team climate and performance. These factors highlight the importance and suggest that successful project implementation is not an isolated process, but a joint effort involving various stakeholders (Jokanović Đajić et al., 2024). The previously mentioned clusters, with the corresponding associated factors, are shown in the following table 1.

*Table 1: Key project managers' and project team members' competences (Jokanović Đajić et al., 2024, Jokanović Đajić et al., 2023)*

| | CLUSTERS | FACTORS |
|---|---|---|
| **F1** | **COMMUNICATION SKILLS** | • frequent and clear communication,<br>• quality of communication,<br>• expressed verbal communication skills,<br>• strong graphic communication skills<br>• spend more time in informal conversations,<br>• active listening<br>• the level of understanding of the communication of all participants in the project<br>• establishment of formal communication channels<br>• appropriate communication with different audiences<br>• establishment of informal communication channels,<br>• explains and continuously communicates any changes to the project plan, as it changes throughout the project's life cycle,<br>• provide specific instructions to team members, related to each task |
| **F2** | **TECHNICAL KNOWLEDGE** | • effective planning,<br>• effective use of technology,<br>• risk management,<br>• abilities (technical skills),<br>• problem solving,<br>• ability to use project management methodologies (process analyses, system design and so on),<br>• focusing on critical elements of technical management (key factors of project success, deadlines, financial reports),<br>• adaptation of traditional and agile tools, techniques and methods for each project,<br>• thorough planning and prioritization,<br>• managing project elements, including schedule, costs, resources, risks,<br>• establishing a technological solution for the customer,<br>• control of the availability of individual competencies,<br>• selection and control of subcontractors,<br>• implementation and management of schedules and their implementation,<br>• establishing and assessing the technical risks of the project,<br>• setting deadlines,<br>• understanding the specific request |

| | CLUSTERS | FACTORS |
|---|---|---|
| F3 | MANAGEMENT SKILLS | • managers capable of managing agile processes,<br>• teamwork,<br>• conflict management,<br>• effective planning<br>• effective coordination,<br>• effective use of managerial skills,<br>• effective control and monitoring,<br>• ability to know the available resources (funds, equipment, people and the like),<br>• manager's ability in agile processes,<br>• project portfolio management |
| F4 | MANAGEMENT-LEADERSHIP STYLE | • self-awareness,<br>• motivation of the team,<br>• human resource management,<br>• development of human resources,<br>• sensitivity,<br>• empowerment of the team<br>• the influence of the project manager on the team members<br>• critical thinking |
| F5 | INPUT | • leadership,<br>• management support,<br>• prizes (awards),<br>• knowledge/skills<br>• team diversity,<br>• clearly defined goals,<br>• management skills,<br>• ability to use tools and techniques,<br>• personal competences |
| F6 | PROCESS | • cooperation,<br>• communication,<br>• activities related to learning,<br>• cohesion,<br>• commitment,<br>• conflict resolution,<br>• team climate,<br>• performance |

## 3. Interpretative structural modeling methodology and MICMAC analysis

The aim of ISM is to analyze complex systems (Warfield, 1974) It is an interactive process where a set of directly and indirectly related elements for a specific case are hierarchically organized and enable developing a map of relationships between the elements involved in situation (Ansari et al., 2013).

In this study this methodology is integrated with MICMAC analysis, in order to establish a hierarchical model of the identified key project managers' and project team members' competences and to explore their interrelationships. The choice of ISM over other methods like AHP is justified by its ability to map complex interdependencies in a structured and visual manner. Additionally, the fuzzy approach to MICMAC analysis will account for uncertainties in expert judgment, providing a more robust classification of competencies.

The steps of an ISM are as follow (Ansari 2013):

**I**: Identification variables/factors to be studied. In our research 6 key project managers' and project team members' competences have been identified as key factors for project success, as shown in table 1.

**II**: Contextual relationship among factors identified in step I should be examined. To indicate pair wise relationship among factors a structural self-intersection matrix (SSIM), table 2. Four symbols are used to denote direction of relationship between factors *i* and *j*: V – competence *i* will influence competence *j*; A – competence *j* will influence competence *i*; X - if both *i* and *j* are related together equally and O - competences *i* and *j* are unrelated.

**III**: An initial reachability matrix (IRM) is substituting the symbols (V, A, X and O) by 1s or 0s. The IRM for key project managers' and project team members' competences has been obtained as shown in table 2 adopting the following rules: if the entry in cell (i, j) in SSIM is V, then (i, j) is replace by 1 and (j, i) is replaced by 0 in the IRM; if the entry in cell (i, j) in SSIM is A, then (i, j) is replace by 0 and (j, i) is replaced by 1; if the entry in cell (i, j) in SSIM is X, then (i, j) is replace by 1 and (j, i) is replaced by 1 and if the entry in cell (i, j) in SSIM is O, then (i, j) is replace by 0 and (j, i) is replaced by 0 in the initial reachability matrix.

By adding the transitivity final reachability matrix is obtained (table 2). The transitivity of the contextual relationship is a basic assumption made in ISM and it states that if variable X is related to variable Y and variable Y is related to variable Z, then variable X is related to variable Z (Ansari et al., 2013).

*Table 2. Final reachability matrix*

| | F1 | F2 | F3 | F4 | F5 | F6 |
|---|---|---|---|---|---|---|
| F1 | 1 | 0 | 1 | 1* | 1 | 1 |
| F2 | 1* | 1 | 1 | 1 | 1* | 1 |
| F3 | 1 | 0 | 1 | 0 | 0 | 0 |
| F4 | 1* | 0 | 1 | 1 | 1 | 1 |
| F5 | 0 | 0 | 1* | 1 | 1 | 1 |
| F6 | 0 | 0 | 1* | 1 | 1 | 1 |

**IV**: Partitioning of levels of the reachability matrix obtained in step III. This is done to get the importance level of each project managers' and project team members' competence. According to the reachability matrix, the reachability set and antecedent set of every factor is determined. Reachability R(Si) and antecedent set A(Si) are calculated to partition the reachability matrix. R(Si)

refers to a set of factors on which the factor i has an impact while A(Si) refers a set of factors which impact factor i. The Intersection set is obtained by:

$$I(S_i) = R(S_i) \cap A(S_i)$$

If $I(S_i) = R(S_i)$ then the factors that are in a common $Li$ will be located on the same level of the ISM and will be taken out from the set before the next partition (Zeng He and Huihua Chen, 2021), Table 3 for firs level.

*Table 3. Decomposition of the reachability matrix for first level*

| Factor (i) | Reachability Set $R(S_i)$ | Antecedent Set $A(S_i)$ | Intersection Set $I(S_i)$ | Level (Li) |
|---|---|---|---|---|
| 1 | 1, 3, 4, 5, 6 | 1, 2, 3, 4 | 1, 3, 4 | |
| 2 | 1, 2, 3, 4, 5, 6 | 2 | 2 | |
| 3 | 1, 3 | 1, 2, 3, 4, 5, 6 | 1,3 | I |
| 4 | 1, 3, 4, 5, 6 | 1, 2, 4, 5, 6 | 1, 4, 5, 6 | |
| 5 | 3, 4, 5, 6 | 1, 2, 4, 5, 6 | 4, 5, 6 | |
| 6 | 3, 4, 5, 6 | 1, 2, 4, 5, 6 | 4, 5, 6 | |

**V**: Drawing the graph based on the contextual relationship in the reachability matrix. In accordiance with the results of partitioning the reachability matrix, structural ISM relationships diagram for this case was drawn as three-layer hierarchy, figure 1.

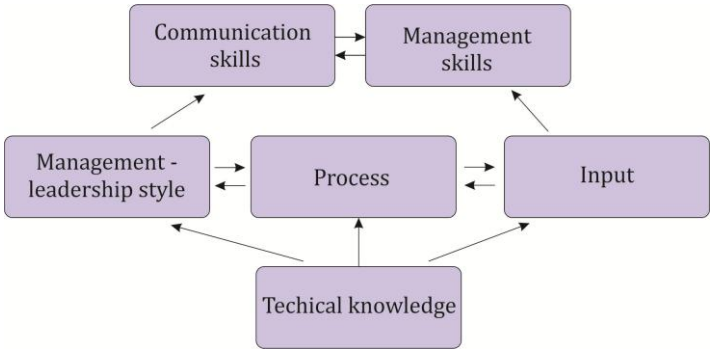


*Figure 1: ISM based model*

### 3.1. MICMAC analysis

MICMAC analysis analyze the dependence and driving power (Figure 2) of factors. Based on their dependence and driver power, the elements are subjected to MICMAC analysis and classified into four sectors, namely autonomous, dependent, linkage and driver/ independent. Factors with more driver power can strongly influence other factors, while factors with more dependence power are influenced by others.

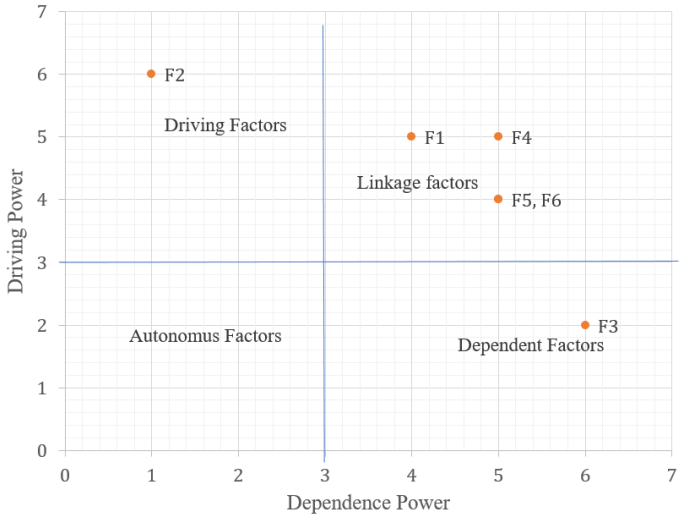


*Figure 2: MIMAC analysis*

## 3. Discussion

Figure 1 illustrates relationship between each pair of competences. As we can see factor F2 (Technical knowledge) is the root factor and this factor influence on other factors. On the other hand factors F1 (Communication skills) and F3 (Management skills) are direct factors and they are appearing at the top level of hierarchy.

Based on dependence and driving power competences have been classified in four categories using MICMAC analysis, figure 2. The autonomous competences have weak driver and weak dependence power. Relatively disconnected from the system, these elements have few links, which may be strong. In our research, no competences lies in this range. The dependent competences have weak driver power, but strong dependence power. These elements are sensitive to the action taken on the influent variables. (Poduval et al., 2015). In our study management skills is dependent factor and any action on this element will have effect on other elements**.** The linkage elements on the other hand have driver power and dependence, both of which are strong. These elements are unstable due to the fact that any action on these elements will affect the others and also a feedback on themselves. (Vivek et al., 2007). In our study four factors are lying in this range. The driving/independent elements strongly influence the system but is not influenced by the system. A competence with strong driver power called the “key factor” falls into this category. In our study one element named technical knowledge is lying in this range. This aligns with the PMI Talent Triangle’s emphasis on technical project management. However, our analysis positions 'Management Skills' lower in hierarchy, challenging the traditional views of its immediate importance."

## 4. Conclusions

This paper identifies and examines six key competencies of project managers and project team members that are critical to project success. Through the application of Interpretative Structural Modeling (ISM), we have developed a comprehensive hierarchical structure that reveals the contextual relationships among these competencies. ISM is particularly well-suited for analyzing the complex interrelations between competencies because it allows for a systematic breakdown of the factors into a clear hierarchy, providing insights into how each competency influences others. This enables project managers and organizations to better understand the priority of skill development and resource allocation.

Additionally, MICMAC analysis has been employed to classify the competencies based on their driving and dependence power, helping to identify the most influential factors. This method is invaluable in determining which competencies serve as key drivers for project success and which are dependent on others. Specifically, our analysis highlights that technical knowledge (F2) is the most critical driver, influencing all other competencies, while communication skills (F1) and management skills (F3) emerge as high-priority areas that require immediate attention due to their direct impact on project outcomes.

The findings suggest that a focused effort on enhancing technical knowledge as a foundational skill, complemented by improvements in communication and management capabilities, can significantly elevate the success rate of projects. Moreover, the classification provided by MICMAC enables project managers to strategically target key competencies for development, ensuring that training and resource allocation align with the overall objectives of project success.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# STRATEGY TO DEVELOP PROJECT BY USING HYBRID APPROACH

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***Abstract***

*A project is undertaken to create unique product, result, or services by executing set of activities to meet project objective. The success of project is measured towards achievement of project objective, project quality, timelines, budget compliance and degree of customer satisfaction. Currently, in competitive business environment product development is more dynamic and changing very frequently. The common challenges observed with failed project which has experienced overrun & schedule delays as compared to successful project are related to project planning, estimation, Accepting/Managing changes in requirements and quality management. Today in era of frequently changing technology and requirement, an adaptive approach is much needed for the product development. At present for the most complex and highly unstable projects, the Agile methodologies are implemented to increase the efficiency of the project and to exceed the customers satisfaction. This research will provide an insight on the challenges that management and team face after transitioned to Agile Project Management. Outcome of this research would be useful for project managers who has transitioned to Agile Project Management but are unaware of the difficulties. It will also help department in the organization who recently transitioned to Agile Project Management and revolutionize the workflow from within. Finally, team will get useful insights on how to handle this change, if they do not have any previous agile project management experience. In addition, it will propose a new conceptual framework i.e., hybrid framework that comprises of Agile and DevSecOps methodologies to enhance the predictability and efficiency of project.*

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***Key words**: Project, Traditional Project management, Customer satisfaction, Agile, DevSecOps, Predictability.*

# 1. Introduction

Agile project management is gaining popularity nowadays due to its ability to offer early and frequent iterations. This is in contrast to the traditional project management approach, which follows a sequential phase of planning, designing, creating, and testing. Designers collect feedback only at the final phase. In the aerospace business, where projects are complex and rely on an ever-changing world of digital technology, rapid adaptation and response are critical. As previously said, aerospace projects are already difficult; moving to agile methodology adds an additional degree of complexity that could jeopardize the project's success. However, with the correct tools and insights, these risks can be reduced.

After analyzing the outcome of few projects in detail where Agile methodology (AM) was used for Software Development Life Cycle (SDLC), it is found that AM provides flexibility to change, quickly adapt to new approach, improve, and scale the product but there is a scope to improve predictability of result. Agile methodology will work for short to medium term project but for long term project along with adaptability and flexibility, predictable project performance is must to have.

In summary, there is a need for a better understanding of challenges that are faced by the team and management after transitioning to Agile Project Management, concept of predictable result for any project, constraints and dependency that can hinder project outcome, mitigation plan which can make project result predictable and way to optimize project delivery process to provide value to customer frequently. In Aerospace industry for any projects that can hinder predictable performance, its recommended to have structured approach which can pave path for "Predictive Agile Delivery" along with optimized delivery process to ensure value delivery to customer more often with defined standard.

# 2. Primary Research Method: Literature Review and Conceptual Modeling

This research primarily utilized a **literature review** and **conceptual modeling** approach to investigate the challenges in Agile Project Management and to develop a new framework that combines Agile and DevSecOps methodologies.

### Literature Review

The literature review focused on exploring existing studies related to Agile Project Management (APM), its benefits, and its limitations in complex and dynamic environments. The goal was to understand common issues such as predictability, project delays, and scope creep that teams and managers face when transitioning to

Agile methodologies. Sources included peer-reviewed journals, industry reports, and case studies that provided insight into Agile practices, stakeholder management, and hybrid frameworks. The literature review helped identify key themes and knowledge gaps in existing research, including:

- Challenges faced by team and management after transitioning to Agile Project Management (Fitzgerald et al., 2006).
- The challenges of implementing Agile project management in large, distributed teams and industries requiring strong compliance and security measures (Drury et al., 2012).

Additionally, the review examined how DevSecOps complements Agile methodologies by embedding security practices early in the development process, ensuring continuous and secure delivery (Ahmed & Francis, 2019). The literature also emphasized the need for a structured approach that blends the flexibility of Agile with the predictability of traditional project management, suggesting that a hybrid model could address these issues (Shahin et al., 2017).

**Conceptual Modeling**

Building on insights from the literature review, the research employed **conceptual modeling** to develop a new framework—Predictive Agile Delivery. Conceptual modeling involves creating an abstract model that represents key components of a complex system or process. In this study, the process involved defining the core components of both Agile and DevSecOps methodologies and integrating them into a unified approach.

The conceptual modeling approach followed these steps:

- **Identifying Key Agile Components:** Based on the literature review, core Agile practices such as iterative development, continuous feedback, and flexibility were identified. These practices were analyzed for their strengths (e.g., adaptability to change) and weaknesses (e.g., lack of predictability).
- **Integrating DevSecOps:** The next step was to explore how DevSecOps practices—such as continuous integration, automated testing, and security integration—could complement Agile to enhance predictability, efficiency, and security. DevSecOps' focus on embedding security from the beginning of the development process was identified as a solution to the challenge of integrating security in Agile environments.
- **Developing a Hybrid Model:** Finally, a hybrid model, termed "Predictive Agile Delivery," was conceptualized by combining Agile's flexibility with DevSecOps' security-oriented approach. This model introduces structured processes for more predictable project outcomes, emphasizing continuous delivery and integrated security checks without sacrificing Agile's adaptability.

- **Defining Predictive Components:** To ensure the model improves project predictability, elements such as clear deliverables, defined timelines, and security checkpoints were integrated into the framework. The result is a conceptual model that balances Agile's iterative cycles with the predictability needed in complex, regulated environments.

The **conceptual model** developed through this research provides a structured yet adaptable approach that addresses the pain points identified in the literature review. It offers project managers a framework to enhance predictability, optimize delivery processes, and manage security in an Agile environment.

By employing both literature review and conceptual modeling, the research delivers a comprehensive understanding of Agile Project Management's challenges and proposes an innovative hybrid framework that can be applied in real-world projects.

## 3. Research Methodology

The research employs a multi-phase approach, including literature review, surveys, focus groups, and interviews. This combination of qualitative and quantitative methods allows for a comprehensive understanding of the challenges faced during the transition to Agile Project Management.

**Phase 1: Survey and Focus Group Method**: A survey was distributed to project managers and team members (who recently transitioned to Agile) to identify the main challenges they encountered. Focus group discussions were also conducted to explore these issues in greater depth and to propose potential solutions (Morgan, 1997).

**Phase 2: Interview Method**: Interviews were conducted with senior project leaders to understand how Agile Project Management impacts the predictability of project performance. These interviews provided insight into the importance of predictability for overall project success and how it can be improved through a structured Agile approach (Silverman, 2013).

**Phase 3: Conceptual Framework Development**: Based on the research findings, a new conceptual framework was developed, combining Agile methodologies with DevSecOps. This hybrid approach, called "Predictive Agile Delivery," focuses on improving predictability by introducing structured delivery processes and incorporating continuous security practices (Shahin et al., 2017).

## 4. Results

**Phase#1 Result:** A survey was conducted with the Managers, Product Owner, Scrum Master and Development Team to find out the challenges that faced by team and management after transitioning to Agile Project Management to draw solution.

Following are the ways to overcome agile transition challenges:

- **Better Agile Understanding:** Emphasize adaptability, learning, and quick recovery, focusing on long-term development rather than just productivity.
- **Top Management Involvement:** Management support is crucial to establish vision, values, and guide mindset shifts for business growth.
- **Organizational Culture:** Build a culture of commitment, trust, and teamwork, evolving from old mindsets.
- **Customer Independence:** Educate customers on agile principles to empower them for self-sufficiency.
- **Custom Agile Techniques:** Develop internal agile coaches and practices for continuous learning and transformation.
- **Collaboration and Communication:** Foster teamwork and allocate time for collaboration in agile processes.
- **Middle Management Support:** Appoint managers to serve as visionaries, architects, coaches, and catalysts.
- **Transparency and Trust:** Share knowledge openly and provide constructive feedback to improve practices.
- **Valid Agile Justification:** Understand customer context and maturity and focus on their actual needs.
- **Self-Organizing Teams:** Encourage teams to manage their tasks and priorities independently, supported by mentors.

**Phase#2 Result:** According to the findings of the Leader's interview, Agile will significantly improve the predictability of project performance. Nevertheless, predictability may suffer if an Agile Team is unable to implement Agile as planned, making it more challenging to reap the benefits of Agile. Though there have been numerous instances in a release train where the team has not performed up to the standards required of them, leaders observed that overall, there has been a noticeable increase in predictability; the predictions simply suggest that the work will not be completed as quickly or inexpensively as the business would like.

**Phase#3 Result:** Predictive Agile delivery with DevSecOps is a methodology that blends the automation-driven, security-focused practices of DevSecOps with the flexibility and iterative nature of Agile approaches. Below is an explanation of how these ideas relate to each other:

**Predictive Agile Delivery:**

1. **Hybrid Model:** Predictive Agile combines the iterative and adaptable methods of Agile with some aspects of traditional predictive planning. This implies that even with preliminary planning and forecasting, the project is still adaptable and may be changed in response to changing needs and input.

2. **Forecasting:** Predictive Agile use data-driven forecasting techniques to anticipate project results, deadlines, and resource requirements. Traditional Agile development methods concentrate on iterative development. This entails using performance measurements, trends, and historical data to forecast next releases and sprints with confidence.
3. **Continuous Improvement:** Using data to forecast and fine-tune Agile methods, the predictive component concentrates on streamlining operations via continuous improvement.

DevSecOps Integration with Agile:

1. **Security Integrated into the Pipeline:** By including security procedures into each phase of the software delivery lifecycle, DevSecOps builds upon DevOps. This guarantees that security is integrated from the beginning of planning through development, testing, and deployment in a Predictive Agile framework.
2. **Automation and Compliance:** To guarantee that security procedures are regularly followed without impeding the Agile delivery process, DevSecOps encourages automation in security checks, code analysis, vulnerability scanning, and compliance.
3. **Continuous Monitoring:** Predictive Agile in conjunction with DevSecOps entails keeping an eye out for performance problems, compliance infractions, and security vulnerabilities in pipelines, environments, and apps. This aids in anticipating possible security threats and taking proactive measures to mitigate them.

Advantages of Using DevSecOps and Predictive Agile Together:

1. **Enhanced Protection:** The team may produce secure code more quickly and with fewer vulnerabilities by including security into the Agile process, assuring adherence to rules and specifications.
2. **Better Predictability:** Agile's predictive feature makes it possible to plan, allocate resources, and estimate timelines more accurately, all of which contribute to more dependable delivery results.
3. A quicker time to market DevSecOps methods such as automation and continuous integration/continuous deployment (CI/CD) speed up releases by streamlining the delivery process and minimizing manual interventions.
4. **Resilience and Scalability:** Agile's flexibility combined with DevSecOps' emphasis on automation and security results in a software delivery process that is both more scalable and resilient.

## 5. Discussion

After understanding concept of Agile methodology (AM) for couple projects, it is found out that AM provides flexibility to change, quickly adapt to new approach, improve, and scale the product. But Agile methodology approach still have scope for improvement i.e. predictable project performance along with agility. The concept of "Predictable Project Performance" refers to the ability to forecast and anticipate the

outcomes of a project with a high degree of accuracy. In the realm of project management, achieving predictable project performance is a crucial goal, as it enables organizations to plan effectively, allocate resources efficiently, and mitigate potential risks. This research would be paving path for predictable project performance along with optimized delivery process by using DevOps. Additionally, strategies and insights find out from this research would empower project managers to forecast project outcomes with precision, ensuring efficient resource utilization, timely delivery, and customer satisfaction.

## 6. Conclusions

It is observed from the survey that roles and responsibilities within Agile are clearly defined. When considered as a whole, it seems to address a number of issues with the software development process in general. Agile doesn't address situations where team members aren't performing up to par with their roles. What occurs if a Scrum Master is unable to effectively lead a Scrum team. What takes place when a PO fails to fulfill their obligations? Significantly, Agile presupposes (and this is the main reason for its application) that the development team is made up entirely of experts who are the "best" people to decide on matters such as the length of a story and the technical solution, and that they will naturally want to fulfill their obligations. Additionally in conclusion, enterprises may produce high-quality, secure software more quickly by combining Predictive Agile delivery with DevSecOps to improve traditional Agile methods. This is achieved by making these practices more automated, predictable, and secure.

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# USE OF EXPLORATORY DATA ANALYSIS AND VISUALIZATION TECHNIQUES TO MEET ORGANIZATION STRATEGIC GOALS

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***Abstract***

*In the era of frequently changing technology and requirements, a competitive team is much needed for the product development. One of the challenging tasks for the Managers are how to effectively analyze the clustered data and use it to visualize the pattern and find the gap areas. To address these gap areas, department needs to first perform Exploratory Data Analysis (EDA) on the available datasets to detect obvious errors, identify outliers in datasets, understand relationships, unearth important factors, find patterns within data, and provide new insights. Secondly, after data has been collected, processed, and modeled, it must be visualized for conclusions to be made. This research will provide an insight on how the existing data could be leveraged to improve departments sustainable growth. To have a better overview on the phenomenon at hand, this research includes a survey from different project teams in the department which investigates the individual competencies and skill set, motivational factors, satisfaction and dissatisfaction, performance level, roles and responsibilities, attrition rate, training needs and effectiveness etc. There are challenges that managers and leaders can mitigate or provide preventing solutions. The analysis section sheds light on them (Ex: attrition) by finding right pattern between problem and solution using EDA and Visualization. These findings are useful for managers who have a task to improve their department competency but are unaware on how to process and visualize the existing data sets effectively. It will also help departments in the organization to retain and improve the quality of their talent pool.*

***Key words****: Exploratory Data Analysis, Data Visualization, individual competencies, skill set, motivational factors, satisfaction*

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# 1. Introduction

## 1.1 Broad Area of Work

According to Tukey (1979) exploratory data analysis "emphasizes looking at data from multiple angles, identifying patterns, and using various visualization tools to reveal insights that traditional methods may overlook" Data Visualization is one of the steps of the data science process, which states that after data has been collected, processed and modeled, it must be visualized for conclusions to be made. "Data visualization refers to the graphical representation of information and data, using visual elements like charts, graphs, and maps", (TechTarget, n.d.).

EDA is a critical first step in data analysis that allows for the identification of patterns, outliers, and trends, providing a foundation for further statistical analysis (Smith-Miles, 2011). This research will provide an insight on how the existing data could be leveraged to improve department competency by utilizing the data that has been collected, processed, and modeled from the Exploratory Data Analysis and Visualization. It also helps in identifying challenges by finding patterns from the analysis and its visualization that helps managers and leaders to mitigate or provide preventing solution to overcome these challenges.

## 1.2 Background

One of the challenging tasks for the Managers are how to effectively analyze the clustered data and use it to visualize the pattern and find the gap areas. Every department in an organization always have these three basic questions to answer:

1. Where do we exist today in terms of our team assets?
2. What is our strategic goal for near future?
3. How to meet the strategic goal with current team assets?

To answer these questions, department needs to perform Exploratory Data Analysis on the available datasets and then visualize those meaningful data to find the pattern and create solution for it.

Exploratory data analysis (EDA) is a critical and important step of analysis in research. The first most objective with exploratory analysis is to examine the data for distribution, outliers, and anomalies to direct specific testing of your hypothesis. It also provides tools for hypothesis generation by visualizing and understanding the data usually through graphical representation. EDA aims to assist the natural patterns recognition of the analyst. Finally, feature selection techniques often fall into EDA. EDA is a fundamental early step after data collection and pre-processing, where the data is simply visualized, plotted, manipulated, without any assumptions, to help assessing the quality of the data and building models.

## 1.3 Objective

The objective behind this research is:

1. Maximize insight from the dataset by finding the meaningful data out of the clustered data.

2. Visualize the processed data and find out the potential relationships between variables.
3. Develop a predictive or explanatory model/observation that helps to mitigate known challenges.

### 1.4 Scope of Work

This research scope covers gathering of raw clustered data through surveys and using the pre available department data, Perform Exploratory Data Analysis (EDA) on the available datasets to detect obvious errors, identify outliers in datasets, understand relationships, unearth important factors, find patterns within data, and provide new insights. After data has been collected, processed, and modeled, it must be visualized for conclusions to be made.

This research will provide an insight on how the existing data could be leveraged to improve department competency for aerospace. To have a better overview on the phenomenon at hand, this research includes a survey from different project teams from aerospace department which investigates the individual competencies and skill set, motivational factors, satisfaction and dissatisfaction, performance level, roles and responsibilities, attrition rate, training needs and effectiveness etc. Exploratory Data Analysis (EDA) plays a central role in forming hypotheses, defining models, and exploring data characteristics (Wongsuphasawat et al., 2019).

## 2. Understanding of Exploratory Data Analysis (EDA) and the Visualization Concept

### 2.1 Literature Review

Exploratory data analysis could be used before the formal analysis as the important data investigation process to test hypotheses with summary statistics and visualizations for finding patterns, outliers, and anomalies, discover trends. “Exploratory Data Analysis (EDA) is a crucial step in understanding the underlying patterns in data before applying any statistical models" (Camelot ITLab, 2019). It provides an idea regarding the data which we will be analyzing in detail and Visualization helps to create meaningful insights easily from massive datasets.

For this research the previously available sample data from public sources was collected, reviewed, and looked for the information’s that we seek. It was observed that the current data was scattered, less informative and had scope for standardization to provide the meaningful detailed information at a department level. There was a case for change to perform Exploratory data analysis on these data, visualize it, summarize the main characteristics, and find out meaningful information for the managers that will help in understanding the overall organization health status. "Exploratory data analysis focuses on discovering the unexpected and can be instrumental in hypothesis generation rather than just confirmation" (Emerson & Hoaglin, 1983).

### 2.2 What is Exploratory Data Analysis?

Exploratory Data Analysis (EDA) is an approach to extract the information enfolded in the data and summarize the main characteristics of the data (Camelot ITLab, 2019).

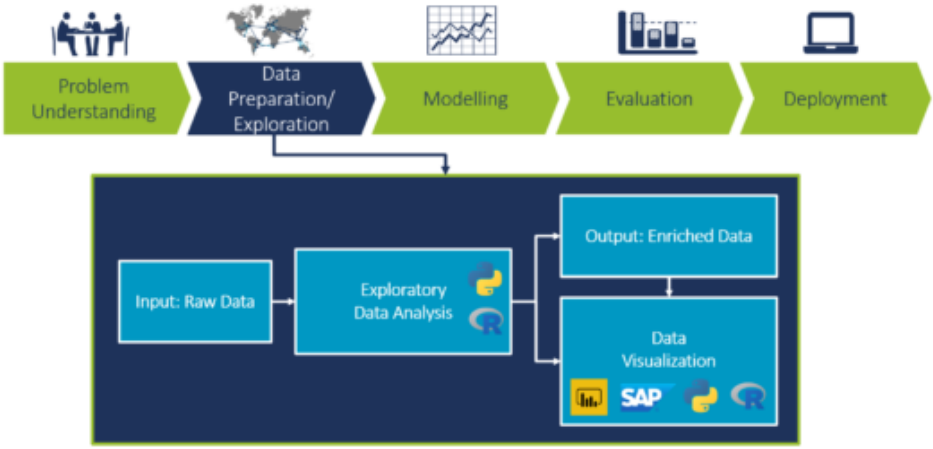


*Figure 1: Project Flow with exploratory data analysis (EDA)*

As defined in Figure 1, the main pillars of EDA are data cleaning, data preparation, data exploration, and data visualization. There are various exploratory tools (Python and R), and enterprise applications (Power BI, SAP Cloud Analytics, Tableau, etc.) to perform EDA, each of them offering a unique set of tools (Camelot ITLab, 2019). In this research we have mostly used Excel and Tableau for data visualization.

## 3. Results

This research has considered attrition attribute for the analysis.

### 3.1 Data Exploration and Visualization for Attrition:

Under this section we performed Univariate graphical (Histogram) and multivariate graphical EDA (Bar chart) using the Tableau Tool for the attrition data.

The goal of exploratory data analysis is to discover hidden insights by using a combination of visual and statistical methods (Patil, 2018).

#### 3.1.1 Collection and Cleaning of data

The raw clustered data is gathered and created after discussion with industry experts and by using the available public source. The data includes respective Employee ID, Age, Attrition information, Gender, Environment Satisfaction, Job Involvement, Job Level, Job Role, Job Satisfaction, Marital Status, Total working

years, Years at company, Number of companies worked, Salary hike (%), Work life balance, Years since last promotion, Years with current manager, Performance rating, Relationship satisfaction etc. Finally, the data was cleaned for any misses, empty field, duplicacy and overlaps.

### 3.1.2 Visualization and Observation from data

Tableau tool used for extracting appropriate information out of the data set and for its visualization to understand the current attrition rate against various factors through analysis and observation. "Data visualization allows patterns, trends, and correlations to be revealed that might not be obvious in raw data", (Tableau, n.d.). Extracted observations and analysis report would be shared to Managers to take necessary actions.

Development of retention strategies is important for the health of organization. Employee attrition has many consequences such as low morale, work life balance, Job dissatisfaction etc. The goal of this analysis is to discover why employee leave and provide the observations to the Managers to help alleviate attrition.

**Example: Age v/s Attrition trend**

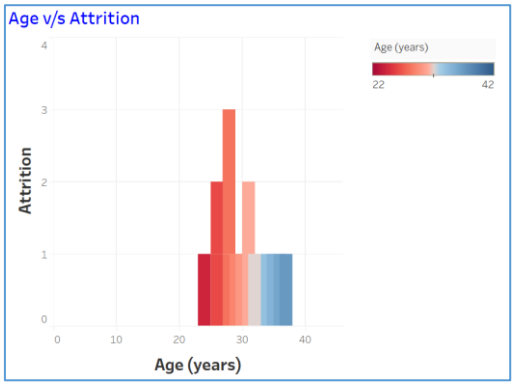


*Figure 2: Age v/s Attrition Chart*

**Observations:** To understand the impact of the age factor on attrition rate, we need to divide age into different age group. The entire workforce of any workplace has multiple generations, and they have their crucial role to play in the successful working of the organization. As per gathered data, the workforce belongs to the age in between 22 years to 42 years.

As per Figure 2, it is observed that the employees belonging to the age in between 25 years to 35 years, tends to change their job more frequently. They change their job position at least once. The percentage of changing their job often keeps reducing with the increasing age group. This means with increasing age; employee prefer more stability and like to stay in their comfort zones. Therefore, we could conclude as Age is inversely proportional to Attrition.

**Example: Satisfaction v/s Attrition trend**

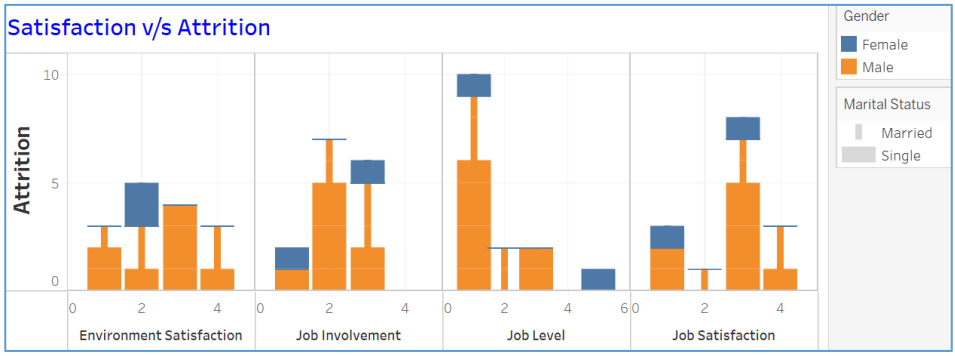


*Figure 3: Satisfaction v/s Attrition Chart*

**Observations:** As per Figure 3, observations are drawn below for each subcategory:

1. Environment Satisfaction v/s Attrition: Organization environment plays crucial role to embrace diversity. After visualizing above chart, it shows that when environment satisfaction value is lower then, female employee tends to change their job. But on the other hand, the Male employee have lesser impact on attrition due to Environmental satisfaction. The male attrition rate (either single or married) does not depend on Environmental satisfaction factor.
2. Job Involvement v/s Attrition: The job involvement factor has more impact on attrition for male employees compared to female employee. The single female employee tends to change their job if they are not feeling more inclusive in the work which they are performing in the organization. The employee (male or female) attrition rate (either single or married) is zero when they are more involved in their current job.
3. Job Level v/s Attrition: Job level is directly proportional to the attrition rate. Employee with lower job level have more turnover compared to higher job level employees.
4. Job satisfaction v/s Attrition: Job satisfaction factor has less impact on the male attrition rate. Either the job satisfaction level is high or low, it does not contribute to retaining the male employees within the organization, that is, attrition still happens. In contrast, for married female employees job satisfaction has no impact on attrition rate. They still prefer to stay in the organization irrespective of job satisfaction level.

## 4. Conclusion

This report set out to understand how the existing data from the respective data against various factors could be leveraged to improve department health in terms to alleviating attrition rate by utilizing the observation from the collected and processed data. These observations will help managers and leaders in identifying

challenges by finding patterns from the analysis and its visualization that help them to mitigate or take necessary action to overcome the challenges. Learned data exploratory and visualization concept could be utilized for other areas like individual competencies and skill set, motivational factors, satisfaction and dissatisfaction, performance level, roles and responsibilities, training needs and its effectiveness etc for improvement management.

## Acknowledgments

The making of this research has been a wonderful learning experience when we had an opportunity to learn several details about attrition and its impact, that we were previously blissfully unaware of. We are sure that just the writing of this paper will help us improve as a professional. We would like to first and foremost thank and appreciate the opportunity provided to us by the FUTURE-BME for granting us to submit full paper. We are really grateful to our mentor, Dr. Minja Bolesnikov for his valuable feedback and time throughout the course of this paper submission. Lastly, we would like to thank our mother Seema Singh and our son Advay Singh without whose love and continued support none of this would have been possible.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE POTENTIAL OF MEDICINE IN THE REPUBLIC OF CROATIA

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***Abstract***

*The health system is one of the most complex systems that includes sources, participants and institutions, and relates to the financing, regulation and supply of health actions. Quality health care is one of the key goals of the welfare state. Considering the resources, the Croatian health system should achieve significantly more favorable outcomes and have a positive perception. Problems in healthcare are a significant topic for experts and the general public, because failure to solve them means a potential collapse. The aim of this work is to confirm the importance of capacity and the development of potential in health care with an emphasis on medicine through statistical analysis. The scientific contribution is manifested in the highlighting of significant factors of medicine in Croatia that describe positive trends and build the health system and shape attitudes about the functioning of the same.*

***Key words:*** *Doctors in Croatia, education, migration, problems in the health system.*

## 1. Introduction

Doctors are the bearers of healthcare and there is a continuous growth in the number of doctors as well as qualitative growth in the context of scientific development in addition to professional development. So, in every respect, the profession is developing and strengthening, and all this is accompanied by an increase in the price of labor. On the other hand, negative attitudes are formed and there are problems regarding dissatisfaction and poor working conditions of doctors, which harm the public health system and patients. From which it follows that the current situation in healthcare is not satisfactory and the public's perception of the system is negative, and the employees themselves confirm the same. We learn from the media that there are no primary health care doctors in more than 50 municipalities on the mainland and on the islands. The healthcare system lacks 2,000 doctors and 4,000 nurses. Every third doctor in the system is over 50 years old. It is legally allowed to work 180 hours of overtime per year, while

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doctors work 200/300 per month, which is about 3 million overtime hours in one year (Žorić, 2022). Doctors see 80 to 100 patients a day and can devote a few minutes to them, while a doctor in general family medicine sees about 40 patients a day. In 2021, the average waiting time was 200 days, with individual tests waiting up to 600 days, in 2022 the average waiting time is 155 days (Krnić, 2023). While on the other hand, there is a small elite group of doctors who have high salaries and receive 20% of their salary from the university and 80% of their salary from the hospital for eight-hour working hours (Index.hr, 2023a). Despite large investments and strategic guidelines for the active development of healthcare and statistically excellent parameters, the sector is under fire from the public, and solving numerous problems should be approached analytically through reforms.

## 2. Methodology

The research methodology of this paper is of statistical features, where the resources in the current data sector are analyzed. Statistical data from the annual reports from the department on human resources in medicine are reviewed with the enrollment quotas of medical schools, salary growth and workplace coefficients as positive trends and negative ones in the form of the number of healthcare institutions and the number of hospitalizations with a tendency to fall with outbound labor migration, and all this is a consequence of the negative demographic trends that have characterized Croatia since its foundation.

*Table 1. Current positive and negative trends in healthcare*

| **Positive trends** | **Negative trends** |
|---|---|
| Growth in the number of doctors | The decline in the number of health care insured persons as a reflection of negative demographic trends and the natural movement of the population |
| The growth of the salary grade, ie the coefficient of the workplace - the growth of total expenditures for employees in health care | Reduction in the number of hospitalizations (cases of hospital treatment (acute) and days of hospital treatment (acute)) |
| The number of Ph.D. is also increasing with the selection of scientific positions | The number of medical institutions |
| Enrollment quotas of about 1,200 per year at medical faculties | Outbound labor migration of doctors |
| Foreign doctors + doctors from Bosnia and Herzegovina and Serbia | |

Source: Author's analysis

## 3. Education of doctors in Croatia

Of the total number of students enrolled in higher education programs in the field of biomedicine and healthcare, 12% of students are enrolled (State Statistical

Office, 2021). In the field of biomedicine and healthcare, there are 240 study programs in the academic year 2023/24: 15 in dental medicine, 16 in pharmacy, 19 in public health and health care, 148 in clinical medical science, 16 in basic medical science and 26 in veterinary medicine (Mozvag , study program browser). The number of students enrolled in the field of biomedicine and healthcare is continuously increasing by 18,959 in 2021/22. (table 2). In Croatia, the study of medicine is conducted at five faculties: the Faculty of Medicine of the University of Zagreb with 2,937, the Faculty of Medicine of the University of Split with 1,335, the Faculty of Medicine of the University of Osijek with 735, the Faculty of Medicine of the University of Rijeka with 1,381 enrolled students in 2023/24 and at the Croatian Catholic University, where the study of medicine began only in 2021/22. There were 862 students at the Faculty of Dentistry in Zagreb, 254 at the Faculty of Dental Medicine in Rijeka, and 1,103 students at the Faculty of Dental Medicine and Health in Osijek in 2023/24. (Students in the academic year, 2022/2023).

Strengthening the profession from a scientific point of view is also topical. There are more and more doctors of medical science in 2024, 952 doctors of science and 330 primarius are recorded as professional titles (table 2). When looking at the number of doctoral students in biomedicine and healthcare, those in the age group of 25-29 predominate, totaling 257 of them, and in the age group of 30-34, totaling 195 of them in 2022/23. year. In the field of biomedicine and healthcare in 2022/23. there were about 780 enrolled doctoral students, and 213 of them received their doctorates in the field of biomedicine and healthcare, 40 in basic medical sciences, 125 in clinical medical sciences, 7 in public health and health care, and 20 in dental medicine in 2023 (Students in the academic year, 2022/2023). In 2022, the most PhDs were at the Zagreb Faculty of Medicine, 59 in total, 32 at the Split Faculty of Medicine, 22 at the Osijek Faculty of Medicine, and 17 at the Rijeka Faculty of Medicine in 2022. In Croatia, female doctors of science dominate numerically, the same is true for the field of biomedicine and healthcare. There are more women PhDs, medical assistants and assistant professors, but analyzing the higher titles in the profession and science, men dominate (table 2).

*Table 2. Presentation of scientific and professional titles in medicine (March, 2024)*

| | **Men** | **Women** | **In total** |
|---|---|---|---|
| Academics | 15 | 2 | 7 |
| Associate academics | 8 | 3 | 11 |
| Prof. Ph.D.Sc. | 183 | 106 | 289 |
| Prof. prim. dr.sc. | 90 | 64 | 154 |
| Associate Professor, Ph.D. | 137 | 112 | 249 |
| Assoc. Prof. Prime Minister, Ph.D. | 89 | 78 | 167 |
| Assoc. Ph.D.Sc. | 186 | 164 | 350 |
| Associate Professor, Ph.D. | 92 | 97 | 189 |
| Prim. Ph.D.Sc. | 171 | 206 | 377 |
| Prim.M.Sc. | 84 | 84 | 168 |
| Prim. M.Sc. | 2 | 1 | 3 |
| Ph.D. | 422 | 530 | 952 |
| Dr.sc.biomed | 1 | | 1 |

| | Men | Women | In total |
|---|---|---|---|
| Dr.sc.soic. | | 2 | 2 |
| Primarius | 156 | 174 | 330 |

*Source: Press release from the Croatian Medical Chamber*

## 4. Doctors in Croatia

In the healthcare system of the Republic of Croatia at the end of 2021, a total of 75,186 healthcare workers and associates were employed, of which 5,644 were administrative workers and 11,334 technical workers. In the same year, Croatia had 3.5 doctors per 1,000 inhabitants compared to the EU average of 3.9 (OECD, 2021). In the structure of the total number of employed healthcare workers and associates, the largest share is those with a medium level of professional education, 44.3%, the share of those with a high level of professional education is 34.1%, higher education 20.7% and lower level professional education 1.0% ( Croatian health statistical yearbook for 2021, 2022). The number of health personnel is continuously growing and today there are around 16,300 doctors working in Croatia, of which around 7,400 are in the hospital system (table 4). In 2022, there were 300 more doctors in the hospital system than in 2021 (Index, 2023b). The number of inhabitants per 1 doctor has fallen drastically in two decades, in 2000 it was 393 and in 2023 it will be 240 (table 3). The average age of doctors is 45 years, there are 3,336 doctors over 60, 71 (0.4%) are foreign nationals, 667 are pensioners who work 4 hours a day. A total of 14,747 (89.9%) of them work in public institutions. while 1,657 (10.1%) of them are in private (Atlas of Medicine HLK, 2024). The general characteristics of the medical profession in Croatia are that 36.4%, i.e. 5,963, work in the tertiary level of health care, and 31.2%, i.e. 5,124, in secondary and 24.1%, i.e. 3,959, in primary health care. 4,119 are employed in clinical hospital centers, 3,394 in general hospitals, 2,290 in health centers and 1,519 in private practice (Atlas of medicine, 2024). The most residents are family medicine, 1,095, gynecology and obstetrics 770, anesthesiology, resuscitation and intensive care medicine 767, pediatrics 753, clinical radiology 620, clinical radiology 620, psychiatry 529, cardiology 424 (Atlas of Medicine HLK, 2024). Spatial distribution of doctors is greatest in regional centers. There are 5,584 doctors in the city of Zagreb, 1,336 in the Primorje-Gorski Kotar County, 1,789 in the Split-Dalmatia County, 1,094 in the Osijek County, and 100 in the Ličko-Senj County. The density of doctors is highest in the regions of larger cities as a gravitational zone where we have a smaller number of inhabitants per one doctor. In the city of Zagreb, the number of residents per doctor is 138, in Primorje-Gorski Kotar County it is 199, in Split-Dalmatia County 238, in Osijek 237, while in Lika-Senjska there are 429 residents per doctor.

Croatia is traditionally a country with a small number of doctors, which was reflected in the entire work. It is a profession that has always been highly paid with a high job coefficient. Cumulatively, healthcare employees are among the best-paid occupations, along with the finance and IT sectors (table 5). Despite the continuous increase in the number of employees in the system, the price of labor still does not fall as the law of supply and demand. At the beginning of 2024, the growth of coefficients in healthcare is recorded. Tables 6 and 7 show the positional coefficients of positions in medicine with the increases in 2023 shown.

*Table 3. Total number of doctors employed in state and private health institutions*
**Fixed and indefinite contracts.*

| Year | Doctors of medicine | Doctors of dental medicine | Number of inhabitants per 1 doctor |
|---|---|---|---|
| 2023. | 16 374 | 3 999 | 240 |
| 2020. | 15 417 | 3 840 | 262 |
| 2010. | 13 286 | 3 331 | 334 |
| 2000. | 11 162 | 3 012 | 393 |
| 1995. | 10 457 | 2 658 | 454 |

*Source: Author's analysis of data from the Croatian Health and Statistical Yearbook by year*

*Table 4. Number of doctors, interns, residents and specialists by year*

| Year | Doctors of medicine | Doctors of medicine working under supervision | Specialists in progress | Specialists | Doctors of dental medicine | Specialists of dental medicine | Specialists in progress of dental medicine |
|---|---|---|---|---|---|---|---|
| 2023. | 16 374 | 318 | 3 123 | 10 679 | 3 999 | 530 | 132 |
| 2022. | 15 862 | 325 | 3 257 | 10 291 | 3 972 | 526 | 125 |
| 2021. | 15 707 | 321 | 3 057 | 10 210 | 3 928 | 511 | 125 |
| 2020. | 15 417 | 313 | 3 045 | 9 894 | 3 840 | 496 | 114 |
| 2019. | 15 318 | 132 | 3 005 | 9 910 | 3 847 | 516 | 76 |
| 2018. | 15 047 | 512 | 2 874 | 9 649 | 3 765 | 476 | 76 |
| 2017. | 14 810 | 442 | 2 674 | 9 549 | 3 714 | 472 | 62 |
| 2016. | 14 427 | 437 | 2 472 | 9 443 | 3 615 | 464 | 58 |
| 1995. | 10 457 | 559 | 1 148 | 6 666 | 2 658 | 562 | 39 |

*Source: Author's analysis of data from the Croatian Health and Statistical Yearbook by year*

*Table 5. Average monthly net salary by sector and the number of employees in the 3 highest paid sectors*

| | K - Financial and insurance activities | J - Information and communications | Q - health care and social welfare activities |
|---|---|---|---|
| Average monthly net salary in 2021. | 868 - 1743 EUR | 1 062 - 2 535 EUR | 898 - 1630 EUR |
| Entrepreneurs number of employees in 2019 | 5 916 | 43 212 | 13 465 |
| Entrepreneurs number of employees in 2023 | 5 058 | 53 780 | 16 442 |
| Budget number of employees in 2019 | 536 | 268 | 75 567 |
| Budget number of employees in 2022 | 593 | 313 | 79 923 |

*Source: Author's analysis according to data from Info.Biz and Portal MojPosao, 2024.*

*Table 6. Increase in coefficients of healthcare jobs voted in April, 2023.*

| Jobs | Old workplace coefficient | New coefficient |
|---|---|---|

| | | |
|---|---|---|
| Position coefficients of the first type | | |
| Doctor of medicine with specialization, doctor of dental medicine without specialization | 1,659 | 1,880 |
| Master of Pharmacy, Master of Medical Biochemistry without specialization | 1,659 | 1,825 |

*Source: Author's analysis according to the data Srdoć (2023).*

*Table 7. Positional coefficient of healthcare jobs with salary calculation*

| **Position** | **Number of employees** | **Hybrid coefficient** | **Current gross salary (in euros)** | **New gross salary** |
|---|---|---|---|---|
| Directors of KBC, KB, HZJZ | 11 | 4,889 | 4629 | 5014 |
| Directors of other clinical constitutional and state institutes | 12 | 4,470 | 4233 | 4649 |
| Directors of hospital institutions | 80 | 4,051 | 3826 | 4314 |
| Directors of other health and healing institutions | 25 | 3,456 | 3272 | 3598 |
| Deputy director of hospital institutions | 113 | 3,379 | 3199 | 3503 |
| Assistant director of hospital institutions | 248 | 3,153 | 2985 | 3399 |
| Head of organizational unit | 131 | 3,969 | 3758 | 4072 |
| Head of organizational unit | 362 | 3,537 | 3359 | 3598 |
| Head of a stand-alone unit with over 40 employees | 115 | 3,407 | 3226 | 3532 |
| Head of a stand-alone unit with up to 40 employees | 31 | 3,397 | 3216 | 3513 |
| Doctor of medicine specialist primarius + doctor of dental medicine | 91 | 3,461 | 3227 | 3494 |
| Doctor of medicine specialist 1 + doctor of dental medicine | 3527 | 3,432 | 3250 | 3418 |
| Doctor of medicine specialist2 + doctor of dental medicine | 452 | 3,290 | 3115 | 3314 |
| Doctor of medicine specialist 3 + doctor of dental medicine | 1073 | 3,195 | 3025 | 3219 |
| Doctor of medicine | 596 | 2,89 | 2581 | 2736 |
| IN TOTAL | 6 867 | | | |
| Doctor of medicine on specialization | 2205 | 2,538 | 2403 | 2556 |
| IN TOTAL | 2 205 | | | |

*Source: Author's analysis according to data from the Regulation on job titles, schedule conditions and coefficients for salary calculation in public services, 2024.*

Professional associations in healthcare HLK - Croatian Medical Chamber, HLS - Croatian Medical Union systematically, HUBOL - Croatian Association of Hospital Doctors, KoHOM - Coordination of Croatian Family Medicine, Young Doctors Initiative systematically work to promote the rights of doctors and strengthen the profession. Citizens consider the Government and the Ministry of Health equally

responsible for long waiting lists (39%), while in third place (22%) are directors of health institutions, the survey showed, and 11% of citizens consider doctors responsible for long waiting lists. Almost 9 out of 10 respondents (87 %) support an increase in salaries for doctors, 3 out of 4 respondents (74 %) support the adoption of the Law on the Labor and Legal Status of Doctors, which would regulate the rights and obligations of doctors, separately from other public services, the survey showed survey conducted by the Ipsos agency on a sample of 603 respondents in April for the Croatian Medical Chamber (Press release HLK, 2023). More than 14,000 Croatian doctors were surveyed and 97% of them are dissatisfied with their labor-legal status, and 94% of them support one or more protest activities, 73% chose a public protest. On September 24, 2022, one of the largest protests of Croatian doctors was held, according to the official, with 900 doctors (Luetić, 2022). Medical associations ask the relevant ministry and the Government to fulfill the following requirements (HLS, 2023):

- Equalization of the coefficients of the complexity of the jobs of specialists with narrow specialists, doctors in primary health care with hospital doctors, as well as increasing the coefficients for specialists by at least 10%.

With the proposal of the Regulation on coefficients, in April 2023, the Government voted to equalize the coefficient of the complexity of the work of specialists in hospital and outpatient health care and the primary level of health care. Coefficients of Position I, which include doctor of medicine resident, doctor of dental medicine without specialization, the old coefficient was 1.659, while the new one is 1.880. (Srdoć, 2023).

- Adoption of the Law on the labor-legal status of doctors by the end of the spring session of the Parliament
- harmonizing the work of doctors at all levels of health care with time and personnel norms.
- Abolition of existing "employee" contracts for resident doctors.

Young doctors are in a particularly difficult position. 1,148 of them have a contract which, in the event of earlier termination of employment, includes an obligation to return gross wages to the employer for a period equal to the duration of specialization (usually five years), and 181 doctors have an obligation to return gross wages for double the period of specialization (most often ten years). According to the current Health Care Act, if a doctor applies for a competition for specialization and signs a contract on specialist training with a health institution and terminates the contract early, the highest amount he must pay is around HRK 250,000, depending on when the contract is terminated.

In a survey in which 1,531 young doctors participated, "Satisfaction of young doctors in the Republic of Croatia: Are we going in the right direction?" carried out by the Committee for Young Doctors of the Croatian Medical Chamber, 58% of them would leave Croatia if they were offered an opportunity somewhere abroad, and the main reasons were better working conditions, better organization of the health system and better pay (Babacanli et all, 2016). The results of the survey from 2022 for the purpose of researching the doctoral dissertation in which 1,543 doctors

participated, 82.1% of the respondents answered that they believe that radical changes are needed in Croatian health care (Stanić, 2023). All relevant research describes a negative perception of the sector itself and great dissatisfaction within the profession.

## 5. Resources of health institutions in Croatia

In 2023, a total of 1,815 health care institutions were registered, of which the number of hospitals has been the same for more than a decade, 5 clinical hospital centers, 3 clinical hospitals, 6 clinics, 22 general hospitals, 35 special hospitals, 309 polyclinics and 7 sanatoriums (Croatian Health statistical calendar, 2024). In 2019, it had 566 available hospital beds per 100,000 inhabitants, which is slightly above the EU average of 532 beds per 100,000 inhabitants (OECD, 2021). Since its independence, Croatia has already recorded negative natural growth and, since 2010, a negative migration balance (table 8). The number of insured persons using health care is continuously decreasing, and in the period of the last 8 years, a decrease of 190,258 beneficiaries is recorded, while expenditures for health care employees in the same period increase by 17,800,000 euros. The number of cases of hospital treatment in the same observed period decreased by 84,596, and the total number of hospital days also decreased by 900,908 (tables 9 and 10). The number of doctors, i.e. personnel resources, tends to increase while user resources decrease, which can be reflected in the price of work, because a resource that has many prices falls, while the price of the one that is missing can be manipulated.

*Table 8. Natural movement of the population and external migration of the Republic of Croatia 2010-2020. years*

| Year | Live births | Deaths | Natural increase | Immigrants | Migration | Balance |
|---|---|---|---|---|---|---|
| 2010. | 43 361 | 096 | 8 735 | 4 985 | 9 860 | 4 875 |
| 2020. | 35 845 | 023 | 21 178 | 33 414 | 34 046 | - 632 |

*Source: Author's analysis according to data from Women and Men in Croatia, 2022. and data from the Central Bureau Statistics, 2022.*

*Table 9. Analysis of statistical data of the health sector*

| | 2016. | 2017. | 2018. | 2019. | 2020. | 2021. | 2022. | 2023. | |
|---|---|---|---|---|---|---|---|---|---|
| Expenses for employees | 30.944.066 ,34 eura | 31.425.514, 13 eura | 31.018.51 7,13 eura | 32.687.56 3,85 eura | 36.11.1664, 24 eura | 38.309.3 18 eura | 41.081. 296,44 eura | 48.701.5 52,12 eura | ↑ |
| Cases of hospital treatment (acute) | 581.744 | 579.784 | 569.099 | 567.560 | 453.061 | 487.199 | 482.778 | 497.148 | ↓ |
| Days of hospital treatment (acute) | 3.982.298 | 4.019.294 | 3.871.332 | 3.798.010 | 3.034.097 | 3.266.60 3 | 3.115.1 23 | 3.081.39 0 | ↓ |
| Number of insured persons | 4.298.008 | 4.244.232 | 4.203.382 | 4.188.658 | 4.161.628 | 4.161.62 8 | 4.148.8 49 | 4.107.75 0 | ↓ |

*Source: Author's analysis according to data from the Report on the operations of the HZZO by year*

*Table 10. Number of hospitals by year 1995./2023.*

| | 1995. | 2000. | 2017. | 2018. | 2019. | 2020. | 2021. | 2022. | 2023. |
|---|---|---|---|---|---|---|---|---|---|
| Clinical hospital centers | 2 | 2 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Clinical hospitals | 12 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Clinics | | 7 | 5 | 5 | 5 | 3 | 5 | 6 | 6 |
| General hospitals | 23 | 23 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Special hospitals | 29 | 30 | 32 | 33 | 34 | 34 | 35 | 35 | 35 |
| Polyclinics | 21 | 154 | 353 | 355 | 358 | 330 | 321 | 316 | 309 |

*Source: Author's analysis from data from the Croatian Health - Statistical Yearbook*

In 2024, 2,014 entrepreneurs and 4,421 craftsmen were registered in the health care sector. In the same period, there were 799 businesses in the City of Zagreb, 222 in Split-Dalmatia County, 177 in Primorje-Gorski Kotar and 98 in Osijek (Info.Biz, 2024). Table 11 shows companies in the health care sector according to the year of establishment, and a significant growth of newly founded companies due to the Corona crisis is evident, and the positive trend continues, which is a reflection of the favorable business climate and good opportunities in the sector.

*Table 11. Presentation of the years of establishment of companies in the field of health care*

| Year | Number of newly established companies | Year | Number of newly established companies | Year | Number of newly established companies | Year | Number of newly established companies |
|---|---|---|---|---|---|---|---|
| 1974. | Polyclinic for hemodialysis Rovinj | 1998. | 41 | 2007. | 52 | 2016. | 74 |
| 1983. | Zagreb University Hospital | 1999. | 24 | 2008. | 61 | 2017. | 66 |
| 1990. | 1 | 2000. | 24 | 2009. | 66 | 2018. | 80 |
| 1991. | 1 | 2001. | 41 | 2010. | 45 | 2019. | 99 |
| 1992. | 1 | 2002. | 41 | 2011. | 56 | 2020. | 100 |
| 1994. | 8 | 2003. | 48 | 2012. | 61 | 2021. | 110 |
| 1995. | 14 | 2004. | 35 | 2013. | 56 | 2022. | 117 |
| 1996. | 44 | 2005. | 33 | 2014. | 64 | 2023. | 136 |
| 1997. | 48 | 2006. | 40 | 2015. | 55 | October, 2024 | 95 |

*Source: Author's analysis from data from Info.Biz*

## 6. Migration of doctors

From 2013 to 2023, 1,309 doctors left Croatia, and another 912 doctors expressed their intention to leave Croatia. Nevertheless, at the same time, from 2016 to 2023, 2,492 doctors and 2,187 nurses were employed (Krnić, 2023). The average age of doctors who decide to migrate is 35 with about 8 years of work experience,

of which 57% are female doctors, the most preferred destination is Germany with a total of 378, Great Britain 167, Austria 126, Sweden 112. Most of them without specialization, 789 in total, therefore dominate those without a dominant employment institution (table 12 and 13) (Atlas of Medicine HLK, 2024). There is a possibility of hiring health personnel from countries outside the EU, but it is necessary to certify diplomas, which is a long-term process (Index, 2023). The number of graduates who went to work abroad by 2024 is a total of 203, of which 92 are from the Faculty of Medicine in Zagreb, 97 from the Faculty of Medicine in Split, and 14 from the Faculty of Medicine in Rijeka (Atlas of Medicine HLK, 2024).

*Table 12. Number of migrations of doctors to work abroad by year*

| Year | Number of departures of doctors abroad | Number of returning doctors abroad | Number of incoming doctors (+ doctors from Bosnia and Herzegovina, Serbia) |
|---|---|---|---|
| 2013. | 50 | 3 | 30 |
| 2014. | 122 | 2 | 19 |
| 2015. | 139 | 2 | 19 |
| 2016. | 96 | 3 | 22 |
| 2017. | 126 | 1 | 15 |
| 2018. | 130 | 1 | 11 |
| 2019. | 145 | 0 | 19 |
| 2020. | 102 | 0 | 11 |
| 2021. | 84 | 3 | 22 |
| 2022. | 125 | 3 | 14 |
| 2023. | 159 | 2 | 12 |
| 2024. | 31 | | |

*Source: Atlas of Medicine HLK, 2024 and data from the Ministry of Interior issued on request*

*Table 13. Number of doctors migrating to work abroad by type of health care institution*

| Institution | Number of migrations | Institution | Number of migrations |
|---|---|---|---|
| The others | 491 | Private practice - doctor's office | 31 |
| Clinical Hospital Centre | 161 | Special hospital | 33 |
| General Hospital | 144 | Clinic | 27 |
| County institutes for emergency medicine | 147 | County Institutes of Public Health | 14 |
| Health center | 131 | State institutes institutes | 9 |
| Clinical Hospital | 66 | Private practice - concessionaires | 7 |
| Polyclinic | 34 | Trading companies for performing health care activities | 9 |
| Spas | 1 | Health care institutions | 2 |

*Source: Atlas of Medicine HLK, 2024.*

## 7. Conclusion

A number of positive trends and strengthening of human resources in qualitative and quantitative terms are noted in Croatian health care. The number of available beds in hospitals in Croatia is above the EU average, and the number of residents per 1 doctor is decreasing. Research conducted on a sample of doctors indicates a negative perception of the profession, despite the fact that the capacities of human resources and advancement in the profession are increasing, therefore there are twice as many doctors of science and scientific staff in the field of biomedicine than professional titles of primarius, which is characteristic of healthcare, as well as the number of residents and specialist in health care institutions is growing. Medical professional associations aim to promote positive policies with the aim of solving numerous problems in healthcare, the biggest of which are related to human resources, which further burden migration. The Ministry of Health is making great efforts and is openly advocating for building a positive image of the department, and there is a continuous increase in salaries in the sector, there are numerous proposals for better working conditions. Entrepreneurship in health care shows a positive trend, and from the former 50 to 60 newly founded companies, in the last 5 years, about 120 have been recorded annually, which is a reflection of good opportunities in the sector. Statistically, all econometric data presented in this paper have a favorable sign: the capacities of the medical staff are growing and are among the highest-paid activities and are developing scientifically, while the user capacities of service seekers tend to fall, the volume of work is decreasing in terms of the number of hospital treatment cases (acute) and the number of days of hospital treatment (acute) as a direct consequence of the continuous decline number of inhabitants in Croatia. However, there is still great dissatisfaction within the medical profession and a negative perception of the public as users of health services.

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# SUPPLY CHAIN MANAGEMENT AND RESILIENCE

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-053 Review paper

# E-COMMERCE IN SLOVAKIA

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***Abstract***

*We can observe quite a big development in the present global view on the purchase of goods and services. We are living in a very fast time and e-commerce offers us very effectively solutions how to shop and at the same time to save our time. Nowadays, e-commerce is used very much all around the world as well as in Slovakia and we can see the significant growth of the share of enterprises with electronic sale on the market and the turnover from this type of sale. In Slovakia, e-commerce has become for many people the priority and it has opened the opportunity for this type of business to entrepreneurs. Internet shopping is gaining the popularity in Slovakia and people feel more and more comfortable when shopping online. It is expected that the number of users on e-commerce market in Slovakia is going to grow constantly from 2023 to 2027, every year by 10,27 percent.*

***Key words:*** *e-commerce, market share, Slovakia, development.*

## 1. Introduction

We can state that e-commerce has become in the modern world the part of our everyday life. In the last 10 years, e-commerce became the irreplaceable part of global retail framework. Just like many other sectors, the retail sector transferred itself significantly after the arrival of the Internet and thanks to the ongoing digitalization of modern life consumers from practically every country make profit from the advantages of online transactions, now. As the access to the Internet and its admission is increasing worldwide, the number of digital buyers increases every year. A well-organized e-commerce chain management mainly depends on sales strategies, available customer service and benefits such as fast purchases and cheap shipping (Dihovični & Škrbić, 2020).

E-commerce represents purchase, sale, payments for goods or services in the Internet environment. It is necessary to recognize two important types of virtual shopping malls and shops when trading:

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a) enterprise – a seller is considered a direct producer of goods, while the Internet represents the medium which tries to address the customer and offer him/her its services and products.

b) mediatory – this way, we can talk about a seller not as a producer but only as a distributor, mediator of the business while this person often need not be in the contact with the product at all (Dorčák & Pollák, 2010).

Nowadays, e-commerce prevails in the whole world as well as in Slovakia, mainly by means of online business. In the last years, Slovakia registered significant increase of the share of companies with the electronic sale and with the turnover from this type of sale.

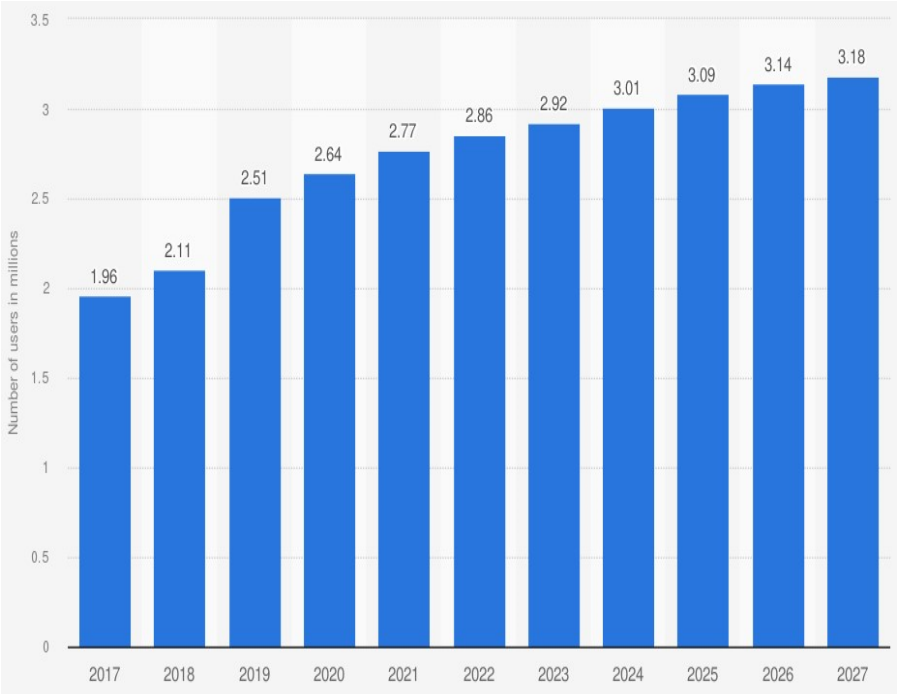


*Figure 1: Number of users of e-commerce in Slovakia 2017-2027 (in millions)*

The e-commerce market in Slovakia was predicted to grow continuously by a total of 0.3 million users (+10.27 percent) between 2023 and 2027. After a tenth consecutive year of growth, the indicator is estimated to reach 3.18 million users, a new peak in 2027. The number of users in the e-commerce market has been steadily increasing in recent years (Statista 2024).

## 2. Revenue of the e-commerce industry in Slovakia

E-commerce represents the sale and purchase of goods or services by means of the Internet. E-commerce markets can create rich user profiles that enable to adapt offered products and to design other products. The costs for creation,

processing, distribution, storage, and reception of information where paper form was used have decreased thanks to the e-commerce (Delina & Vajda, 2008).

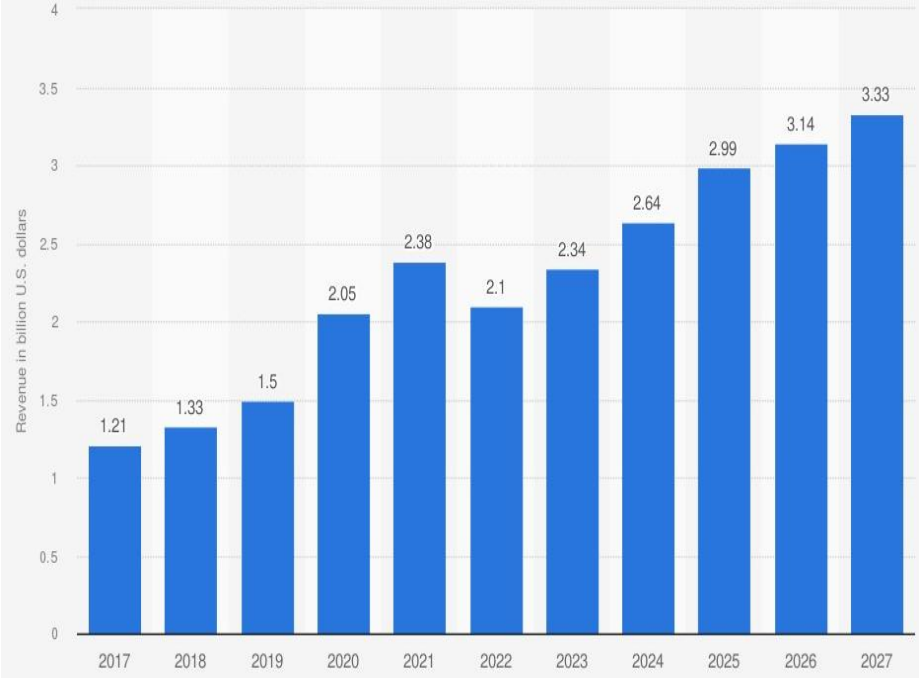


*Figure 2: Revenue of the e-commerce industry in Slovakia 2017-2027 (in billion U.S. dollars)*

The revenue in the E-commerce market in Slovakia was forecast to continuously increase between 2023 and 2027 by in total one billion U.S. dollars (+42.74 percent). After the fifth consecutive increasing year, the indicator is estimated to reach 3.33 billion U.S. dollars and therefore a new peak in 2027 (Statista 2024).

## 3. Leading online stores in Slovakia

E-commerce has increased its market share on the expense of brick-and-mortar stores. E-commerce sector has the potential of strong growth regarding modernization, development of information-communication technologies. (Mulačová et al., 2013). In Slovakia, e-commerce has become for many people the priority and it has entered doors for entrepreneurs. It has provided them with possibilities how to keep improving and enforcing the prevailing position of their products or services on market. On the graph, we can see the chart of 10 most popular online stores in Slovakia.

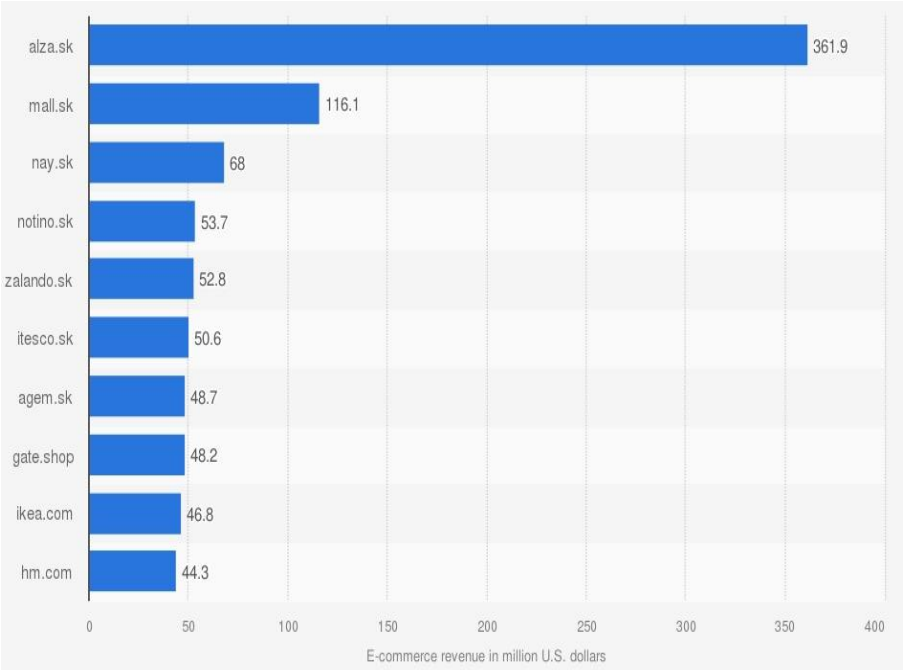


*Figure 3: Leading online stores in Slovakia in 2022, by e-commerce net sales revenue*

Resulting from the graph, the brand alza.sk is the biggest player in the Slovak e-commerce market. Alza.sk on the Slovak e-commerce market in 2022 had net sales of USD 362 million. Following is the store Mall.sk with revenues of 116 million € and nay.sk with revenues of 68 million €.

## 4. Internet purchases by individuals in Slovakia

E-commerce provides customers and companies: purchase, sale, payments for goods or services in the environment of the Internet. The positive experience of customers in Slovakia is that they usually shop in online shops electronics, food, clothes, furniture, drinks, etc. These purchases are very popular mainly among the young generation who are directly connected to internet explosion (Aziz & Wahid, 2018). On the following graph we can see online purchases of individuals in Slovakia. The tracked period is the range of years 2010 till 2023.

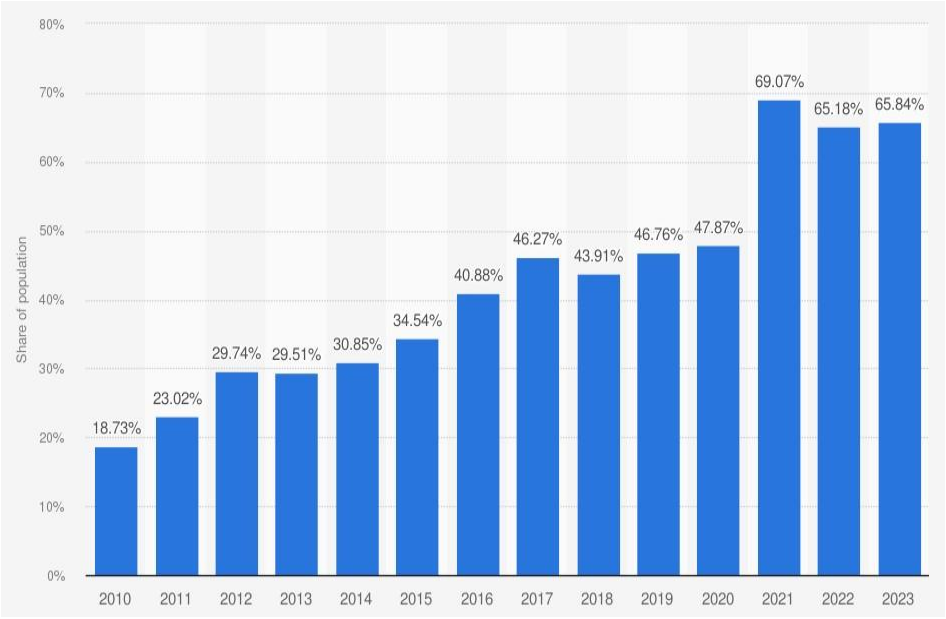


*Figure 4: Internet purchases by individuals in Slovakia from 2010 to 2023 (Statista 2024).*

In 2023, nearly 66 percent of the population in Slovakia purchased something on the internet in contrast, the figure for 2010 was just around 18,7 percent.

## 5. The way of shopping by means of the Internet in Slovakia

Online shopping in Slovakia has been gaining the popularity and people feel more and more comfortable when shopping online. Majority of people who have the Internet access at home shop online. When shopping online, customers use phones, computers, or notebook. The use of mobile devices has been progressing very fast, mainly in the regions where there is not any other digital structure. Shopping, mainly by means of mobile devices will keep raising in the future.

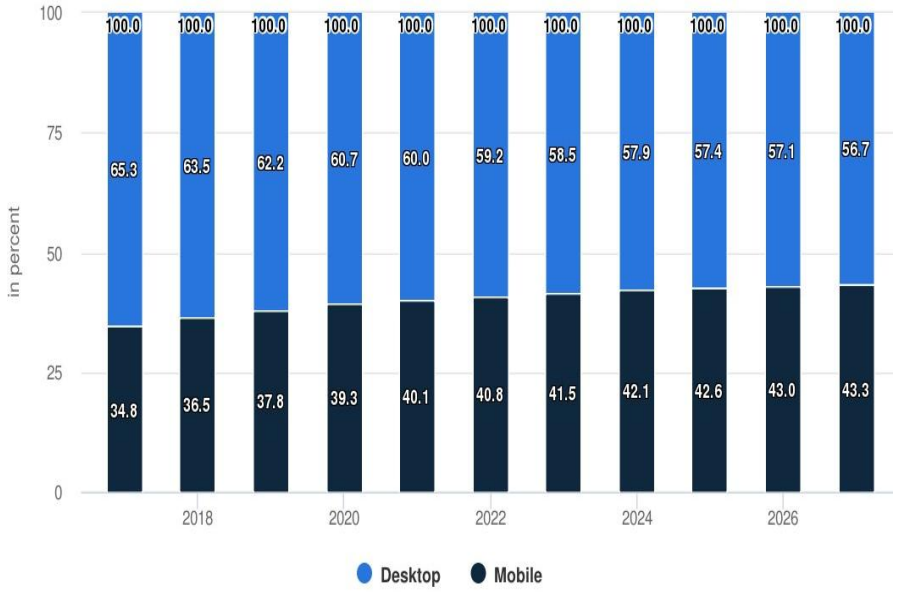


*Figure 5: eCommerce - Slovakia (Statista 2024).*

On the graph, we can see that people in Slovakia use mobile device more and more when shopping online. The current trend in e-commerce and online business is shopping by means of mobile shopping applications.

## 6. Conclusions

We can understand e-commerce as the entrepreneurship realized by means of information-communication technologies and this is the entrepreneurial performance in electronic form. The future of e-commerce as a field of entrepreneurship is going to grow henceforth. In Slovakia, every year, the amount of people who will prefer online shopping against shopping in brick-and-mortar stores is going to increase. Nowadays, shopping is much easier, faster, and comfortable by means of e-commerce, what brings the comfort to customers and entrepreneurs.

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# PRINCIPLES AND MODELS OF STOCK MANAGEMENT BEFORE AND AFTER THE PANDEMIC

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***Abstract***

*The main purpose of this work is to examine the current models of inventory management in manufacturing and trading companies and make a comparison with the pre-pandemic period in the context of the supply chain, through relevant and available information. Also, a comparison of stock levels of representative companies, before and after the pandemic, will be presented, in order to draw certain conclusions and possible guidelines. The emergence of the pandemic has led to major changes in the entire supply chain, especially in the domain of inventory management due to unstable and uncertain delivery times. Before the pandemic, in the largest number of companies, the most prevalent principle of inventory management was the JIT (Just in time) approach, however, after the pandemic, the JIC (Just in case) principle was increasingly used, which leads to a higher level of inventory, in order to protect companies from possible disruptions in the supply chain, such as longer delivery times, lack of energy sources, etc. Also, after the pandemic, there is a noticeable trend of Reshoring, i.e. returning production to companies' home countries and diversifying supply chains, in order to reduce supply dependence on one region or continent, due to growing geopolitical challenges. The pandemic has fundamentally reshaped inventory management, forcing companies to rethink their existing strategies, and to adopt more robust, flexible and technology-driven approaches, which enable a comparative advantage in the market, which we want to identify in this paper.*

***Key words:*** *Supply chain, Stock management, Pandemic, Flexibility.*

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# 1. Introduction

Inventory or stock management, is a crucial component of supply chain operations, plays a pivotal role in ensuring that businesses can meet customers demand efficiently while minimizing costs (Emmett, 2011; Brodetskiy, 2015). Before the COVID-19 pandemic (2019-2020 year), stock / inventory management primarily were based around established principles designed to optimize and organize inventory levels, reduce holding costs in order to increase cash flow, and streamline operations to have satisfied customers. Many traditional models of inventory management, such as Economic Order Quantity (EOQ) (Brodetskiy, 2015; Rao & Mangal, 2018). Just-in-Time (JIT) (Rao & Mangal, 2018; Singh & Singh, 2013; Fazel, 2013) and ABC analysis (Pandya & Thakkar, 2019), were widely adopted and used to balance efficiency with cost control. These methods relied heavily on stable supply chains and predictable demand patterns and their use gave a excellent results in real life.

However, we were witnesses that the COVID-19 pandemic revealed significant vulnerabilities in these traditional stock management approaches. The unprecedented disruptions in global supply chains exposed the limitations of models that prioritized efficiency over resilience (Tarek, 2022). We have had examples of quarantine of entire cities, closing of borders between countries, closing of seaports that in certain situations prevented any physical movement of goods. As a result, businesses faced great challenges such as sudden shortages, increased lead times, and general supply chain interruptions that had not been accounted for in pre-pandemic and pandemic strategies (Ke et al., 2022).

In response, there has been a substantial shift towards more adaptable and resilient stock management practices. To survive in such situations, companies have adopted new approaches such as Just-in-Case (JIC) inventory models, advanced data-driven forecasting, and enhanced automation to better navigate uncertainty and mitigate risks (Siddiqui et al., 2023).

Before the COVID-19 pandemic, stock management primarily focused on efficiency and minimizing costs through various traditional principles. The global pandemic, exposed vulnerability and susceptibility to unplanned influences in global supply chains and led to significant changes in stock management practices due to fact, that companies had to find ways to meet customer demand.

For example, the Ukraine conflict has disrupted the supply of key commodities and materials, including steel, grain, and energy for European companies, leading to increased inventory levels in many industries reliant on these inputs. Similarly, the Middle East tensions have raised concerns about oil supplies, transportation routes, and commodity market volatility. Companies facing such disruptions are diversifying suppliers and stockpiling essential materials to safeguard against further instability (Michael, 2023; World Bank, 2023).

Several organizations have taken concrete steps to adapt. Automakers like Volkswagen have increased inventory buffers for critical components, such as semiconductors, to avoid shortages (World Bank, 2023). Many companies in those turbolent period, especially in COVID, and after COVID period have shifted to a JIC

model to mitigate risks of supply chain interruptions [12] (Disney et al., 2003; Hongyong & Ha, 2023). These shifts illustrate how global supply chain disruptions (Lafrogne-Joussier et al., 2023), whether from pandemics or geopolitical conflicts, are reshaping inventory management on a fundamental level. For example, a lot of U.S. companies shifted in 2022 from a "just in time" supply chain model to a "just in case" model — essentially carrying more inventory and often use of more suppliers closer to the United States as opposed to reliance on Chinese manufacturing. This shift is expected to increase costs while U.S. consumers are also dealing with historic inflation (Frank, 2022).

This paper explores the evolving and adaptive approaches and practices in inventory / stock management, emphasizing how businesses have transitioned from pre-pandemic models to new strategies focused on building resilience and enhancing adaptability in an increasingly volatile global environment. Additionally, the paper compares pre- and post-pandemic inventory management strategies in table form, offering concise insights into their implications for operational efficiency and supply chain resilience to global change.

## 2. Theoretical Review

### 2.1 Stock Management Principles Before the Pandemic

Before the pandemic, stock management focused on efficiency and cost minimization, relying heavily on global supply chains and JIT models, which have been practically used for decades, as proven methods, which were not exposed to global disturbances. The methods and principles that prevailed until this period were:

#### 2.1.1. Just-in-Time (JIT) Inventory

- **Principle**: Minimize inventory holding costs by receiving goods only as needed in the production process. Focused on efficiency, minimizing overstock, reducing warehouse needs, and limiting costs tied up in excess stock (Rao & Mangal, 2018; Singh & Singh, 2013; Fazel, 1997). Highly dependent on a smooth supply chain (Hofmann, 2013), JIT is attributed to the Japanese automaker Toyota Motor Corporation. Executives at Toyota in the 1970s reasoned that the company could adapt more quickly and efficiently to changes in trends or demands for model changes if it did not keep any more inventory in-store than was immediately needed (Ohno, 2019).

#### 2.1.2. Economic Order Quantity (EOQ)

- **Principle**: Determine the optimal order quantity that minimizes total inventory costs, including holding and ordering costs. Calculates when and how much to reorder, balancing carrying costs and stock-out costs (Brodetskiy, 2015; Rao & Mangal, 2018; Render et al., 2017).

### 2.1.3. ABC Analysis

- **Principle**: Classify inventory into three categories (A, B, C) based on value and usage frequency. 'A' items are high-value, low-quantity; 'B' items are moderate in value and quantity; 'C' items are low-value, high-quantity. Helps focus on more valuable stock (Pandya & Thakkar, 2016; Render et al., 2017; Kehinde et al., 2017). Very often, as part of the ABC analysis, the XYZ analysis is also used, which examines the seasonality of sales, and which provides a basis for decisions regarding the level of inventory (Zenkova & Kabanova, 2018).

### 2.1.4. Safety Stock

- **Principle**: Keep additionally inventory on hand to prevent stockouts due to demand variability and market disturbances. Levels are determined based on demand forecasts, lead time, and service levels (de Kok & Graves, 2003; Simchi-Levi et al., 2001).

### 2.1.5. Vendor-Managed Inventory (VMI)

- **Principle**: Suppliers manage and replenish stock based on agreed-upon levels. Companies share real-time sales and inventory data with suppliers to reduce stockouts and excess inventory (Sabila et al., 2018; Disney & Towill, 2003). The most famous example of VMI approach is collaboration between a manufacturer (Procter and Gamble) and a retailer (Wal-Mart). Both major players in their industries, P&G and Wal-Mart found a way to leverage on information technology by sharing data across their mutual supply chains (Grean & Shaw, 2002).

## 2.2 Stock Management Challenges and Evolving Models After the Pandemic Principles Before the Pandemic

### 2.2.1. Shift from Just-in-Time (JIT) to Just-in-Case (JIC)

- **Principle**: Maintain higher inventory levels as a buffer/ shock absorber, against supply chain disruptions. Focuses on stocking more goods to protect against uncertainties like factory shutdowns, transportation delays, or supplier failures (McKinsey, 2021; Willy, 2022; Valerie, 2022). By having more inventory than initially forecasted, a company can be confident it will always have stock ready to fulfill customer orders (Hongyong & Ha, 2023; Brakman et al., 2020). JIC inventory management is used in all types of companies and industries. For example, manufacturers maintain extra raw materials, while distributors and retailers hold additional stock of finished goods. This area of inventory management is still not sufficiently covered in scientific works, but it certainly deserves more attention, because companies use it to a significant extent

### 2.2.2. Demand Forecasting and Data-Driven Models

- **Principle**: Use real-time data analytics, artificial intelligence, and machine learning for accurate demand forecasting. Predictive analytics help adjust inventory levels based on consumer behavior, economic conditions, and external shocks (Vineet, 2023; Ivanov & Dolgui, 2021). By leveraging a wide range of data sources and sophisticated algorithms, data-driven forecasting models can provide more accurate predictions (Kane, 2024).

### 2.2.3. Omnichannel Inventory Management

- **Principle**: Align inventory management across multiple sales channels (e-commerce, in-store). Integrated systems manage inventories in real time across different channels to meet e-commerce demands and balance in-store inventory (Fernie & Sparks, 2018; Bigcommerce, 2024). In multichannel, it is harder to manage inventory, because each channel is treated as a separate entity. This siloed approach puts the focus on individual touchpoints rather than the overall customer journey and can lead to inconsistencies in the supply chain (Silbermayr & Waitz, 2024). Omnichannel is about providing a joined-up customer experience, no matter which channel the customer visits or which device they prefer to use for browsing and buying. A good example can be some retail chain, which displays the stock of its products online in all its stores, and for example if some customer place order for a product online, everyone in the chain will see that the stock has decreased in a specific store.

### 2.2.4. Supplier Diversification, Reshoring and Localization

- **Principle**: Reduce reliance on single suppliers or overseas supply chains by diversifying and localizing sources (Alicke et al., 2021). Sourcing from multiple suppliers in different regions to reduce risk of supply chain breakdowns (Stefano et al., 2021; IMD, 2022). Reshoring is the process of bringing manufacturing and part or all of the supply chain back to the home country from a foreign country (Linn and Lanng, 2020). Nearshoring is a similar process but refers to a location near the home country. Reshoring is a long game. The decision-making process does not happen overnight, nor does the movement of a supply chain (Cristopher & Christoph, 2022). The length of time to reshore also depends on how much of a supply chain is moving — whether it's the final assembly point or several tiers of suppliers.

## 2.2.5. Automation and Technology Integration

- **Principle**: Increase automation in warehouse and stock management for efficiency and accuracy (Baryannis et al., 2019), Here it is very important to make distinguish between digital automation and physical automation. Digital automation involves advanced warehouse warehouse management systems (WMS) that go beyond tracking inventory and orders. Modern WMS are getting

better at integrating warehouse control system (WCS) features, which help coordinate the real-time activities of automated equipment for smoother operations. These advanced systems combine traditional WMS and WCS capabilities for a more integrated and efficient way to manage your warehouse (SAP, 2024).

Physical automation deals with the hands-on tasks of moving and handling goods, using technologies like automated guided vehicles (AGVs), conveyor belts, and robotics. These solutions help automate tasks such as moving products, sorting, and packaging, reducing the need for manual labor while speeding operations. Adoption of robots, automated guided vehicles (AGVs) (Bluepath, 2024), and advanced warehouse management systems (WMS) (SAP, 2024), to streamline inventory handling.

### 2.2.6. Resilience and Flexibility Focus

- **Principle**: Supply chain resilience pertains to a supply chain's capacity to recover from disruptions, (Sheffi, 2015) such as natural disasters (Harapko, 2021), economic downturns, or supplier failures, while maintaining its essential functions and delivering products or services to customers. Build resilient supply chains that withstand disruptions and adapt quickly (Economist, 2024). Creating flexible contracts, adding redundancy, and using technology to react faster to disruptions (Gartner, 2024).

## 3. Discussion

Based on reviewed articles from professional literature in the field of Supply Chain, relevant institutions, as well as published scientific works, a comparison of inventory management models before and after Covid-19 could be shown in the following Table 1

*Table 1: Comparison - Inventory Management Models Before and After the Pandemic*

| Principles/Models | Before the Pandemic | After the Pandemic |
|---|---|---|
| **Just-in-Time (JIT) vs. Just-in-Case (JIC)** | Focus on minimizing inventory (JIT) | Shift towards holding more stock (JIC) |
| **Forecasting** | Based on historical data and seasonal trends | Data-driven, real-time analytics & AI |
| **Supplier Strategy** | Lean, cost-focused global suppliers | Supplier diversification, reshoring and localization |
| **Safety Stock** | Minimal to reduce holding costs | Increased safety stock to manage uncertainty |
| **Automation** | Slow adoption | Accelerated adoption of automation & AI |
| **Omnichannel** | Limited to traditional supply chains | Integrated online-offline inventory systems |

In this paper, we would like to give a few real examples when it comes to increasing inventory levels, but also returning production from foreign countries

(process of localization) due to an uncertain global market and unexpected disruptions in the Supply Chain.

According to publicly available data, the US company NVIDIA has significantly increased inventory, due to unpredictably increased demand, persistent global semiconductor shortages, but also, increased demand for GPUs in gaming industry, AI, and data centres. All those factors have prompted NVIDIA (Figure 1) to build up inventory to ensure product availability and respond to market fluctuations, so Just in Case inventory management model was obviously applied and used (Ann, 2024).

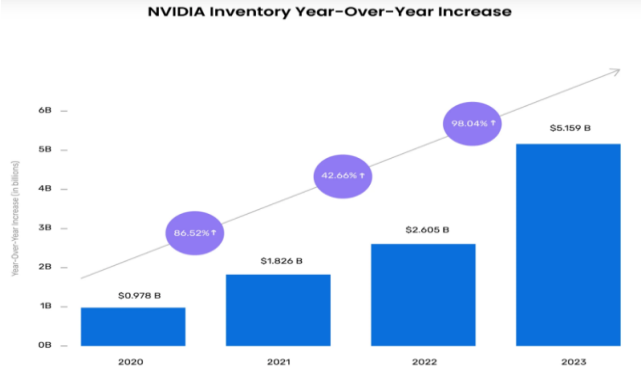


*Figure 1: NVIDIA inventory development*

The situation with a high level of inventory in the NVIDIA company can certainly be a good basis for further research and determination of the valid reasons that led to such an inventory level.

Regarding Reshoring (localisation), good example of this process is famous company Intel, which announced a $20 billion investment to build two new semiconductor factories in Arizona, USA. This decision came in response to global supply chain disruptions, including the COVID-19 pandemic and geopolitical tensions like the U.S.- China trade war, which also has a political character (Sabrina, 2021). Similarly, company General Motors has been reshoring its battery production to Michigan in USA, developing a domestic hub for lithium-based products to strengthen its electric vehicle production capacity and make more autonomous supply chain. These reshoring efforts aim to reduce dependency on overseas suppliers and increase supply chain resilience, particularly in sense of the pandemic's challenges (Sabrina, 2021).

Additionally, U.S. Steel is investing in a new plant within the USA rather than abroad, a decision driven by rising steel prices and disruptions in global supply chains. These reshoring trends reflect a broader shift in supply chain strategies post-COVID, with companies looking to mitigate risks by producing critical components domestically or country closer to home country (Sabrina, 2021; Peter, 2022).

In the context of reshoring in Europe, a political recommendation was made as early as 2021, in order to strengthen the European economy and reduce dependence on overseas countries (Raza et al., 2021)

The situation in United Kingdom is very similar, but with transparent figures and statistics, for example, 58% of manufacturers have started to reshore their supply chains - a process in which companies move production from overseas to the countries where goods are sold (Manufacturing & Logistics, 2024).

## 4. Conclusions

Before the pandemic, stock management primarily aimed at efficiency through JIT principles. The pandemic highlighted the sensitivity and fragility of this model, leading to a shift towards close to the JIC approach, which emphasizes resilience by maintaining higher inventory levels. Companies have increasingly adopted data-driven forecasting, omnichannel management, and technology integration to navigate new challenges. Looking ahead, companies are expected to continue balancing JIC and JIT approaches to maintain resilience while optimizing costs. With the integration and combination of advanced technologies and sustainable practices will likely play a crucial role in shaping future inventory management strategies. Geopolitical uncertainties and ongoing global challenges will further drive the evolution of inventory practices.

Looking further, several key trends are likely to shape the future of stock management and supply chains:

- The integration of advanced technologies as AI (Artificial Intelligence), machine learning, and blockchain will continue to evolve, providing more accurate demand forecasting, improved inventory tracking, and greater transparency across supply chains. Many scientific texts address this topic and explain the advantages and necessity of applying modern technologies (Ammar et al., 2022) and one of the conclusions from the World Economic Forum (Sultan, 2022), confirm, these technologies are crucial for future supply chain efficiency.
- Environmental considerations will become increasingly integral to stock management. Companies are expected to adopt more sustainable practices, such as reducing carbon footprints (CBAM), optimizing resource use, and enhancing waste management, emphasizes the growing importance of sustainability in supply chain strategies (El-Garaihy et al., 2024), which will contribute to companies deciding to adapt to the new facts.
- The emphasis on building more resilient and flexible supply chains will persist. This includes investing in dual-sourcing strategies, localizing production, and developing contingency plans to mitigate the impact of future disruptions. The McKinsey & Company article (Knut & Cengiz, 2022), and observations by MIT (Massachusetts Institute of Technology) (Eric, 2022) provide valuable frameworks for these practices.
- Greater Collaboration and Integration between companies, suppliers, and technology providers will drive more synchronized and efficient supply chains. Real-time data sharing and joint problem-solving will become standard practice, as discussed in book *"The LIVING Supply Chain"* (Handfield, R., & Linton 2017).

- Personalization and Consumer-Centric Approaches, as consumer expectations continue to evolve, supply chains will need to adapt (Rydecki, & Chłąd 2023) by offering more personalized products and services, and by being able to respond swiftly to changing consumer demands. Insights from consulting company Deloitte (Adam, 2020) reflect this trend.

In summary, the pandemic has created the needs for higher inventory (stock level) and requested supply chain management practices that are not only efficient but also resilient and adaptable. Combination and integration of advanced technologies, focus on sustainability, and an emphasis on flexibility will define the future base for supply chain management to make right decisions. Companies which proactively embrace and anticipate these trends will be better positioned to navigate future challenges and seize new opportunities in an increasingly dynamic global market. As we could see from real examples in western countries (USA, EU countries), there has definitely been a change in the way of inventory management, which will certainly remain until global changes become more predictable. Also, the mentioned examples from practice can eventually help modern managers when making decisions in the current, very turbulent environment. Generally speaking, this paper can be a good basis for some future research works, in order to examine the topic in more detail, because it is definitely a paradigm shift in supply chains and it is unlikely that there will be a return to traditional models of inventory management.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# SUPPLY CHAIN FLEXIBILITY AND SMEs: THE ROLE OF HUMAN RESOURCE FLEXIBILITY

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***Abstract***

*SMEs are always at a disadvantage when dealing with market or supply chain disruptions. However, compared to large business systems, these enterprises are able to adapt more quickly to changes in the business environment. These reasons indicate that the flexibility of supply chains of SMEs is becoming a significant feature that allows companies to adapt their business process to the new situation. Flexibility can be a powerful tool for gaining a competitive advantage, reducing costs, and improving response to unforeseen situations. This article explores the relationships between human resource (HR) flexibility (especially employee skill flexibility) and business performance. Based on previous works, the simulation is used to assess the ability of the company to cope with the changing environment. Using the example of a real company, the effects of different personnel flexibility strategies on supply chain performance were observed.*

***Key words****: supply chain, human resource flexibility, SMEs.*

## 1. Introduction

The COVID-19 pandemic has disrupted global supply chains due to a sudden disruption in supply and demand. Given their relative lack of resources, finances, and "power", SMEs will always be at a disadvantage when it comes to dealing with significant market or supply chain disruptions. However, compared to large business systems, these enterprises are able to adapt more quickly to changes in the business environment (Utomo et al, 2021; Subramaniam et al, 2022;).

More recent works recognize the significant relationship between supply chain management, its flexibility and business performance (Dragic & Sorak 2016,

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Shakeel et al. 2017, Katou 2022). At the same time, the authors have expanded the purpose of supply chain management, so in addition to efficiency and effectiveness, the flexibility of supply chains has become imperative. Moreover, the flexibility of SME supply chains becomes a powerful tool for gaining competitive advantage, reducing costs and improving response to unforeseen situations. Therefore, traditional supply chain performance measurement systems, which usually only contain business performance measures, do not provide enough information.

The term Supply Chain Flexibility encompasses various aspects of flexibility that directly affect chain participants, management decisions and performance measures. Traditionally, the following dimensions of flexibility are most often discussed in the literature: Volume flexibility, Delivery flexibility, Mix flexibility, Sourcing flexibility and New product flexibility.

However, today's pronounced lack of human resources poses a new challenge for SMEs. Namely, even when SMEs are able to financially provide capacity expansion, in order to satisfy customer requirements, the lack and fluctuation of labour force have an extremely negative impact on the achieved business performance.

Stokes and Harris (2012), human resource flexibility define as the extent to which the firm's human resources possess skills and behaviour repertoires which offer the organization a chance to develop strategic alternatives within its competitive environment. Sabuhari and Irawanto (2020) study introduced a conceptual framework to enhance the understanding of the versatility of human resources flexibility. They suggested that the performance of workers can be affected by various factors such as the versatility of employee abilities, flexibility of employee actions, flexibility of human resource practice and flexible work arrangements. Several authors point to the complexity of measuring flexibility by recognizing its sub-dimensions such as, employee skill flexibility, behaviour flexibility and human resource practice flexibility (Ngo & Loi, 2008; Barinua & Fubara, 2022). Finaly, Fadi and Abed (2022) research has shown that there is a significant impact of human resource flexibility on the success of supply chain management.

In this context, the purpose of this paper is to develop a comprehensive simulation model to examine the interrelationships between human resource flexibility, supply chain flexibility and business performance. The work methodology includes improvement of the existing simulation model, planning and execution of simulation experiments, and analysis of results, and drawing conclusions.

## 2. Materials and Methods

Experimenting with real SMEs is not always possible. However, experimentation on a simulation model can provide information about the behaviour of a real system. In this paper, we propose a modular system dynamics model of integrated business processes. This model has been described in previous works (Sorak & Dragić, 2013; Dragić & Sorak, 2016; Dragić, 2021). It shows the

elements and equations of the model, which are equivalent to the behaviour of the real system. The described model consists of the following four modules: M1 – Forecasting and initiation of customer demands, M2 – Sales and delivery, M3 – Preparation and execution of work processes, and M4 – Inventory management of raw materials.

Figure 1 shows the flow diagram for the module M3- Preparation and execution of work production processes. The module follows the course from the opening of the task to delivery of finished goods. Production process is organized as a process focused, and each batch goes through one stage of the production process before moving onto next stage.

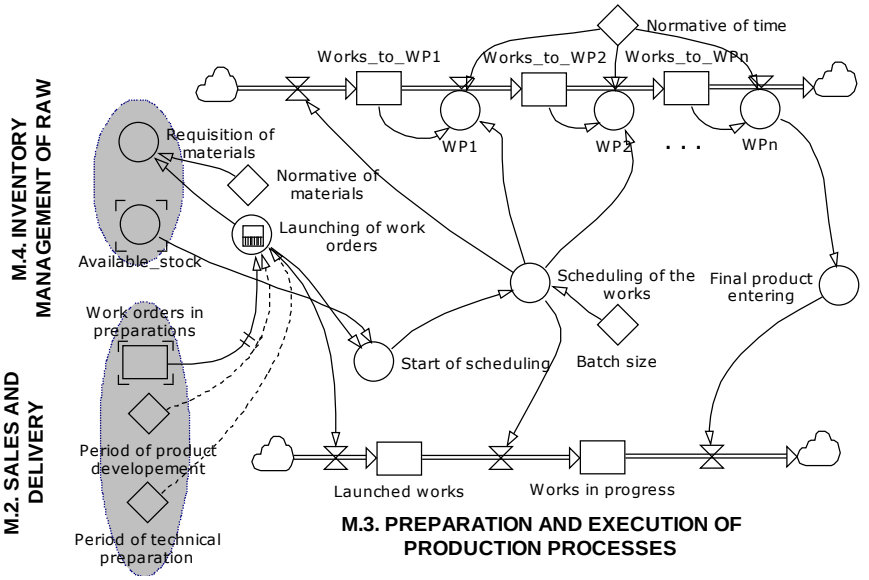


*Figure 1: Flow diagram for the module M3- Preparation and execution of work production processes*

The applied model recognizes the specificities of SMEs, such as a large range of products, the use of a wide variety of materials, production in small batches and requests for reduction of lead time. Through a series of experiments, the behaviour of the system can be simulated under different conditions, including different inventory management policies, customer demand management practices, scheduling and availability of resources (equipment and human resources). The effects of simulated actions are monitored by measuring performance.

An adequate system for measuring the performance of an SME's supply chain is crucial for successful supply chain management. This system can be defined as a set of elements used to quantify the effectiveness and efficiency of supply chain management. Performance measures of SMEs companies' supply chains generally use a combination of cost measures and measures of response to customer demands. In addition to quantitative measures, more and more authors recognize other suitable performance measures, which are not adequately used in supply

chain research. Examples of such measures include user satisfaction, information flow, supplier performance, as well as risk management (Shepherd & Gunter, 2006; Anderson et al., 2017; Dragić, 2021). The chosen set of supply chain performance measures should be directly related to the strategy of supply chain management. This paper will use the classification framework described in the author's previous works (Sorak & Dragić, 2013; Dragić & Sorak, 2016; Dragić, 2021;), expanded for human resource flexibility measures (Table 1).

*Table 1: Proposed Framework for defining Supply Chain Performance Measures*

| **Supply chain structure** | **Supply chain management** | **Performance** | **Performance measures** |
|---|---|---|---|
| Participants<br>Resources<br>Processes<br>Material flows<br>Information flows | Who manages the supply chain?<br><br>What management strategies are used? | Resource utilization | • Funds engaged<br>• Productivity<br>• Capacity utilization<br>• Inventory turnover... |
| | | Desired output | • Value of completed orders<br>• Fulfilled orders on time<br>• User satisfaction<br>• Costs of non-compliance... |
| | | Flexibility | • Flexibility of delivery times<br>• Flexibility of delivery volume<br>• Flexibility of the product range<br>• Procurement flexibility<br>• Human resource flexibility... |

## 2. Results

The experiment was conducted on the sample of a small company in the field of metal production. There are about 30 workers of different professions. The production program of the company consists mainly of products made of sheet metal. For research purposes, the product range, and number of raw materials were reduced. So, we have 6 kinds of products (with two order fulfilment options: Make-to-Order and Make-to-Stock), 36 kinds of raw material, 10 kinds of equipment recourses (28 units), and 10 phases of production. In the first step, the period of one working hour (1 WH) is adopted as the basic time unit (step of the simulation). The period of the simulation execution corresponds to the fourth quarter of the fiscal year 2024. If we assume that the enterprise operates five days a week, in this period there are 65 working days (with 8 WH), the total time will be 520WH. Part of the initial data is shown in tables 2 and 3.

*Table 2: Reduced product range with the demand model parameters*

| PRODUCT: | | *WH* – the working hour | Price (€) | Order fulfilment options | Safety stock | Batch size (Units) | Demand lead-time (WH) | Demands units/WH) +/- deviation | Order lead-time +/- deviation |
|---|---|---|---|---|---|---|---|---|---|
| | **ID** | **Name** | | | | | | | |
| 1 | 400000 | Surface-mounted lamp | 15 | MTS | 50 | 150 | 0 | $4^{+/-2}$ | $8^{+/-4}$ |
| 2 | 410000 | Archive cabinet | 65 | MTO | 0 | 0 | 160 | $20^{+/-8}$ | $2^{+/-1}$ |
| 3 | 420000 | El. distribution cabinet | 200 | MTO | - | - | 120 | $2^{+/-1}$ | $14^{+/-6}$ |
| 4 | 440000 | Rack 400x1000x2000 | 30 | MTS | 100 | 150 | 0 | $20^{+/-10}$ | $4^{+/-2}$ |
| 5 | 470000 | Net stand 10x1800x500 | 90 | MTO | - | - | 160 | $4^{+/-2}$ | $24^{+/-8}$ |
| 6 | 490000 | Distribution board | 6 | MTO | - | - | 0 | $40^{+/-10}$ | $16^{+/-6}$ |

*Table 3: Capacity required per product unit (reduced list)*

| Required equipment | HMZ | LAS | EUR | MHP | APP | CO2 | BRU | LAK | MON | MONE | Total production time (min) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Preparation time | 15min | 15min | 20min | 20min | 15min | 15min | 10min | 30min | 20min | 30min | |
| Product | *Production time (min)* | | | | | | | | | | |
| 400000 | 0.00 | 2.80 | 2.83 | 2.00 | 3.40 | 3.00 | 2.00 | 3.00 | 6.00 | 4.00 | 29.03 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 490000 | 1.60 | 0.00 | 1.50 | 0.00 | 1.60 | 3.00 | 0.00 | 0.25 | 0.00 | 0.00 | 7.95 |

Performing simulations for a certain period of time and under certain conditions (adjusting process parameters) the future behaviour of the process can be predicted and shown through the expected performance of the process (Table 4.). These performances are compared to planned performances, and if necessary, corrective actions are initiated (by changing the parameters of the process). The effectiveness of corrective actions can be predicted by performing simulations under new conditions. The experiment needs to show how such changes affect other measures of business performance. In these experiments, the focus will be on the actions resulting from the human resources flexibility.

The first experiment was conducted using the model parameters adopted from the real data of the simulated system (Table 2 and 3). The behaviour of the simulated system is represented by monitoring performance measures (Table 4).

*Table 4: Measure performance definition, and overview of the basic experiment results*

| Goal | Name | Definitions | Value |
|---|---|---|---|
| ↓ | The average level of finished goods | The average value of finished goods supply over time | 4673.20€ |
| ↑ | Fulfilment of orders from existing stocks | Percentage of the amount of goods that can be met with existing supplies | 46.30% |
| ↑ | Delivery timeliness | The percentage of orders that are met before or as scheduled / promised delivery date. | 67.87% |

| Goal | Name | Definitions | Value |
|---|---|---|---|
| ↑ | The value of executed orders | The total value of orders received in the relevant period | 347800.00€ |
| ↑ | Equipment capacity utilization | The relationship between the required and available capacity of equipment | 73.37% |
| ↑ | HR Capacity utilization | The relationship between the required and available capacity of HR | 73.37% |
| ↓ | The average level of work in progress | The average value of work in progress | 75670€ |
| ↓ | Manufacturing Cycle Time | Total time taken to convert raw materials into finished goods. | 689h |
| ↓ | Delivery time flexibility | The percentage of surplus time on the realization of customer requests | 11.20% |

Customer satisfaction is the key to continuing success of the enterprise. The results of the experiment show a low level of fulfilment of orders from existing stocks (44.99%), and a low percentage of orders fulfilled on time (67.87%). So below, we'll predict the effects of increasing the flexibility of human resources. Suggested solutions are given in Table 5. Simulation experiments should show how such changes affect performance measures. A comparative overview of the experiment results is shown in the table 6.

*Table 5: The solution plan*

| | |
|---|---|
| **S1** | *Increased available equipment capacity and HR Skill Flexibility*<br>We shall increase the number of equipment which have the highest capacity utilization like as APP, CO2, MONT, and EUR. At the same time, the number of workers remains the same, but the workers have additional skills for work. |
| **S2** | *Human resource practice flexibility*<br>Flexible working hours are being introduced, i.e. the possibility to, if necessary, increase working hours by 20% for overloaded workplaces. |

## 3. Discussion

The increase in capacity, with human skills flexibility, had a positive effect on the improvement of almost all output performances. Thus, the fulfilment of orders from existing stocks increased from 46.30% to 83.92%, the delivery timeliness increased from 67.87% to 100%, the value of orders realized in the simulated period increased by 25%, the duration of the production cycle decreased by 81 term units, and the average level of unfinished production decreased by about 40%. Due to the larger number of equipment, capacity utilization decreased from 73.37% to 67.73%, while at the same time the utilization of human resources increased significantly. (Table 6).

The second solution of the experiment, increasing working time, also showed significant positive effects on delivery performance. Although the improvements are not as great as in the first case, this option does not require additional financial investments in equipment.

*Table 6: A comparative overview of the experiment results*

| Goal | Name | Basic Exp. | S1 | S2 |
|---|---|---|---|---|
| ↓ | The average level of finished goods | 2673€ | 4825€ | 2448€ |
| ↑ | Fulfilment of orders from existing stocks | 46.30% | 83.92% | 64.62% |
| ↑ | Delivery timeliness | 67.87% | 100.00% | 84.26% |
| ↑ | The value of executed orders | 347800€ | 433560€ | 350432€ |
| ↑ | Equipment capacity utilization | 73.37% | 67.73% | 76,24% |
| ↑ | HR Capacity utilization | 73.37% | 88.56% | 76,24% |
| ↓ | The average level of work in progress | 75670€ | 48247€ | 74418€ |
| ↓ | Manufacturing Cycle Time | 689h | 606h | 694h |
| ↓ | Delivery time flexibility | 11.20% | 68.39% | 24.14% |

## 4. Conclusions

The results show that human resources flexibility can be a significant source for improving the SMEs performance. The presented model can be used to find solutions for a wide range of problems related to human resource management, starting from determining the type of human resources competence (long-term decision), and to considering the effects of flexible working hours in the production work schedule (current decision).

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# ECONOMICS AND FINANCE

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH IN SERBIA

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***Abstract***

*Financial markets represent a crucial part of the overall economic and financial system of any country. It is the most sensitive part of the mentioned system because financial instruments are traded on it, and its main role is to facilitate capital allocation and risk management. An unstable financial system can cause a financial crisis with negative consequences that spread throughout the country's economy, thus, it is essential that the financial system is safe, sound and sustainable. Financial development is an integral part of economic development, and it implies healthy, safe and developed financial institutions and financial markets. The aim of this paper is to examine the relationship between financial development and economic development on the sample of Serbia as a developing country. The observation period is from 2003 to 2023. In order to examine the mentioned nexus, Pearson's correlation analysis was applied. The contribution of this paper would be that it can make an positive contribution to policy makers, especially in the area of the financial sector.*

***Key words:*** *Financial development, Economic growth, Correlation analysis, Pearson correlation.*

## 1. Introduction

In conditions of financial stability, economic actors have confidence in the banking system and gain access to financial services, such as payment execution, lending, deposit investment and risk protection (National Bank of Serbia, n.d.). Financial stability means that the financial system – financial intermediaries, financial markets and financial infrastructures – is capable of ensuring efficient allocation of financial resources and fulfilling its key macroeconomic functions even

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if financial imbalances and shocks occur in the domestic and international environment (National Bank of Serbia, n.d.). Financial stability indicators are: financial soundness indicators (capital adequacy ratio, capital to assets, gross non-performing loans to total gross loans, return on equity, etc.); banking sector indicators (the capital adequacy ratio, foreign currency loans, net operating income, liquidity coverage ratio, etc.); non-banking financial sector indicators (profitability indicators, the fondex daily value, emerging market bond index global, etc.); financial markets and real estate market – the best known indicator is the bid-to-cover ratio, which is defined as the ratio between the nominal value of total submitted bids and the nominal value of sold securities (National Bank of Serbia, 2024, p. 41).

The literature generally agrees on the notions of growth and development. It refers to growth when dealing with proportional changes in GDP or, more frequently, in GDP per capita, and to development when analysing living standards – including features that do not necessarily form the object of monetary measurement (Colombatto, 2006, p. 243). GDP has been accepted as a standard in measuring the national economy and can be calculated by the method of production, the method of income and the method of expenditure, thus, the purpose of the three methods is the same, namely the dimensioning of the economic activity of any society, offering governments an important tool in managing the levers of the economy, but also a tool that makes possible developments and comparative assessments in time and space of national economies (Chițoiu & Voda, 2022, p. 88).

This paper aims to investigate the relationship between financial development and economic growth in the Republic of Serbia. The first part of the paper presents an overview of the previous research on the mantioned relationship. The second part represents a brief overview of economic growth in Serbia. The third part of the paper is about data and methodology used in study. The fourth part represents results and discussion about the research results, and the fifth part of the paper presents conclusions and guidelines for future research.

## 2. Literature review

Božović (Božović, 2019) investigated the relationship between financial development and economic growth in Serbia, with focus on the influence of stock market and banking-sector development on growth. Research has revealed a positive and statistically significant impact of stock market liquidity and bank credit on economic growth.

Afonso and Blanco-Arana (2018) investigated the relationship between economic growth and the main determinants of financial development in OECD countries, with special focus to the recent economic crisis. The research results showed that an increase in domestic credit, provided by financial sector, in market capitalization and in the turnover ratio of domestic shares, results wit a significant positive effect on the GDP per capita, and effects during the period of crisis were different.

Megnigang (2024) conducted a critical analysis of the literature related to the relationship between financial system development and economic growth. It turned out that theoretical and empirical work does not really illustrate the nature of the mentioned relationship in the case of developing countries, thus, banking sector development is, in general, captured by credit to the private sector, and in developing countries, the majority of bank credit is allocated to large commercial enterprises that sell mainly imported products.

A group of authors (Lum et al. 2024) investigated the impact of financial development on economic growth in Sub-Saharan Africa. The results revealed that certain financial development indicators, such as credit to the private sector and stock traded have positive impacted on economic growth, while other indicators, such as broad money supply and stock market capitalization, have a negative impact on economic growth.

Another group of authors (Trebicka, Harizi, Krasniqi & Kalaja, 2024) have explored the impact of financial systems, stability, and institutional quality on economic performance. The results showed that significant improvements in financial systems correlate positively with economic growth, highlighting the crucial mediating roles of improved financial inclusion, market stability, and governance.

Many other studies conducted in this area (Igbinosa & Chijuka, 2024; Durusu-Ciftci, Ispir & Yetkiner, 2016; Graff, 2001) have shown that financial development has a significant positive impact on economic growth.

## 3. Economic growth in Serbia – a brief overview

Causal relationship from financial development to economic growth empirically has been the crucial issue so far, thus, authors King and Levine used a regression across different countries in one of the first attempts to test the mentioned causality, and they found that the size of the country's banking system relative to GDP predicts long-term growth rates, even when one controls for other explanatory variables (Božović, 2019, p. 78).

Hence, the following figures (figure 1 and figure 2) represent the trend of GDP and GDP per capita in Serbia, therefore, economic growth.

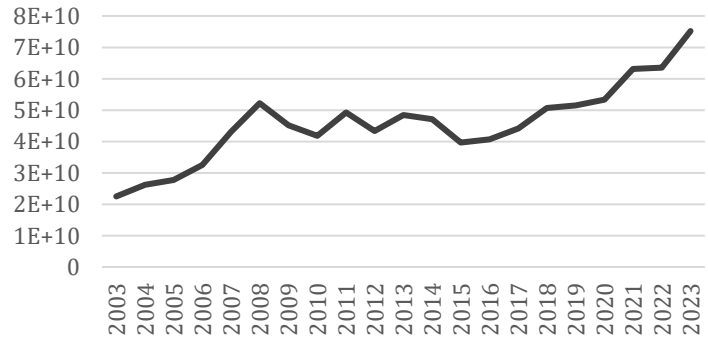


*Figure 1: GDP trend in Serbia, in the last twenty years (current US$).*

*Source: World Bank (n.d.a), Author's creation.*

From 2003 to 2008, there was a constant growth in GDP in Serbia, and then, from 2009 to 2015 an uneven trend was recorded, with frequent rises and falls. Starting from 2016, there was a constant growth in GDP in Serbia, with the highest value in 2023 (even 75187125427 US$).

The following figure 2 represents annual GDP per capita growth in Serbia.

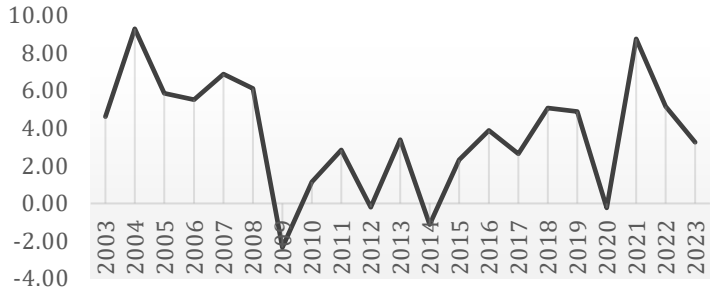


*Figure 2: GDP per capita growth in Serbia, in the last twenty years (annual %).*
*Source: World Bank (n.d.f), Author's creation.*

As for GDP per capita growth rate in Serbia, the trend was very uneven in the observed period. The highest value was registered in 2004 (9.28%), followed by 2021 (8.75%), while negative values were recorded in 2009 (-2.34%), 2012 (-0.20%), 2014 (-1.13%) and 2020 (-0.24%).

## 4. Data and methodology

For the purposes of this study, the data were collected from the official website of the World Bank Group. The observation period is from 2003 to 2023, given the availability of data. The research was conducted on the sample of the Republic of Serbia. The aim was to examine the linear relationship between the following variables – *GDP* (gross domestic product as the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products (World Bank, n.d.a)), *M1* (broad money, as the sum of currency outside banks, demand deposits other than those of the central government, the time, savings, and foreign currency deposits of resident sectors other than the central government, bank and traveler's checks, and other securities such as certificates of deposit and commercial paper (World Bank, n.d.b)), *DCPS* (domestic credit to private sector by banks refers to financial resources provided to the private sector by other depository corporations (deposit taking corporations except central banks), such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment (World Bank, n.d.c)), *GCF* (gross capital formation, formerly known as gross domestic investment, consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories (World Bank, n.d.d)), and *FDI* (foreign direct investments net inflows are inflows of investment to acquire a lasting

management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor (World Bank, n.d.e)). In other words, financial development is examined using four indicators – *M1*, *DCPS*, *GCF* and *FDI*, because it is not possible to examine it using only one variable. In order to examine the relationship between financial development and economic growth, Pearson correlation was applied. Table 1 gives definitions of variables with their unit and sources.

*Table 1: Definition of variables, unit, and data source*

| Variable | Definition | Unit | Source |
|---|---|---|---|
| lnGDP | Gross domestic product in Serbia | current US$ | World Bank |
| lnM1 | Broad money | % GDP | World Bank |
| lnDCPS | Domestic credit to private sector by banks | % GDP | World Bank |
| lnGCF | Gross capital formation | % GDP | World Bank |
| lnFDI | FDI net inflows | % GDP | World Bank |

In order to achieve linearity, all values are logarithmized by the natural logarithm (ln). Statistical data processing was performed using IBM SPSS Statistics 25 software. The missing data for variable lnFDI are from 2003 and 2006.

## 5. Results and discussion

Figure 3 gives the relationship of the variables, represented by the scatter matrix.

The figure above shows potential bivariate relationships between the analyzed variables. It can be concluded that there are probably positive, very strong linear relationships between lnM1 and lnDCPS, lnM1 and lnGDP, lnDCPS and lnGDP, and lnGCF and lnFDI. The next step is to calculate the Pearson's correlation coefficient (R).

As can be seen in the table above, for the observed period from 2003 to 2023, there is a positive correlation between lnM1 and lnDCPS, due to the positive value of correlation coefficient ($R = 0.877$). Since $0.70 < 0.877 < 0.90$, this is a strong correlation, thus, since $p < 0.01$, there is a statistically significant relationship between the observed variables. There is also a positive correlation between lnM1 and lnGDP ($R = 0.892$), thus, since $0.70 < 0.892 < 0.90$, this is a strong correlation, and statistically significant ($p < 0.01$). There is positive, strong correlation between lnDCPS and lnGDP ($R = 0.769$; $0.70 < 0.769 < 0.90$), and, since $p < 0.01$, this is statistically significant correlation. There is one positive, moderate correlation between lnGCF and lnFDI ($R = 0.603$; $0.50 < 0.603 < 0.70$), and since $p < 0.05$, this is statistically significant correlation.

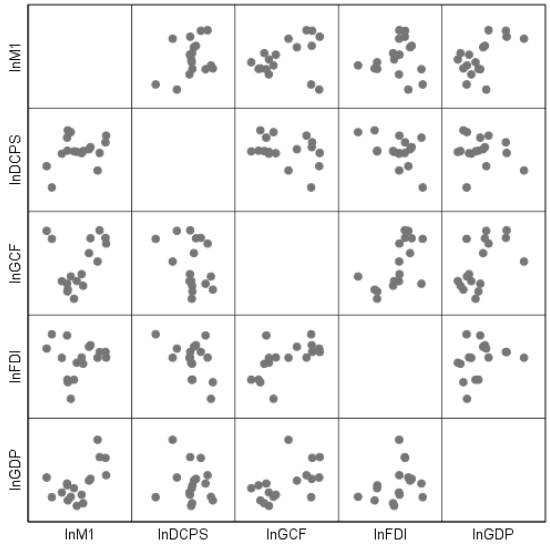


*Figure 3: Relationship between broad money, domestic credit to private sector by banks, gross capital formation, FDI net inflows, and gross domestic product in Serbia.*
*Source: SPSS output.*

*Table 2: Correlation between broad money, domestic credit to private sector by banks, gross capital formation, FDI net inflows, and gross domestic product in Serbia, from 2003 to 2023.*

| | | lnM1 | lnDCPS | lnGCF | lnFDI | lnGDP |
|---|---|---|---|---|---|---|
| lnM1 | R | 1 | 0.877** | -0.028 | 0.058 | 0.892** |
| | p | | 0.000 | 0.905 | 0.826 | 0.000 |
| | N | 21 | 21 | 21 | 17 | 21 |
| lnDCPS | R | 0.877** | 1 | -0.245 | -0.473 | 0.769** |
| | p | 0.000 | | 0.285 | 0.055 | 0.000 |
| | N | 21 | 21 | 21 | 17 | 21 |
| lnGCF | R | -0.028 | -0.245 | 1 | 0.603* | 0.128 |
| | p | 0.905 | 0.285 | | 0.010 | 0.579 |
| | N | 21 | 21 | 21 | 17 | 21 |
| lnFDI | R | 0.058 | -0.473 | 0.603* | 1 | 0.297 |
| | p | 0.826 | 0.055 | 0.010 | | 0.248 |
| | N | 17 | 17 | 17 | 17 | 17 |
| lnGDP | R | 0.892** | 0.769** | 0.128 | 0.297 | 1 |
| | p | 0.000 | 0.000 | 0.579 | 0.248 | |
| | N | 21 | 21 | 21 | 17 | 21 |

*R – Pearson's correlation coefficient; p – significance level; N – number of observations*
***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*
*Source: SPSS output.*

It can be concluded that there is a significant impact of broad money on economic growth and domestic credit to private sector by banks in Serbia, as well as that domestic credit to private sector by banks in Serbia has a significant impact on economic growth. Likewise, gross fixed capital formation has a significant influence on foreign direct investments in Serbia.

## 6. Conclusions

Increased economic growth and preserved financial stability, along with a decrease in the share of problematic loans in total loans, confirms that Serbia managed to ensure medium-term price stability with an adequate monetary policy, which was continuously tightened in the previous period.

The aim of this paper was to examine the relationship between financial development and economic growth in Serbia, thus, linear relationship between the representative variables of financial development (broad money, domestic credit to private sector by banks, gross capital formation, FDI net inflows) and GDP as the proxy of economic growth. In order to examine the relationship between financial development and economic growth, Pearson correlation was applied. The results revealed four positive, strong and statistically significant correlations between broad money and economic growth, broad money and domestic credit to private sector, and domestic credit to private sector and economic growth, and gross capital formation and foreign direct investments.

The recommendation for future researchers in this field would be to expand the research with a more complex statistical method, such as regression analysis, as well as to have more studies dedicated to the relationship between financial stability and economic development in Serbia and the region.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-057 Original scientific paper

# ESG AND THE COST OF CAPITAL: EXAMPLES FROM EASTERN EUROPE BANKING INDUSTRY

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***Abstract***

*This paper aims to test the hypothesis that higher ESG scores lead to a lower cost of capital for publicly traded companies in Eastern Europe. In recent years, ESG factors have become increasingly important in the investment industry, influencing the cost of capital for publicly traded companies from banking industry. As companies seeking capital are increasingly scrutinized based on ESG factors, most publicly traded companies publish ESG disclosures and strive to be ESG compliant. Although there is no definitive governing body for ESG, capital providers benchmark companies based on ESG scores—either internally created or from external providers—and integrate these scores into their investment decisions. With cost of capital on the rise during previous period, the authors want to test the hypothesis that ESG score have positive influence on the cost of capital for public companies in banking industry, with lower cost of capital compared to their peers. Using the Weighted Average Cost of Capital (WACC), this paper breaks down the cost of capital to test the effect of ESG scores on both the cost of debt and the cost of equity for publicly traded banking corporations from Eastern Europe.*

***Key words:*** *ESG, Cost of Capital. Corporate finance.*

## 1. Introduction

ESG (Environmetnal, Social, Governance) represents set of non-financial factors that are used to assess the impact that the subject have on different stakeholders. According to the United Nations Principles for Responsible Investment (PRI, 2020) ESG factors encompass, but are not limited to:

- Environmental factors: climate change, resource depletion, waste, pollution, deforestation

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- Social factors: human rights, modern slavery, child labour, working conditions, employee relations
- Governance factors: bribery and corruption, executive pay, board diversity and structure, trade association, lobbying and donations, tax strategy

ESG is increasingly integrated into corporate evaluations, investment strategies, and policymaking, reflecting a shift towards sustainable and responsible business practices. The goal of any company is to maximize shareholders value, and ESG factors should therefore increase the value of the firm, but so far the results of different researches are inconclusive. Some previous researches found that ESG factors, as presented, increase shareholders values through improving company performance (Broadstock er al., 2020; Buallay 2019) while others (Devinney, 2009) argue that ESG could lead to opportunity costs associated with inefficiently allocated capital. Friedman go as far as to argue that socially responsible initatives to make world a better place should not be pursued as the sole responsibility of managers is maximization of owners wealth (Friedman, 1980).

One of the problems that authors encounter when analyzing ESG factors is large number of ESG score providers, each with different methodology that is usually proprietary ownership of ESG data provider. Most of ESG score providers are part of large financial services groups, such as: Bloomberg, Morningstar, MSCI etc.; Part of a stock exchange itself, such as FTSE; or specialised platforms formed by safety and environmental NOGs, like CDP or RepRisk. These ESG scores show convergence to an extent, but inability to assess different methodologies prevent researchers to use the most suitable ESG scores for their researches.

Most ESG score providers put greater emphasis on Social and Governance factors when assesing banking industry. Althouhg banking industry doesn't have direct environmental impact, it does have indirect influence through financing different projects that could have negative environmental impact. However, there is some evidence from European banking market than environmental dimension of ESG influence bank value (Azmi et al., 2021).

Banking industry in Eastern Europe area is characterized by mix of wholly owned subsidiaries, partially owned subsidiaries and independent banking corporations, with most of the wholly and partially owned subsidiaries owned by banks from either Western Europe or United States of America. Besides other banking institutions, governments, equity funds and other private owners are present on the market as well. This makes most of banks that are present on the domestic stock exchanges the basis of the market, their stocks attracting high investors attention and making them constituents of most important market indices.

## 1.1 Section (methods)

Banking industry is specific when compared to other industries because one of its main functions is to aggregate debt financing so it can distribute funds to other entities in need of financing. Because of that, it can be presumed that debt will be prevalent source of capital in banking industry. Also, because most of debt for

companies is generated through deposits by individuals and institutions, calculation of debt cost should take cost of deposits into account.

WACC represents standard measurement of funding cost, either for company, part of the company or separate project. It considers all sources of funding and its associated costs and weights them according to the share of each funding source in financing. We used Capital Asset Pricing Model (CAPM) to calculate cost of equity capital. For cost of debt, we used interest expenses on interest-paying liabilities. Although in its basic form cost of debt is expressed as current yield on company debt securities, our reasoning to deviate from usual practice is because structure of liabilities in banking industry, as majority of interest-paying liabilities are not in debt but in deposits from clients. Taking into account both deposits and other interest paying liabilities, we arrived at real cost of borrowed capital. Because interests on deposits are usually much smaller than interest on other debt, and that deposits carry most of the liabilities, the cost of debt is expected to be smaller than if we used standard methodology.

As a source of ESG ratings we used Sustainalytics, which is part of Morningstar, Inc. financial group. Sustainalytics provide total ESG score in range from 0 to 40+, with lower scores showing lower ESG risks and better ESG management. Each industry has different sets of observable variables that define that industy, and the ranking among companies inside industry is provided. For this paper, companies are ranked according to their ESG scores on 10th of September 2024. We ranked Eastern European banks according to their Sustainalytics ESG score.

We use Spearman's rank correlation coefficient to test if the rankings of the banks according to ESG influence ranking of banks according to cost of equity, cost of debt and WACC, with larger Spearman's rank correlation coefficient points to the stronger connection between ESG ranks and cost of capital for the banks. Since Sustainalytics is providing only the curent score, not its previous values, Spearman's rank correlation coefficient is adequate to capture the relationship between ESG scores and cost of financing. We hypothesize that there should be positive correlation between ESG score ranks and cost of debt, cost of equity and WACC ranks.

## 2. Section (results)

First, we calculated the cost of equity, cost of debt and WACC for observed banks (Table 1.). From it can be observed that 8 out of 14 of banks used in this research were from Poland, and some of them were part of larger banking groups, however their ESG scores were independent of ESG scores of parent companies.

*Table 1: List of banks with cost of equity, debt, WACC and Sustainalytics ESG score*

| Name | Country | Cost of equity | Cost of debt | WACC | ESG |
|---|---|---|---|---|---|
| Alior Bank | Poland | 81.264% | 2.943% | 10.355% | 24.2 |
| Banca Transilvania | Romania | 21.662% | 2.639% | 3.820% | 13.3 |
| Bank Handlowy | Poland | -1.619% | 1.784% | 1.073% | 22.0 |
| Bank Millennium | Poland | 65.619% | 2.755% | 5.701% | 23.0 |
| Bank PEKAO | Poland | 14.510% | 2.208% | 2.932% | 22.5 |
| ING Bank Slaski | Poland | 39.822% | 1.858% | 3.685% | 16.0 |
| Komercni Banka | Czechia | -4.097% | 7.066% | 4.927% | 22.2 |
| mBank | Poland | 15.647% | 2.550% | 2.926% | 12.8 |
| MONETA money bank | Czechia | 5.228% | 3.406% | 2.923% | 15.6 |
| Nova Ljubljanska Banka | Slovenia | 39.787% | 0.985% | 5.198% | 14.6 |
| OTP Bank | Hungary | 17.260% | 3.755% | 4.854% | 14.5 |
| PKO BP | Poland | 27.120% | 2.599% | 4.481% | 23.9 |
| Santander Bank Polska | Poland | 22.264% | 2.175% | 4.148% | 16.0 |
| Tatra banka | Slovakia | 9.316% | 1.802% | 1.997% | 18.3 |

The results of Spearman's rank correlation coefficient (Table 2.) for show that there is no correlation between the cost of equity, cost of debt, or WACC with ESG score, implicating that ESG scores do not have any kind of influence on WACC or any of its constituents.

*Table 2: rankings and Spearman's rank correlation coefficient*

| Bank | de | dd | dw | de2 | dd2 | dw2 |
|---|---|---|---|---|---|---|
| Alior bank | 0 | -3 | 0 | 0 | 9 | 0 |
| Banca Transilvania | 6 | 7 | 5 | 36 | 49 | 25 |
| Bank Handlowy | -7 | -7 | -8 | 49 | 49 | 64 |
| Bank Millenium | -1 | -2 | -4 | 1 | 4 | 16 |
| Bank PEKAO | -6 | -5 | -6 | 36 | 25 | 36 |
| ING Bank Slaski | 7 | -3 | -1 | 42 | 6 | 0 |
| Komercni Banka | -9 | 4 | 2 | 81 | 16 | 4 |
| mBank | 5 | 6 | 3 | 25 | 36 | 9 |
| MONETA money bank | -2 | 7 | -2 | 4 | 49 | 4 |
| Nova Ljubljanska Banka | 8 | -3 | 9 | 64 | 9 | 81 |
| OTP Bank | 4 | 10 | 8 | 16 | 100 | 64 |
| PKO BP | -3 | -5 | -3 | 9 | 25 | 9 |
| Santander Bank Polska | 3 | -2 | 3 | 6 | 2 | 6 |
| Tatra banka | -4 | -5 | -6 | 16 | 25 | 36 |
| | | | ρ = | 0.15275 | 0.11099 | 0.22088 |

## 3. Section (discussion)

ESG scores do not have any influence cost of equity, cost of debt or weighted average cost of capital for Eastern European banks, showing that both constituents of WACC are independent of ESG scores.

These results show that good ESG governance does not cause benefits in cost of funding for the banking institutions, which contradicts one of the purposes of ESG.

Good governance should at least improve the cost of financing as it should provide better transparency and accountability of management, as well as better cost management. Environmental aspect of ESG depends on methodology, however when there is no benefit for banks and their shareholders when they engage in different environmental actions, there is a possibility that banks would not prioritize projects or would not engage in activities that are environmentally friendly.

To be meaningful, we argue that good ESG scores should show good correlation with financial performance of banks, as capital providers are interested in their own returns. If pursuing ESG scores does not influence their own benefit, there is a possibility that banking industry would consider ESG aspect as nuisance, not as an important part of their strategy. If good ESG governance does not correspond with either lower cost of equity or lower cost of debt, there is no reward for being "good" and only by forceful implementation banks will keep on following ESG guidelines. Debt providers (both institutional and private) should reward banks with higher ESG scores with lower interest rates, while equity providers should ask for lower expected stock appreciation.

## 4. Section (conclusions)

This study examines influence of ESG scores on cost of financing shown through Weighted average cost of capital. At the beginning we gave a short glance at literature overview concerning Environmental, Social and Governance ESG factor, with detailed overview of ESG factors in banking industry. The universe of ESG data providers is presented, with their most obvious similarities and differences pointed out.

We argued for using extended WACC to capture the cost of deposits, not just cost of debt that is part of WACC. For equity, we used Capital asset pricing model, while for debt we used interest expense over interest bearing liabilities. For weights we used market values of both debt and equity. For ESG scores we used scores provided by Sustainalytics. By using Spearman's rank coefficient correlation, we established that there is no correlation between ESG scores and cost of funding, either debt, capital, or combined.

For ESG to have influence, we argue that there should be positive correlation between cost of capital and ESG scores. If pursuing ESG principles does not provide any benefit to the banks, there is a possibility that banks would consider ESG as nuisance, and not as principles of good governance that should

## Acknowledgments

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ARTIFICIAL INTELLIGENCE AND FINANCIAL MODELLING

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***Abstract***

*Predictions suggest that artificial intelligence will lead to the reduction of 300 million jobs in Europe and the US. Accountants are professionals who are most exposed to the potential impact of artificial intelligence on their work. Does this also mean the end for experts in financial modelling? Keeping this in mind, how can those of us involved in financial modelling ensure that we remain relevant in this constantly changing world? The answer lies in those who learn and adapt to changes will continue to thrive. Artificial intelligence brings advantages, not just threats; let's leverage them.*

*How can artificial intelligence help in finance and financial modelling? By helping us understand the vast amounts of data we encounter every day and uncovering connections between them. This information will help us improve our business processes, facilitate decision-making, and enhance forecasting. Companies should leverage artificial intelligence to improve competitiveness, mitigate differences caused by human errors, and automate repetitive tasks as much as possible. Through our work, we will attempt to showcase use cases of artificial intelligence in financial operations and financial markets. We will try to demonstrate the benefits of artificial intelligence for financial modelling and forecasting as an efficient way to gain advantages in this field by processing complex tasks that ordinary people cannot perform and automating them. The automation process is essentially the key advantage of AI for financial modelling.*

***Keywords:*** *financial modelling, artificial intelligence, automation Information, business processes.*

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# 1. Introduction

Financial modelling is the process of creating a mathematical representation or simulation of a financial situation or business using various financial data, variables and assumptions. It is a key financial and investment analysis tool used for decision-making, forecasting and planning. Financial models, in short, help predict a company's future financial performance by bringing together accounting, business metrics, and finance (Rafa, 2023). They can be applied to a variety of scenarios, including valuing a company, projecting future financial performance, evaluating investment opportunities, and assessing risk.

According to experts, the introduction of artificial intelligence will lead to the reduction of about 300 million jobs in Europe and the USA. Financial professionals will be most exposed to the possible impacts of artificial intelligence on their work. Does this also mean that it is the end for financial modelling experts? We who deal with this profession, that is, creating financial models, and predicting possible scenarios of events caused by financial decisions, how can we ensure that we remain relevant in this world that is constantly undergoing changes. This is the answer to the question posed above, which is that those who learn and adapt will continue to work and progress and use all the benefits that artificial intelligence brings. From this, it follows that artificial intelligence is not a threat to financial modelling experts, but that we should use it.

How can artificial intelligence help build financial models? In a way to understand and successfully process the huge amount of data we encounter every day and to discover the interdependencies between them. Artificial intelligence will help us to make better use of this everyday information and thus improve our business processes, improve forecasting and ensure successful business decision-making (Al-Okaily & Al-Okaily 2024). By applying AI tools, companies will reduce human errors to a minimum, automate many tasks, primarily those that are repetitive, and thus better understand the needs of our customers and increase competitiveness.

In the paper, we will try to show the benefits of using artificial intelligence in creating financial models and on financial markets. Primarily the benefit of using AI in predicting future possible scenarios, is an efficient way that leads to competitive advantage. In addition, AI helps us to process complex tasks that ordinary employees cannot do or automate as reliably as possible when creating financial models. Process automation is essentially a key advantage of AI for financial modelling.

# 2. How AI is used in financial modelling

Financial models are used for a wide range of purposes in the world of finance, business and investment. Here are some applications of financial models: valuation, investment analysis, planning, mergers and acquisitions, project finance, budgeting and forecasting, risk assessment, portfolio analysis, leveraged analysis,

sensitivity analysis, capital structure, financial reporting, supply chain management, pension fund management etc (Perumalsamy et al., 2023).

AI can address several challenges in traditional financial modelling, offering solutions that improve accuracy, efficiency and decision-making.

How is AI used in financial modelling? As we mentioned above all, it helps employees understand huge amounts of data and discover interdependencies within them. In this way, the company tries to offer better prices for products and services, better understand the needs and demands of customers, reduce employee errors and automate all repetitive tasks.

Financial models are often reminiscent of a tower of cards, where it is necessary to balance every assumption that will keep the tower from falling or the business from failing (Saxena et al., 2023). Artificial intelligence can help make financial models stable. In what way and what can we expect?

- Artificial intelligence will take over solving tasks and concepts that are complex, and time-consuming, with a lot of data. In this way, it will make them simple and quickly accessible. Modelling requires a lot of manual work and making models from scratch and according to pre-prepared templates, and statistics say that about 90% of such templates contain an error, which would be eliminated in this way. A mistake in big companies and big jobs can cost several millions.
- AI can help make financial modeling and forecasting faster and easier, while at the same time adapting to emerging changes on the fly. AI will help us use a language that is understandable to most employees for complex models and reports, and even help AI recognize trends, risks and possible omissions. All this reduces the risks for the company's operations.

In one paper, we already discussed the integration of business risks into financial models, and there we saw how much it is possible to reduce risks and improve business decision-making.

We will list a few common applications of AI in the financial market.

1. Process automation in corporate finance
2. Improved customer relations. One of the most practical applications of AI in finance is in customer relations. Financial companies are using ML technology such as chatbots to improve customer experience through on-demand assistance and real-time recommendations. In addition, customer acquisition and onboarding are often automated at insurance companies to make the process faster and easier.
3. Security analysis and portfolio management. robo-advisors
4. Stock market forecasting
5. Online lending platforms
6. Fraud prevention
7. Risk assessment
8. Property valuation etc

At one of the discussions on the use of AI in financial modelling, Rob Matthews of Spiff said that we should use AI to do "the simplest jobs that are essentially the weakest". Why is that?m These tasks take a lot of time and can easily be automated. These jobs bring the most mistakes and damages in business. The first thing that should be applied in financial modelling is the organization of data. Collecting the information we need to create financial models comes from multiple sources, and Ai can help us by combining and categorizing this data into sets, to help us in the analysis. By analyzing this data, we can see deviations in that data, opportunities and potential risks.

From this we see that AI is becoming a combination of data administrator, financial analyst and data modeller, giving us good model foundations from which experts in the field can fine-tune the financial model. This allows experts in this field to spend less time on creating a financial model and creating possible scenarios, and more time on "Why" it is so and could it be different.

We see that there are very clear advantages of applying AI in the creation of financial models in the company. However, the question arises how to implement AI in your business. Will it lead to an advantage or is it a danger for our experts. Will there be fear of application and rejection of such type of business? That's why key steps should always be considered before implementing AI in financial modelling.

- Consider whether there is a need to apply AI in financial modelling
- Find the right solution. If there is a need to implement AI, it is necessary to find the right solution for our company, because it cannot be copied from other companies
- Choose which tools to use.
- Ask the question of whether to believe or verify. Technology as well as employees need time to become familiar with the processes, in order to be able to trust them, until then the results need to be checked and verified.

### 2.1 Five disciplines of financial modelling

As AI progresses, financial modelling must also adapt to the emerging changes.

The first phase of financial modelling involves scoping and design, where financial experts work closely with stakeholders to understand the specific requirements of the financial model. AI.

In the drafting phase, a real financial model is created, which represents a realistic financial scenario. Financial modellers use a variety of tools, including spreadsheets and software solutions, to create these models. Artificial intelligence can be used to streamline and create automated output generated by scoping and design (Kartanaitė et al., 2021).

**Overview of financial models** is a critical step to ensure accuracy and reliability. This includes validating input assumptions, calculation logic, ensuring formula accuracy, following best practices, output validity, and sensitivity to any changes. While review tools exist to assist financial modellers in this process, AI can improve reviews by detecting errors and increasing model accuracy

Financial modelling helps analyze different scenarios and determine whether the business case is sensitive to changing assumptions. AI can provide a more complex analysis of scenarios, allowing financial modellers to focus on interpreting results and making strategic decisions.

While AI can provide important insights and insights from data, employees are needed to translate and effectively communicate these insights to other stakeholders. The ability to communicate complex financial information clearly and contextually remains a critical skill in financial modelling.

## 3. Advantages of using artificial intelligence for financial models

The term AI has become popular recently. This is not surprising, because the potential of this technology is huge. But because the word is packed with so much excitement, it's easy to lose its true meaning. In the context of financial modelling and forecasting, it can be useful to think of AI as "automation." It's effectively how it benefits the field of finance, taking complex tasks that are usually done by humans and automating them. Now obviously those automations can be multi-step and very complex, but essentially that's the key benefit of using AI for financial modeling and forecasting.

Specifically, some of the key benefits of using AI or automation technology are:

- Simplification of certain jobs
- Reducing the possibility of error
- Reducing the need for a larger number of professional employees. Using AI, formulas and tables can be replaced with a plain language query. This means that everyone on your team can make financial forecasts and build models, not just expert analysts.
- Increasing possible cooperation between employees. Since AI can speed up the forecasting process, this means that the team has the ability to drastically improve their scenario planning capabilities.
- Improves data volume management. With the previous tools, there was a limitation of entering data into certain sets, the application of AI would avoid this.

## 4. Conclusions

The use of artificial intelligence in financial modelling brings numerous advantages that can significantly improve the efficiency and success of our company. From more effective data analysis, customer understanding, error reduction, risk management to increased sales and revenue. AI provides tools that enable deeper market understanding and faster decision-making. In the end, we can conclude that AI will not destroy experts who deal with financial modelling, but will help them to be more efficient, to make better use of information and thus improve their business. By applying AI tools, companies will reduce human errors to a minimum, automate

many tasks, primarily those that are repetitive, and thus better understand the needs of our customers and increase competitiveness (Javaid, H. A. (2024)).

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# ANALYSIS OF THE INNOVATION SYSTEM IN SERBIA FROM A PUBLIC POLICY PERSPECTIVE

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***Abstract***

*The capacity to generate innovation is considered paramount for long-term sustainability of economic development. Given that the nature of innovation creation is collective and dependent on multiple actors and their interaction, the concept of national innovation system (NIS) is a modern approach to public policy that is based on the transformational character of innovation. Innovation policy is particularly significant in emerging and developing economies that lack the necessary market capacity to generate adequate innovation incentives automatically. This paper is focused on the assessment of the key dimensions of the innovation system in Serbia through analysis of the main innovation policy activities. Based on comprehensive data on the activities of the Innovation Fund of Serbia, we conduct an elaborate analysis of the main dimensions and facets of the innovation policy activities in Serbia. Based on this analysis, prominent trends and structural characteristics of the Serbian innovation ecosystem are outlined and interpreted. Finally, we offer several proposals in the area of innovation policy which may address the present weaknesses identified by our analysis..*

***Key words:*** *innovation, public policy, innovation policy, Innovation Fund of Serbia.*

## 1. Introduction

Innovations and innovation-generating research is considered paramount to achieving sustainable economic growth (Romer, 1990). Given that innovation output and novel ideas and knowledge underlying it possess the elements of a typical positive externality, the so-called 'spillover' effects often appear concerning innovation, i.e. the original proprietor of the idea is rarely able to fully capture the complete benefits generated by it, while at the same time innovation surplus is freely captured by the third persons without any reimbursement for the original inventor. Positive externalities ultimately lead to appropriability problems (Nelson,

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1959; Arrow, 1962), which in turn hamper investment in research due to reduced private incentives, thus creating a market failure in the domain of private investment in research and innovative technologies. Prominent public good characteristics, primarily non-excludability (Samuelson, 1954) and the 'free-rider' problem that arise in connection with innovations lead to market failure in terms of financing these activities by economic agents. The stance about the necessity of public intervention in the domain of innovation policy is based on the arguments of market failure in connection with inadequate private incentives to finance innovative activities (Arrow, 1962). Public intervention is deemed as necessary due to positive externalities and spillover effects which cause appropriability problems for original innovators with regards to the innovation surplus, and consequently lead to a suboptimal level of private investment in innovative activities. The role of public policies has long been confined to amelioration of market failures and raising the level of investment in innovation to a socially efficient level in the absence of market incentives. At first, the market failure argument was the dominant rationale for government intervention in the field of innovation by shaping an active research-oriented innovation policy to alleviate market shortcomings (Lewandowska et al., 2022). Predominant model of innovation policy was broadly based on 2 pillars: government spending on research and science due to shortage of private investment; and amplifying incentives for the private sector to engage in R&D investment, directly (by way of providing subsidies) and by strengthening the (intellectual) property rights regime (Ivanovic, 2023). By and large, innovation policy was seen in narrow interventionist terms as merely a means of addressing the gap between insufficient private investment and the socially optimal/desired level of funding dedicated to research and innovation. Following the widespread stagflation in 1970s and subsequent economic crises that lasted into the next decade and led to the breakdown of the until-then prevailing development paradigm, a new concept of competitiveness of national economies centred around innovation and collective learning emerged at the end of 1980s. The construct of national innovation system (NIS) denotes the interaction and interdependence between technological and institutional development, and includes all parts and facets of the economic structure and the relevant institutional environment which influences learning processes and innovation performance (Johnson & Lundvall, 2013). The notion of NIS first appeared in the works of Freeman, whereby he considered NIS as 'the network of institutions in the public and private sectors whose activities and interactions initiate, import and diffuse new technologies' (Freeman, 1987, from Edquist & Chaminade, 2006). From this follows that innovations do not emerge in isolation but rather through a process of continuous interaction between the innovator and the environment, thus implying that production structures and institutional background are equally important dimensions whose interaction defines the national innovation system (Lundvall, 1992). On the other hand, a more narrow approach to NIS can be found in Nelson (1993), who stresses the importance of a nation's R&D capacities and organisations which are crucial in the process of creation and diffusion of innovation. However, a more comprehensive notion of NIS puts emphasis on the fact that these organisations are embedded within a broader

network of socio-economic structures in which the direction and intensity of innovation is influenced by a host of external (political, cultural, social) forces and public policies (Freeman, 2002).

The strategic role of public policies is especially important for developing economies which are in the process of building innovation capacity and stimulating private investment in innovation (largely in absence of adequate market incentives), in order to overcome the development gap by expanding the technological and production possibilities frontier. In addition, specific challenges in the process of development of the innovation system and building of innovation capacity in small countries lies in numerous limitations that are posed by various factors: institutional deficiencies and uncertainty of 'rules of the game', specific level of development of the economic structure that influences needs, strategies and priorities in the development of the innovation system, international circumstances and the global position of the economy (which determines the degree of dependence on advanced systems and globally available resources for innovation development), available domestic potential for commercialisation of knowledge and new ideas, and regulatory framework (Ivanovic & Simic, 2024). According to North (1990), a precisely defined and consistently enforced regime of property rights is the single most important factor for encouraging investment, innovation and efficient resource allocation. Secure property rights are the connection between investment and the resulting benefits that investment generates, in terms that property rights provide the basis for proprietors to claim ownership of the yields stemming from the initially undertaken investment. If property rights are protected and free from political interference then investors face reduced risk and uncertainty over their ability to fully capture the results of their investment, and in that way secure property rights directly contribute to rectifying the appropriability problem related to innovation. Another important consideration that inhibits investment and infringes upon intellectual property rights is corruption. Widespread corruption (both in its petty and political forms) inhibits innovation through undermining enforcement of IP laws and regulations, erodes public confidence in institutions and rule of law and creates artificial barriers for innovators in the domain of registration and enforcement of IP laws through lack of transparency and legal uncertainty, thus making it difficult for businesses to navigate such unpredictable environment (Huang & Yuan, 2021). Both property rights uncertainty and corruption therefore substantially hinder innovation and amplify inherent uncertainty and risk contained in innovation that reduce innovators' incentives.

Taking into account the path dependence of the innovation system and its reliance upon the existing institutional infrastructure, as well as the failure of the market to automatically generate necessary incentives for the development of an efficient innovation system, for countries like Serbia that lag behind developed economies in terms of innovation performance, effective public policies are of paramount importance for the establishment and development of innovation capacity and supporting infrastructure. This imperative stands out particularly in the domain of defining and implementing appropriate public policies to support the construction and development of the innovation system, owing to the fact that

multiple critical elements of the innovation system generated by the market do not necessarily have adequate conditions to automatically emerge in developing economies. Therefore, developing countries as a rule necessarily require public support in the form of effective policies aimed at fostering development of an efficient innovation system.

This paper provides a comprehensive overview of innovation policy in Serbia by conducting a detailed analysis of the activities of the Innovation Fund. We aim to capture the principal dimensions, dominant structural trends and key characteristics of the innovation landscape in Serbia, thus providing a unique perspective on how public policy navigates the challenge of shaping an efficient system for fostering innovation, while addressing the obstacles in the form of resource availability, inherited (and increasingly anachronistic) institutional structures and the imperative to catch up, development-wise, and remain competitive in a complex and increasingly globalised environment.

## Institutional foundations of innovation policy in Serbia

The adoption of the Smart Specialisation Strategy in Serbia (4S) in 2020 established a comprehensive platform for innovation policy which 'involves the efforts of policy-makers, business sector, academia, research community and other stakeholders with the aim of increasing the competitiveness of the economy, economic growth and progress of the society through connecting research, industrial and innovation forces with a limited number of priority economic areas' (Smart Specialisation Strategy of Serbia, 2020). By concentrating efforts and allocating resources to only those sectors deemed a priority, i.e. most competitive and with the highest potential for successful innovation development, 4S contributes to streamlining the resource allocation and improving overall efficiency and productivity of scarce domestic resources, while simultaneously increasing resilience and diversification of the Serbian economy. The 4S defines four priority areas to which policy measures and resources allocation should be targeted: food for the future, ICT, future machines and manufacturing processes and creative industries (Smart Specialisation Strategy of Serbia, 2020). The choice of innovation priorities resulted from entrepreneurial discovery process in which a thorough analysis of available resources and domestic capacities, as well as the future prospects for growth and development based on knowledge and innovation was carried out in the form of a widespread social dialogue involving key stakeholders within the national innovation system (businesses, science and research sector, academia, policy-makers and civil society experts). As such, the final Strategy can be interpreted as not merely another administrative and regulatory framework imposed unilaterally by policy-makers but rather as a more organic and evolutionary bottom-up approach to policy-making that engages various stakeholders and joins their respective expertise and interests in the process of informing and formulating national innovation policy (Estensoro & Larrea, 2023). Taking into account the fragmented structure of Serbian businesses and distinctive lack of cooperation between relevant sectors, implementation of the

entrepreneurial discovery process in itself is an important step forward in the direction of increasing cooperation and synergy within the national innovation system. Another significant potential benefit is the fact that increased stakeholder involvement in policy formulation reduces the risk of policy failures as it boosts transparency and mitigates the available room for rent seeking and regulatory capture by interest groups. However, the implementation of 4S in Serbia diminishes some of the benefits of the entrepreneurial discovery process, given that the strategy was operationalised only on a national level, as opposed to the regional (NUTS 2) approach (Radonjic, 2022).

Given that the regional level is institutionally seldom developed, smart specialisation can be seen as a 'leapfrogging' strategy, i.e. it could provide the necessary catalyst for establishing the missing institutional structures and regional capacities. That way, the region-specific specialisation would initiate bigger inter-regional cooperation and develop regional innovation potentials in a bottom-up manner that would engage local stakeholders with vested interests and the best knowledge of each region's specific needs, priorities and opportunities for development. As it stands, however, the choice of centralised smart specialisation, rather than regional, reflects prioritisation of more immediate concerns (catching up with developed economies) and benefits of a top-down approach for resource mobilisation and targeted allocation over the comparatively more distant and less immediately tangible benefits of establishing a regional perspective in the context of building domestic innovation capacity. Additional possible interpretation involves treating smart specialisation strategy as purely an administrative framework and a formality necessary to facilitate access to the EU funding schemes, thus implying the failure of national government and political elites to fundamentally understand the essence of what 4S is and its role in the national innovation system (National Convention on the EU, 2023). A bureaucratic approach to smart specialisation is not specific to Serbia, given that certain regions of the EU opted for a similarly technocratic perspective (Laranja et al. 2020), which can be attributed to the quality of the intermediary institutions and the ability of policy-makers to engage wider community and sustain stakeholder engagement in the process of development and implementation of the strategy (Cvijanovic et al., 2020; Muur, 2022). Moreover, the observed heterogeneity of experiences of certain EU regions with respect to smart specialisation suggests that there is no universal approach to smart specialisation that is guaranteed to succeed. According to Aranguren et al. (2019) regional structures and mechanisms exhibit strong impacts of path dependence which condition the way in which smart specialisation is implemented. Similarly, smart specialisation impacts are shown to build upon and reinforce existing regional agglomeration and cluster effects (Foray et al., 2021) and therefore tend to perform better in regions with pre-existing networks of innovation resources and infrastructure in place. On the other hand, there are countries that have managed to facilitate a sustainable concept of fostering regional cooperation and innovation synergy through smart specialisation (Kangas & Ryyanen, 2022) , and in some cases (like Romania) did so despite lack of appropriate institutional support on a regional level (Perianez Forte et al., 2016). There are also countries

(like Estonia and fellow Baltic states) that have, due to their size, implemented the national model akin to one used in Serbia and managed to perform successfully in terms of building innovation-based competitive advantages and to achieve certain degree of convergence (in terms of innovation performance) with more successful countries (Muur, 2022).

According to Radonjic (2022), the process of formulating 4S in Serbia involved both regional and national-level approaches, particularly in regards to identifying the 4 priority areas which relied on entrepreneurial discovery and engaged relevant stakeholders in the process of identifying and assessing economic, creative and innovation capabilities of specific regions. Present regional inequalities in terms of economic strength and capacity for development based on knowledge and innovation posed a major hurdle to region-specific implementation of the Strategy, which ultimately resulted in the decision to develop regional competencies and innovation capacities through an integrated centralised approach. In absence of relevant institutional capacity on a regional scale and with considerable inequalities in economic power and resource capacity between different regions of Serbia, advantages of a national approach to smart specialisation ultimately prevailed over regional aspects and distributional concerns. In a centralised structure of NIS the bulk of innovation policy activities are organised through one central institution - The Innovation Fund of Serbia (IF). Its primary purpose is to provide specialised support and manage public funds and other financial resources for promoting innovative projects and adjacent activities. After coming under the umbrella of the new policy paradigm defined by 4S which entails holistic approach to innovation from a systematic perspective, the Innovation Fund's programs were reconfigured to address the imperative defined by 4S and encourage development of the chosen strategic areas. Presently, the IF comprises the following programs: Mini Grants, Matching Grants, Collaborative Grant Scheme, Katapult, Smart Start, Technology Transfer, Innovation Vouchers, Serbia Ventures, Serbia Ventures - Biotech, GovTech and Regional Start-up Centre Capacity Building, and Proof of Concept (which has since transferred to the Science Fund) and a special one-off COVID-19 program (Innovation Fund of Serbia, 2024).

## 2. Assessment of key dimensions in Serbian innovation system - analysis of Innovation Fund activities

The distribution of approved projects across available IF programs indicates that the largest share of all supported projects is taken by the Innovation Vouchers program, followed by Mini Grants in a distant second place and Proof of Concept in third position. The dominant position of the Innovation Vouchers is not surprising given the short time frame of realisation (6 months), relatively low amount of funding provided by the program and the degree of flexibility that is afforded to recipient firms with regards to the use of funds. Additionally, the popularity of the voucher scheme signals the need (and willingness to seek) on behalf of innovative firms for expert advice and scientific support from academia in the process of developing and implementing commercial innovation, suggesting the existence of

significant benefits and potentials for further collaboration between the two innovation pillars. Moreover, the non-predetermined nature of the voucher system with regard to concrete services to be obtained from research institutions goes a long way toward ensuring the widespread scope of availability and access to the program for as many beneficiaries as possible, irrespective of their prior capacity to assess their own specific needs and particular modes of service befitting their project. The 'catch-all' blanket concept does not condition the support on the ability of applicants to accurately specify beforehand the exact knowledge or service they seek to employ, and instead relies on the market mechanisms to determine the best fit for each individual project. Put differently, vouchers provide the necessary funding, but the choice of the exact service and its provider is left to the recipient, thus rendering them more flexible in terms of exploring and choosing between the available options. On the other hand, the Mini Grants program provides financial support for establishing innovative start-ups and supplying novel solutions on the market, and its position in the distribution of IF projects demonstrates the importance and general lack of financial resources available to start-up entrepreneurs. This fact is underlined by the number of applications submitted in this program, which is substantially higher than any other program under the IF umbrella, suggesting the overwhelming need for public funding in the start-up community. Financial assistance is essential during the critical phase of initial funding that is necessarily expense-heavy and therefore requires the financial capacity to operate at a loss on the expectation of future returns once the innovation takes off and begins accruing revenue, something that very few start-ups can afford on their own or through traditional investment channels.

Proof of Concept is the most commonly used program out of the research and scientific-oriented cluster of projects. Its purpose is to provide the necessary funding to researchers in order to conduct the assessment of practical applications and commercial viability of their scientific research. The number of approved applications through this IF scheme points to the extent of existing potential for practical innovation that originates from scientific research. Put differently, it implies the availability of research resources within Serbian academic institutions that can be feasibly transformed into novel practical solutions that are commercially successful, and that there are sufficient innovation capacities to enable that process. Furthermore, the widespread use of the program funds suggests that the consciousness of the fact that innovative potential and scientific capacity of Serbian research institutions can be commercially exploited is recognised as a significant driver of economic innovation. Such recognition on behalf of policy-makers is essential, particularly in the context of the fact that bulk of the SMEs in Serbia perceive public institutions governing the innovation policy as the most important actor within the innovation ecosystem (Djuricin & Beraha, 2021).

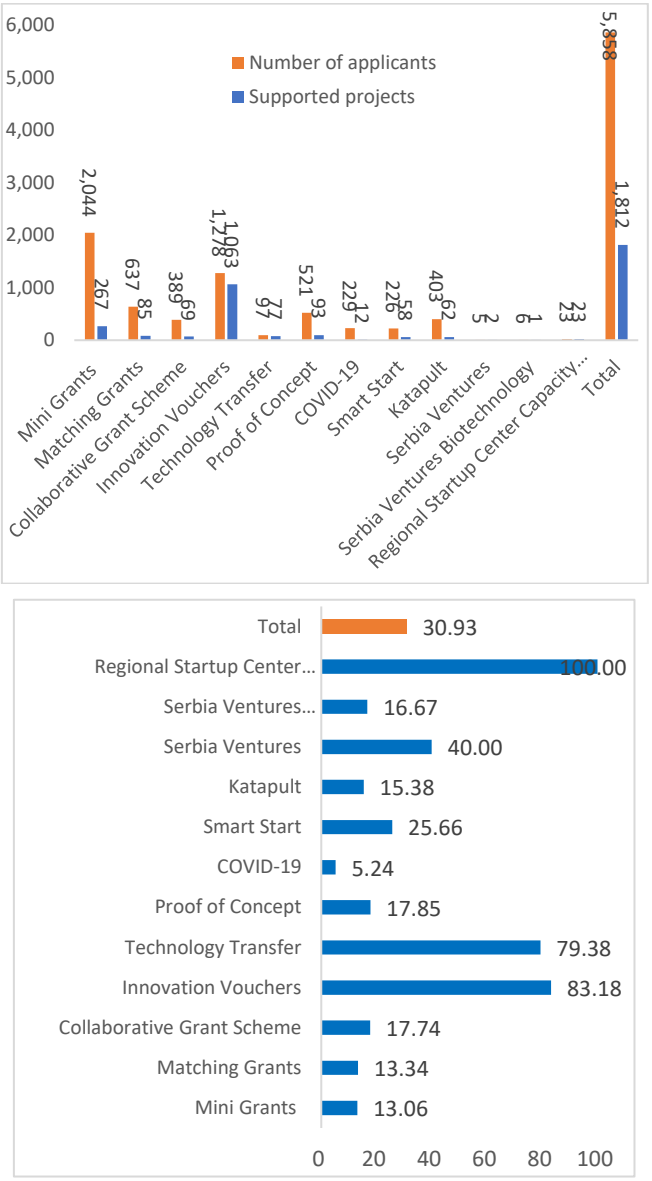


*Figure 1. Number of submitted and approved projects across IF programs and Project approval rate (%) per IF program, until 2024*

Collaborative Grant Scheme and Matching Grants are 2 of the most widely used programs which promote closer collaboration and interaction between research centres and business innovators, apart from the Innovation Vouchers. Unlike the voucher-based scheme, these 2 IF programs directly provide financial support and assistance to businesses and scientific research organisations in the

process of developing joint venture projects aimed at creating commercially feasible innovative products and services, and co-fund commercialisation of business R&D initiatives and activities (Innovation Fund of Serbia, 2024). Therefore, they support a more direct, all-encompassing and long-standing type of collaboration between the science sector and businesses in the process of conceiving and developing commercial innovation. Relative lagging behind the Innovation Voucher program in terms of the number of approved applications indicates that the dominant form of cooperation between the academia and industry is mainly based on the more consultative approach and application of scientific expertise in the process of commercialisation of pre-conceived innovative solutions, rather than integrating the knowledge capacities in the process of collaborative research and development of innovation. Similarly, Technology Transfer is a science and research-oriented program that trails the related Proof of Concept scheme of financing research projects. Given that both programs cater to the same target group and aim to increase researchers' capacity and efficiency in the field of commercial development and application of scientific knowledge and results, the observed discrepancy between the number of approved projects may be evocative of two possible reasons. For one, it can indicate that willingness of research institutions to fully engage in commercialisation of their inventions is limited. However, based on the fact that there is a demand for commercial assessment of research through the Proof of Concept program, another explanation is that there is insufficient capacity or missing entrepreneurial drive in the research community to make the transition from theoretical concept into tangible innovation ready for commercial deployment, which further emphasises the importance of stimulating cooperation between the scientific and commercial sectors in order to facilitate integrated development of innovation.

Besides the absolute numbers of funded projects and their program-wise distribution, another important marker of the dynamics in the Serbian innovation system that can be assessed from IF's activities is the level of competition and efficiency of individual innovative initiatives. These aspects can be explored through analysis of acceptance rate per specific IF programs, which demonstrates the intensity of competition for particular programs' support, and the extent to which individual submissions manage to succeed in meeting the selection criteria necessary to obtain the funding through IF. Overall, IF has so far supported 1.812 projects out of 5.858 applications across all program platforms, amounting to a total approval rate of 31 %. The success rate indicates that nearly a third of submitted project applications managed to obtain funding from IF, while over two thirds of applications were rejected. The interpretation of the performance rate can be twofold. First, the fact that only one third of submissions were evaluated positively and were granted funding suggests that innovation capacities of applicants are limited and therefore unable to meet the performance standards outlined in program requirements. Additionally, the level of interest in financial support provided by IF testifies to the comparative shortage of available funds elsewhere which consequently leads to over-reliance on public resources, thus indicating the under-development of financial markets geared towards innovation and reinforcing

the critical role of public policy in that context. However, the suboptimal rate of positive outcomes may also indicate that the Innovation Fund applies a rigorous and diligent evaluation process that only selects those projects that unequivocally fulfil the required criteria for funding, which minimises resource waste and ensures that the IF's funds are allocated to according to their most effective uses. On the other hand, the 31 % approval rate can be seen as a positive indicator of the vibrancy that exists within the innovation ecosystem. From that standpoint, tough competition for IF funds demonstrates the existence of widespread interest in innovative activities in firms and entrepreneurs, awareness of their innovation potentials and the critical role of innovation in their survival and development. Furthermore, it can be argued that, irrespective of the actual outcome, the act of participation in IF's programs in itself has merits in terms of improving participants' innovation capacity. The rationale behind this argument is the fact that exposure to fierce competition during the application process forces the participating parties on its own to assume a learning trajectory and acquire additional knowledge and resources, improve their skills and aptitude for generating knowledge and innovation. That way, even if the funding is not obtained, the participants still receive intangible benefits from the process which ultimately increases their overall internal capacity for innovation, and can be considered as a form of behavioural additionality (positive change in innovation skills and behaviour of firms) as a result.

Further insights can be gained by examining approval rates per individual program. In that respect, two programs in particular stand out from the rest of the IF portfolio by the above-average margin of success - Innovation Vouchers and Technology Transfer (besides the Regional Start-up Centre program, which is by definition 100%, as it is an intra-institutional program that builds government capacities) . The success rate of Innovation Vouchers is especially remarkable given the popularity of the scheme and the number of applicants that exceeds all other IF programs combined (except the Mini Grants). High demand for vouchers indicates that there are significant benefits in cooperation between businesses and academia as well as the necessary incentives for enterprises to seek support from IF, while the degree of successful applications implies that there are sufficient capacities to capitalise on the aforementioned advantages. Success of the voucher scheme points to the fact that entrepreneurs recognise the value of scientific research and expertise in the process of conversion of innovative ideas into tangible products, thus demonstrating the raising awareness of integration into dense innovation networks as means of supplementing own resource or capacity shortages. Even more significant, however, is the extraordinarily high percentage of approved projects in the Technology Transfer program. Taking into account that this program is targeted at the scientific community and supports commercialisation of research conceived in academic institutions, the 80 % success rate can be attributed to the high quality of submitted research projects and their prospects for commercial success, thus indicating the existence of a high-performing academic research sector with significant own capacity for innovation. Moreover, a strong rise in submissions corresponding to the discontinuation of the Proof of Concept program may demonstrate the ability of the scientific sector to seamlessly transition from the

testing phase into a fully integrated process of innovation development from research to commercialisation. This further suggests that there is an important resource base within the scientific sector in Serbia that is adequately equipped with sufficient internal capacity for generating knowledge and fully developing innovative solutions.

On the other hand, despite outperforming in terms of the strong rate of success, there is still a comparatively low number of applications relative to other IF platforms, which translates to lower level of overall interest in this particular program. Given the apparently high degree of internal capacity for innovation in the scientific sector, lower interest for IF programs can be attributed to the existence of alternative sources of funding available to and used by innovative researchers which implies that this particular part of the innovation ecosystem in Serbia is less dependent on public support in the process of innovation development, especially in comparison with start-up entrepreneurs and SMEs. Furthermore, it may signal the imbalance of innovation capacities between the business and research sectors in favour of the scientific community (an assumption that is corroborated by the fact that 2 of the most popular IF platforms cater to both business and academia and support their interaction), which further underlines the importance of facilitating collaboration between the two parts of the innovation system in order to improve overall innovation performance. Additionally, this may point to the fact that there is a substantial part of the scientific community that is innovation-active and self-sufficient to the extent of being largely independent in their innovative endeavours, and thus out of reach of the innovation policy, which reduces the potential for knowledge sharing through collaboration with other actors within the system that would otherwise be possible.

Another valuable aspect of the analysis is regional (NUTS 2) distribution of projects funded by IF, which gives an approximate estimate of the degree of concentration of innovation resources and regional capacity for developing innovative projects. Put differently, the regional analysis offers useful insights in terms of which regions are drivers of innovation performance on a national level. According to IF's data, the overwhelming majority (over 50 %) of projects approved for funding per each program are located in the Belgrade region. The biggest regional asymmetry in favour of Belgrade is recorded in the Proof of Concept and Technology Transfer programs, indicating that potential for commercial innovation supported by the IF is best recognised by the research entities based in the Belgrade region compared to the rest of the country. This fact further suggests that research activities and capacity for commercial development of innovation in academic institutions are disproportionately concentrated in the capital city. Additionally, the Belgrade- centric distribution of IF's funds aimed at supporting commercial development of scientific innovation is evocative of the awareness of the innovative potential in research organisations located in the capital, and of their integration in innovation networks, which makes the Belgrade based research hub the most active scientific part of the national innovation ecosystem. Given that every macro region in Serbia have their own university centres, the dominant position of Belgrade serves as an indication of the lack or insufficient degree of recognition for benefits

of commercial innovation and corresponding potential for their development in the academic sector outside of the capital city. Similar discrepancy in performance between Belgrade and the rest of the regions in Serbia is apparent from other IF programs as well, although to a lesser extent than in the case of the science-oriented platforms. For instance, in the Smart Start and Mini Grants programs there is also an imbalance in favour of start-ups from the Belgrade region, which account for almost three quarters of successful applicants. This implies that, analogous to resource disparity in the scientific sector, potentials for emergence of novel ideas and capacities for their development and market commercialisation through establishing of start-up companies are substantially clustered within the region of Belgrade. Additionally, significant lag in the number of supported start-up businesses registered in regions other than Belgrade may also be indicative of the comparatively low capacity for establishing start-ups and weak(er) entrepreneurial culture in general.

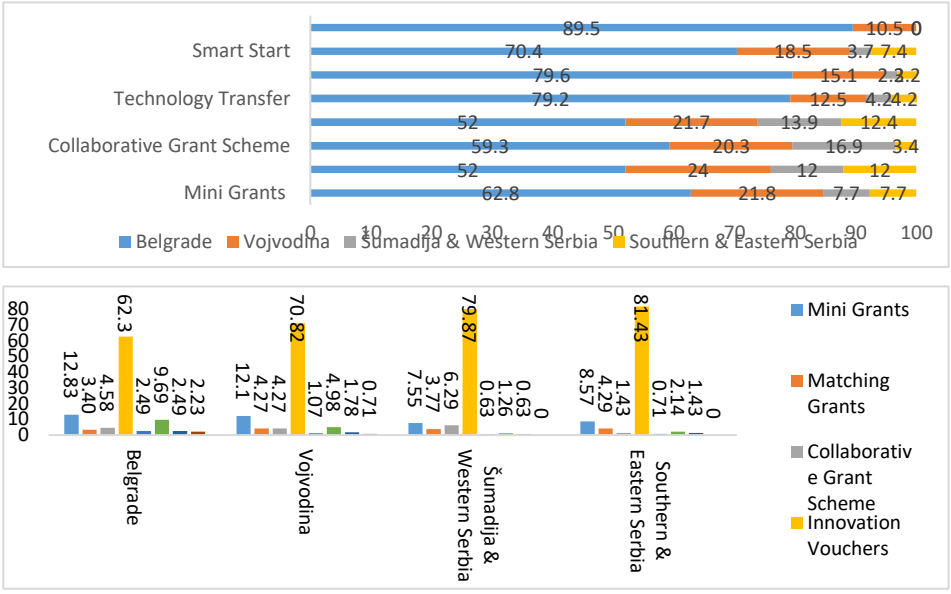


*Figure 2. Regional distribution (%) of approved projects per SF program and Share (%) of programs in the structure of approved projects across regions, until 2021*

Another example of unequal distribution of innovation resources and capacities can be seen in the dominance of Belgrade enterprises in the structure of funded projects through the Matching Grants scheme, which demonstrates that innovation capacities in the private sector are equally concentrated as is the case in the research organisations. Furthermore, owing to the fact that this program supports innovative businesses in the process of commercialisation of their own research projects, it can be argued that private companies located in the capital possess substantially greater capacity to develop their own innovation in a self-

sufficient manner and relying upon internal resources than it is the case for firms in other regions.

Representation of certain programs in the structure of approved projects in different NUTS-2 level regions is important for mapping regional trajectories and dominant mechanisms of development of the innovation ecosystem, and to assess the degree to which the IF support for innovative projects coincides with regional-specific competitive advantages and development levels of regional innovation capacities. In that regard, it is evident that the Innovation Vouchers program is the most frequently utilised IF platform in all 4 macro regions of Serbia. However, the extent of the program's prominence varies across the regions, with the biggest share of the Vouchers being recorded in the Šumadija and Western Serbia and Southern and Eastern Serbia regions respectively, which illustrates that these 2 regions disproportionately rely on the short term programs compared to other available IF venues. Conversely, in the Belgrade and Vojvodina regions the voucher system is comparatively less represented in the overall structure of IF funded projects and the Mini Grants program is more prominent compared to other 2 regions. These trends suggest that the least economically advanced regions - Šumadija and Western Serbia and particularly Southern and Eastern Serbia - overwhelmingly favour the more immediate and applied models of support for the development of their respective innovation systems. Private businesses located in these regions disproportionately rely upon engagement of the short-term academic services in the process of commercial development of existing solutions as the dominant mode of improving their innovation performance, as opposed to establishing a long term strategic collaboration with the research organisations and/or investing in their own research capacity and ability to independently conceive and develop creative innovation. By contrast, in Belgrade and, to a slightly lesser extent, Vojvodina there is a broader appeal of the support measures tailored to the needs of new-founded firms and start-up projects through the Mini Grants program, suggesting an elevated level of business sophistication and propensity for sustainable effort towards establishing and improving own innovation capacities in these regions. One more remarkable aspect is that the Proof of Concept program features prominently in the Belgrade region, thus reinforcing the notion that the research cluster based in Belgrade is the most active and influential sector of academia in the country in terms of commercially feasible and market oriented innovation activity.

However, one somewhat unusual finding is the fact that IF programs such as the Collaborative Grant Scheme that support integration of business innovation with scientific research feature more or at least equally prominently in the project structure of economically and innovative underdeveloped regions. This apparent inconsistency may point to the increased need of innovative enterprises from these areas for supplementing their own lacking research capacity and resources with the external infrastructure and expertise found in the academic field, which ultimately implies that businesses and researchers elsewhere (in Belgrade and Vojvodina) possess a higher degree of own knowledge capacities for developing novel solutions and therefore need to rely less on external resources. Additional argument in favour of the sophisticated and highly developed innovation activity in the Belgrade

region's research sector stems from the fact that in the region of Šumadija and Western Serbia, which is most dependent on the collaborative business/academia schemes of the IF, business seeking academic expertise and partnership in the innovation process disproportionately cooperate with scientific institutions outside of their own region, mainly from Belgrade (Radonjic, 2022). In addition to reinforcing Belgrade's strong position in terms of innovative research capacity in the academic sphere, this fact further suggests that academic capacity for innovation is not sufficiently developed and/or the potential for and value of commercial implementation of knowledge through research and development is not yet adequately valued by the scientific community in the Šumadija and Western Serbia region.

## 4. Conclusion

Based upon the above analysis of dominant policy mechanisms for fostering innovation, certain key out-takes arise from these considerations about the general features, prevailing conditions and developmental patterns in the Serbian innovation landscape. Firstly, the demand for funding and other benefits offered by the Innovation Fund continuously exceeds resources at the disposal of these institutions and therefore the degree of competition involved in the Fund's support programs is significant. This fact indicates that there is a vibrant and dynamic population of innovation actors in all targeted sectors (start-up entrepreneurs, businesses, science and research institutions) that recognises the value of knowledge and creative innovation and possesses the potential and capacity for commercial deployment of knowledge and development of innovative solutions. However, the initial innovation capacity, and therefore dominant mechanisms of innovation development (and corresponding use of support mechanisms) vary substantially between specific innovation actors according to their type, size, industrial area and region of origin.

In that regard, the second salient feature that defines Serbian innovation ecosystem is one of strong and enduring centralisation and asymmetry, primarily of territorial variety that subsequently influences and reflects itself in other dimensions that determine innovation performance. The overwhelming bulk of innovation resources, capacity and activity in Serbia is concentrated in the capital city of Belgrade and its adjacent area, followed quite distantly by the Vojvodina province and leaving the remaining 2 regions of Šumadija and Western Serbia and Southern and Eastern Serbia trailing very far behind. The vast majority of innovators in the two least developed regions (both economically and in terms of innovation) rely more heavily on policy support in their innovation efforts and tend to approach the innovation process (and collaboration with external partners) in a short term fashion that favours adaptation and application of existing solutions rather than development of their own capacity for creative innovation based on research. Contrary to this practice, in Vojvodina and especially in Belgrade there is a more pronounced focus on the more sustainable and advanced approach to innovation through building and improving start-up entrepreneurial capacity for generating

knowledge and its transformation into novel commercial uses, and the policy support mix focuses more prominently on sophisticated research and development of own innovation capacities, as well as on cohesive commercial deployment of creative ideas and scientific outputs. The overall dispersion of projects approved for funding by the Innovation Fund reflects (and indeed often amplifies) the aforementioned asymmetrical tendencies, given that the critical portion of resources is allocated to projects and entities with the largest and most efficient innovation capacity, and those are predominantly based in the Belgrade region. Taking into account that delayed effects and intangible implications of policy support extend beyond the immediate scope of funded projects, and given the critical importance of public funding for emerging innovators with few independent innovation resources, the practice of allocation of the Fund's resources that disproportionately prioritises actors with established and more advanced capacity directly contributes to exacerbating the gap in innovation performance between emerging and sophisticated innovators. In the Serbian context of all-encompassing regional disparities in economic power and innovation ability a policy approach that favours efficiency and performance ultimately reinforces existing discrepancies.

While such policy approach is justified in terms of the imperative of boosting overall innovation performance in the country, and is endorsed by the Smart Specialisation Strategy and its stated objectives, there needs to be awareness of the inherent trade-off that targeted support guided by excellence entails, which in the long run, through compounding present contradictions, may affect the stability and sustainable development of the innovation system itself. The singular focus on benefits of establishing a high-performing innovation system through policy support might result in the creation of sophisticated knowledge-based and innovation-intensive clusters that are embedded in wider European and global innovation networks but have few links with local economy and negligible impact on welfare of the local population, the phenomenon known as the 'desert cathedral' (Hassnik & Shin, 2005; Morgan, 2007). Given that the Innovation Fund has no explicit mandate to consider distributional implications of their activities, in order to alleviate potential risks of further divergence resulting from innovation performance, it is of great importance to devise a carefully coordinated policy response to these challenges. In that regard it is necessary to consider the need for integrating and coordinating innovation policy with other relevant stakeholders, particularly those concerning regional development, industrial policy, gender and socio-economic inequality. Therefore, the overarching conclusion that can be derived from the analysis of the current activities of innovation policy in Serbia is the need to ensure the higher degree of policy coordination, given that innovations are far from an isolated phenomenon both in terms of the manner in which they emerge and their far-reaching and long-standing implications which go beyond the boundaries of the innovation system. In much the same vein as the objective to incite collaboration between different actors in the innovation ecosystem, the challenges posed by the current innovation policy activities also need to be resolved by establishing and maintaining the similar level of coordination and consistency on a policy-making level in order to ensure effectiveness and long-term sustainability of innovation policy.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-060 Review paper

# WEALTHTECH: FUTURE TRENDS AND APPROACHES IN GLOBAL WEALTH MANAGEMENT

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***Abstract***

*The paper aims to research the latest technologies for Wealth Management and use them to present the WealtTech approaches that give the best advice for investment management decisions and refer to the use of technology to provide financial services and solutions for Wealth Management. Wealth Management is a combination of financial planning and investment strategy analysis for capital growth. It includes retirement planning, inheritance tax, estate planning, and other activities according to investment preferences. Since WealthTech is a part of FinTech, it aims to manage investment funds and assets more efficiently, accessible, and personalized through data-driven insights and smart automation. Besides improving their efficiency, WealthTech aims to automate investment and wealth management services. WealthTech utilizes innovations like blockchain, artificial intelligence, and machine learning to improve investment decisions combining technologies for fund transformation and asset handling. These technologies include a wide range of solutions and include robo-advisors, social trading, robot-retirement, quant advisors, and micro-investing. WealthTech refers to the delivery of many kinds of financial services for Wealth Management based on digital solutions. Besides improving investors' decision-making, the technology enables people to manage their finances efficiently. This approach use the best technology solutions more advanced than typical analysis used in financial institutions. Because of the advancements in software as a service (SaaS), big data, AI and machine learning, the programs provide personalized advice concerning wealth management and business strategies. This manuscript will present WealthTech solutions on the practical example and recommend the most attractive investment opportunities on the global market.*

***Key words****: wealthtech, fintech, investment, management*

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# 1. Introduction

Wealthtech refers to providing digital solutions that facilitate the wealth management process. It is fintech's subset, and its objective is to automate investment and wealth management services besides improving their efficiency.

The wide range of solutions under this umbrella term includes robo-advisors, social trading, robo retirement, quant advisors, and micro investing. A key difference between this concept and fintech is that the latter involves catering to a diverse client base. The target audience in the case of fintech organizations is not predominantly limited to individuals and wealth management firms.

# 2. Theoretical Background

Information-based investments are rapidly growing, especially in the financial and banking sectors (Yi et al., 2023).

For high-tech companies, competitiveness among firms may lead to diversified innovation for a single product, which in turn, may make patent portfolios more complex and difficult to understand by investors (An et al., 2023).

With the deepening integration of internet technology and the financial industry, FinTech has offered the public innovative financial services (Jiang et al., 2018) such as online payment, peer-to-peer lending, budgeting and financial planning, crowdfunding, and savings and investments (Xie et al., 2021).

Financial inclusion encompasses various efforts aimed at guaranteeing that individuals and businesses can obtain cost-effective and appropriate financial products and services. This encompasses the provision of savings accounts, credit facilities, insurance coverage, and payment services, along with other financial instruments that facilitate individuals in effectively managing their finances and enhancing their economic welfare. FinTech can positively impact overall traditional financial inclusion because it enables banks to easily reach populations with limited access to banking services or without bank accounts through the use of digital platforms (Kamara & Yu, 2024). The rapid growth in cryptocurrencies has led them to garner investors' interest as a popular diversification choice (Mansour Nomran et al., 2024; Ali et al., 2024).

FinTech is a sector that is extremely exposed to risk, in particular, technological and market risk. Most FinTech institutions operate in the globalized financial market, which, as confirmed by the recent economic crises, induces above-average challenges for risk managers in this industry (Khalil-Oliwa & Jonek-Kowalska, 2024).

FinTech, short for financial technology, denotes the application of technology to provide financial solutions. It encompasses a wide range of sectors and business models within the financial services industry, extending beyond traditional financing to encompass all services and products offered within this sector (Yang & Jung, 2024).

WealthTech is recognized as a specialized subset of FinTech. It focuses on utilizing digital technologies to enhance investment and client portfolio

management, providing customized products and services tailored to individual needs (Chishti & Puschmann, 2018; Dziawgo, 2021). Figure 1 shows WealthTech management mobile application customized for users investment portfolio.

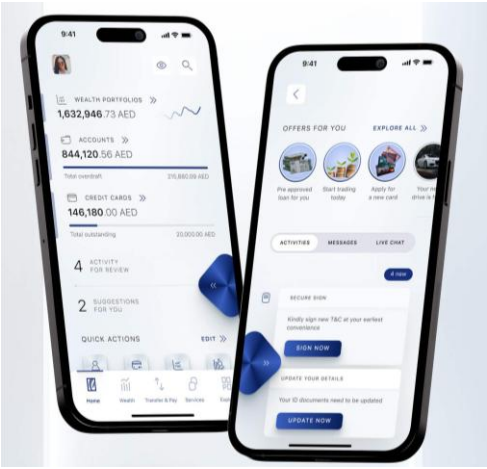


*Figure 1: WealthTech Mobile Application*

FinTech is being used to attract traditional banking clients, optimize commercial transactions, improve credit granting, and simplify banking operations. Financial services are thus being automated, resulting in a correspondingly necessary and accelerated process of transformation. Among the technologies used in this process are big data, blockchain, artificial intelligence, machine learning and cryptocurrencies (Duan, 2024).

The issue of financial exclusion continues to be an important barrier to equitable development in the global financial landscape, even with all the economic progress we are seeing around the world (Amnas et al., 2024).

Individuals can now do their financial transactions anytime, anywhere, thanks to FinTech platforms (Yang & Zhang, 2022). FinTech relates to the usage of technology to deliver better financial services (Almubarak & Aljughaiman, 2024; Thakor, 2020; Goldstein et al., 2019).

FinTech studies mainly concentrate on the implication of FinTech for bank performance (Al-Matari et al., 2022; Arena et al., 2023) or risk-taking (Kamara & Yu, 2024). FinTech is a term that has arisen in recent years; it refers to innovative technologies designed to enhance and automate the provision and utilization of financial services (Balaskas et al., 2024).

The term FinTech refers to the convergence of finance and technology, with an emphasis on the development of new and improved financial solutions (Li & Xu,2021; Thakor, 2020).

Financial innovations (FinTech)—such as automated teller machines (ATMs), mobile payment systems, mobile wallets, internet banking, and blockchain technology—have been a recent development in the financial sector, leading to the digitalization of financial services. The recent adoption and development of FinTech

tools provides consumers with easy access to financial services, fast and easy confirmation of financial transactions, and reduced operational costs (Girma, 2023).

The rapid growth of FinTech adoption and usage has introduced innovative solutions that offer convenience, efficiency, and accessibility (Amnas et al., 2023).

FinTech, a type of technology that enhances access to financial services, has the potential to revolutionize how people manage their finances (Chawla et al., 2023).

Financial technology (FinTech) has permeated every fact of the financial sector during the past ten years, and affected the transformation of investment and financing modes as well as consumers' payment methods (Chen & Wang, 2023; Alkhowaiter, 2022).

FinTech refers to innovative financial services that use technology to create disruptive new trends in services or rewrite financial services to make them more valuable, reasonable, and secure (Jangir et al., 2022).

## 3. WealthTech

WealthTech combines wealth management and technology to transform how funds and assets are handled. It utilizes innovations like artificial intelligence, machine learning, and blockchain to improve personal finance and investing. WealthTech developers build applications that automate manual wealth management processes and provide customized financial recommendations powered by AI.

Wealthtech refers to the delivery of an extensive range of financial services for wealth management via digital means. This technology improves investors' decision-making and enables people to manage their finances efficiently in a manner that is different from how conventional financial institutions work. Because of the advancements in software as a service (SaaS), big data, AI, machine learning, etc., software programs can now provide personalized advice concerning wealth management.

Some noteworthy wealthtech solutions and services are as follows:

Robo-Advisors: These are digital tools often utilizing machine-learning-based techniques to carry out operations for the client or the user. Such software can automatically allocate funds to different financial instruments based on how a user configures it.

Quant Advisors: These are extensions of robo-advisors. Such systems actively utilize AI for managing investment strategies.

Robo Retirement: These are a version of robo-advisors and are quite popular. Robo retirement services involve creating retirement portfolios, managing assets, recommending computer system-generated plans, and providing strategies.

Micro Investing: These solutions enable investing via small credits or microcredits. They provide a more interactive experience compared to robo-advisors.

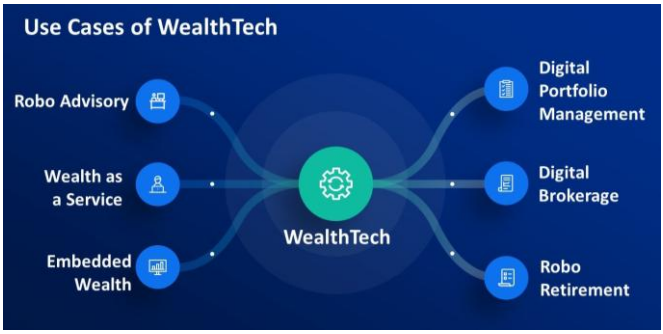


*Figure 2: Use Cases of WealthTech*

*Figure 2 shows one example of the Use Cases of WealthTech.*

Social Trading: It allows investors to share their own trading experience. It combines the concept of social media with that of trading platforms. In this case, traders are able to mimic the investment models of traders who share their opinions. Hence, novice traders can learn from traders who have more experience.

This subcategory of fintech covers more solutions and services, such as the following: Digital brokers, Algorithmic trading, B2B software services, Online marketplaces, Portfolio management tools and Risks.

## 4. Conclusions

By adopting these technologies, both managers and clients benefit from enhanced services and better outcomes. WealthTech marks an exciting shift towards more user-friendly, effective wealth management software development.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-061 Original scientific paper

# THE INFLUENCE OF DEMOGRAPHIC DYNAMICS ON THE LABOR MARKET

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***Abstract***

*The process of globalization and decades of negative demographic trends necessitate a swift and effective systemic response to stabilize the labor market, particularly concerning the skills and numbers of the unemployed able-bodied workforce. This paper highlights the essential legal and ethical alignment with real macroeconomic dynamics influenced by numerous new determinants, driven by technological advancements that create and eliminate various occupations. The objective is to stress the need to align the labor market with the evolving demands for new skills required by the increasingly complex global market. Key steps include the ongoing talent competition, expediting recruitment and selection processes, adequately motivating and retaining employees, and adapting rigid legislative regulations to allow work beyond the age of 65. These measures aim to mitigate current negative labor market trends that could otherwise hinder strategic developmental goals.*

***Key words:*** *labor market, fertility rate, immigration, aging population, demographic decline.*

## 1. Introduction

Global population growth in the 20th century fuelled an expanding labor force and supported economic development. However, the new century has introduced challenges: negative demographic trends are causing significant changes in the labor market and pose a real threat to many national economies. Policymakers are addressing labor market shortages through measures that encourage higher birth rates, promote later retirement, and create incentives for labor force migration.

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Serbia, a traditionally emigrant country, faces population decline, demographic aging, and insufficient economic activity. Nikitović (2013, p. 188) suggests that the quickest and most effective way to address labor force deficits and aging is through immigration. He notes that immigrants are often in their optimal reproductive age, which can increase fertility rates in the host country, aiding its long-term survival.

According to projections, Serbia will have 5.2 million inhabitants in 2040 and 4.7 million in 2050. By mid-century, traditionally depopulated areas are expected to lose over 50% of their populations, with significant losses in Borska (over 75%), Pčinjska (60%), Zaječarska and Rasinska (53% each), Pomoravska (51%), Pirotska (41%), and Raška (31%) (Nikitović, 2019).

Penjišević and Sančanin (2023) highlight the need for policymakers to create a dynamic framework that strengthens the role of the academic community and practitioners in the labor market. They emphasize the importance of intensifying education to meet labor market needs. Ignoring labor market signals jeopardizes natural generational replacement, accelerates internal and external migration, and leads to measures that extend working life and hinder the achievement of strategic goals.

Key indicators reflecting the labor market include the unemployment rate, the activity rate, the long-term unemployment rate, and the youth unemployment rate. In Serbia, the unemployment rate is higher than the average in most European Union countries, except for Spain and Greece. However, compared to other Western Balkan countries, Serbia had the lowest unemployment rate in 2021 at 11%, which is slightly above the benchmark of 10%. The activity rate for the population aged 15 to 64 increased from 59.4% in 2010 to 70.3% in 2021 (Kovačević et al., 2023).

## 2. Long-term reflections of low fertility on the labor market

The fertility rate is the average number of children born per woman of childbearing age, typically between 15 and 45 years. This rate provides insight into a country's economic condition, as well as the health and education levels of its population. In underdeveloped and developing countries, fertility rates are higher due to limited access to birth control and contraception, and because women often lack higher education or any education, as they are expected to take care of their families and household chores. In 2023, Taiwan recorded the lowest estimated fertility rate at 1.09 children per woman. Three countries from the former Yugoslavia are among the 20 with the lowest fertility rates: Bosnia and Herzegovina (1.37), Croatia (1.46), and Serbia (1.46) (O'Neill, 2024).

It is estimated that globally, 9% of couples experience infertility, with 50-60% of these couples seeking medical assistance. This translates to about 140 million individuals of reproductive age who are either unintentionally childless or undergoing reproductive treatment. Approximately 8% of men of reproductive age seek medical help for infertility-related issues (Esteves & Agarwal, 2013).

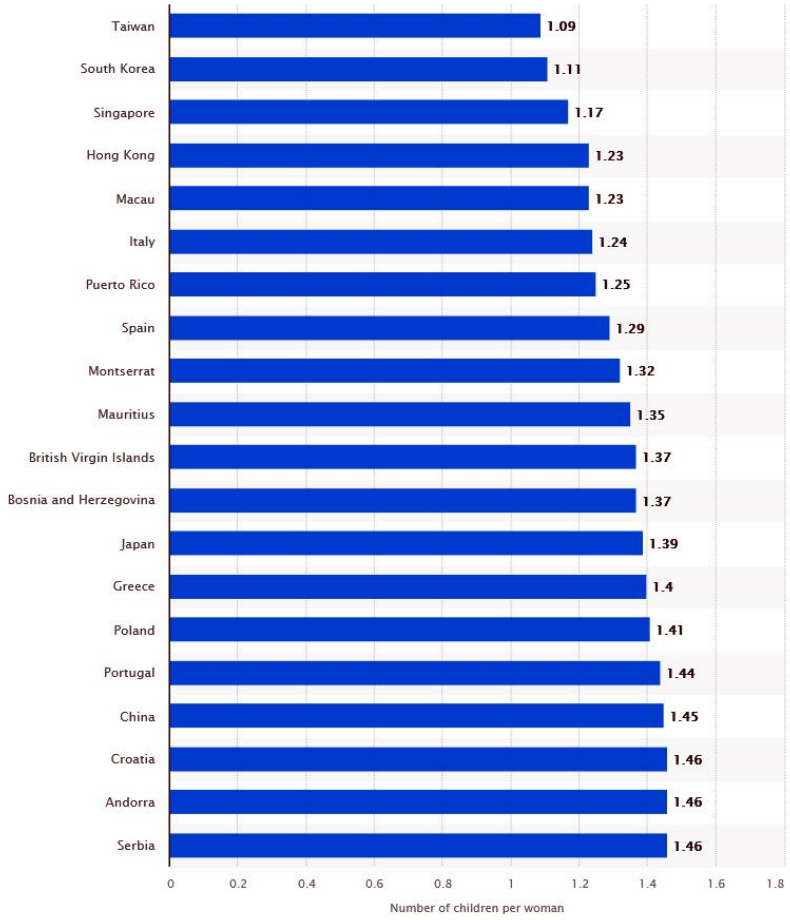


*Figure 1: Countries with the lowest fertility rates 2023*
*Source: O'Neill, 2024.*

The total population in Serbia increased from 4,819,430 in 1921 to 9,313,676 in 1981, but has been continuously declining since then. According to the 2022 census, Serbia had 6,647,003 inhabitants (Statistical Office of the Republic of Serbia, 2024).

Since 2005, Serbia's total fertility rate (TFR) has fluctuated but remains insufficient to sustain generational replacement. Until the 2011 census, only the municipality of Tutin had a TFR above the level needed for simple reproduction. The average age of mothers at the time of live birth increased from 25.9 years in 1991 to 29.8 years in 2017 (Nikitović, 2019).

In the Republic of Serbia, life expectancy in 2022 was 73 years. This indicator was 72.2 years in 2012 and 69.7 years in 2002. In each of these years, women had a life expectancy approximately 5 years longer than men. The average age of the population in 2022 was 43.8 years (Statistical Office of the Republic of Serbia, 2023).

*Table 1: Estimated population - key demographic parameters*

| | Liveborn | Died | Natural increase | Completed marriages | Divorced marriages | Fertility rate |
|---|---|---|---|---|---|---|
| **2022** | 62.700 | 109.203 | -46.503 | 32.821 | 9.813 | 1,63 |
| **2012** | 67.257 | 102.400 | -35.143 | 34.639 | 7.372 | 1,45 |
| **2002** | 78.101 | 102.785 | -24.684 | 41.947 | 9.982 | 1,55 |

*Source: Statistical Office of the Republic of Serbia, 2023.*

## 3. Population migrations

Economic migrations are a common result of market liberalization. The freedom of movement, facilitated by visa arrangements, has accelerated the transfer of residents to more economically developed countries, posing a significant threat to underdeveloped countries and their markets through further depopulation (Stamenović & Ćizović, 2019).

The increasing demand for skilled labor in Western European countries threatens the labor markets of Central and Eastern European countries (CEE or CEECs). Emigration is most pronounced in countries with poorly organized states characterized by high corruption, weak rule of law, and poor quality of public services such as health and education. Countries with easier access to the European labor market, better-educated populations, and lower standards of living experience higher emigration rates (Petrović et al., 2020).

Depopulation is most evident through the exodus of young people from rural areas, leading to reduced populations, economic decline, and the shutdown of various activities. Joksimović et al. (2023) vividly compare depopulated areas to a black hole that expands and "sucks in" surrounding regions, exacerbated by state centralization policies and the gradual reduction of regional center functions. This shifts population distribution from merely a demographic issue to a challenge for future spatial and functional planning.

## 4. Changes in the labor market

In 2006, the National Employment Service recorded 913,293 unemployed individuals, including 493,599 women. By the end of May 2024, the number of unemployed had decreased to 375,793, with 210,798 being women (National Employment Service, 2024).

*Table 2: Unemployed persons by duration of unemployment*

| **May 31, 2024.** | | **1-2 years** | **2-3 years** | **3-5 years** | **5-8 years** | **8-10 years** | **Over 10 years** |
|---|---|---|---|---|---|---|---|
| *Total* | 375.793 | 50.250 | 28.612 | 45.685 | 36.964 | 18.832 | 71.901 |
| *Women* | 210.798 | 27.151 | 16.024 | 26.015 | 21.775 | 10.958 | 43.884 |

*Source: National employment service, 2024*

The Serbian labor market is characterized by a high long-term unemployment rate, an unfavorable qualification structure, high youth unemployment, regionally uneven unemployment distribution, and insufficient active state employment policies. The unemployment rate in Serbia decreased from 18.1% in 2007 to 11.0% in 2021, with the highest rate recorded at 23.9% in 2012 (Šobić et al., 2023).

The long-term unemployment rate is a critical indicator, representing the share of individuals unemployed for over a year within the active population aged 15 to 74, tracked over a three-year period. High long-term unemployment rates suggest poor labor market functionality, as extended unemployment duration decreases the likelihood of re-employment (Kovačević et al., 2023).

In 2023, amendments to the Law on Employment of Foreigners and the Law on Foreigners were adopted in Serbia, unifying and simplifying the process for issuing temporary residence permits and work rights. That year, over 52,000 permits were issued to foreign citizens, a significant increase from the approximately 35,000 permits issued in 2022. Most work permits were granted to citizens of Russia, China, Turkey, India, and Nepal (Ristović, 2024). This trend was evident in the first half of 2023, with 24,785 work permits issued to foreigners, 1,000 more than the total for 2021. Additionally, foreign employers in the European Union can send their employees to Serbia without a work permit (Radosavljević, 2023).

Companies recognize that their employees are their most valuable assets and that finding unemployed individuals with suitable competencies who accept the offered working conditions is increasingly challenging. Sančanin and Dramićanin (2020) warn that the shrinking pool of qualified working-age individuals in the Serbian labor market could increase pressure on domestic companies and foreign investors, potentially reducing global competitiveness. Employment needs are increasingly misaligned with opportunities, and finding jobs for the large number of unqualified people is difficult in the 21st century.

The total number of pensioners has been decreasing since 2019: 1,708,293 (2019); 1,692,282 (2020); 1,660,460 (2021); 1,651,890 (2022); and 1,651,315 (2023). The average pension at the end of 2019 was 26,343 dinars, increasing to 38,320 dinars by 2023 (Statistical Office of the Republic of Serbia, 2024, pp. 40-41).

In 2019, Serbia had about 1.4 million residents over 65 years old (20.7% of the population), with more than 320,000 (4.6%) in the oldest age group (80+). This trend of population aging is expected to continue, with projections indicating that by 2041, the share of people over 65 will exceed 24%, and those over 80 will make up 7.5% (Matković, 2022).

A new indicator for population aging, which adjusts the fixed age limit based on life expectancy, is increasingly being used. In this context, Sanderson and Scherbov (2008) introduced the concept that classifies individuals with a life expectancy of less than 15 years as elderly. Using the conventional old age dependency ratio (OADR), the three oldest countries in the world in 2005 were Italy, Japan, and Germany, with Spain expected to replace Germany by 2045. However, applying the Prospective Old Age Dependency Ratio (POADR), the oldest countries

in 2005 were Ukraine and Bulgaria, and these countries are predicted to remain the oldest in 2045.

Raising the retirement age is not suitable for Eastern European countries. For instance, a 65-year-old man in Ukraine has the same life expectancy as a 69-year-old man in the United States.

## 5. Conclusion

The decades-long trend of declining populations and shrinking workforces has compelled companies to adopt new strategies for attracting and engaging both the unemployed and those interested in changing jobs. The focus has shifted significantly to foreign labor markets. In 2023, amendments to the Law on the Employment of Foreigners and the Law on Foreigners fully digitized and streamlined the process of issuing work permits, greatly improving access to the Serbian labor market. That year, over 52,000 work permits were issued to foreign citizens in Serbia, a substantial increase from the approximately 35,000 permits issued in 2022.

Balancing work obligations with private life, particularly by valuing parenthood, through formal guarantees of employment type, flexible work arrangements, and the ability to choose working hours, is essential for maintaining a balance between work and family responsibilities. Conversely, shift work, extended working hours, inadequate compensation, lack of career advancement opportunities, and neglect of employee motivation are among the most common reasons for leaving a company or opting not to have children.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# VULNERABILITY IN AGRICULTURE – DATA ANALYSIS

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***Abstract***

*This paper explores the vulnerability in agriculture in Serbia. Agricultural sector is extremely important for both country and the farmers. The country's exposure to hazards has a direct effect on the economy, since around 20% of the population are farmers. This sector is exposed to all kinds of hazards and climate changes. When a hazard occurs, it is essential to act quickly and determine recovery and risk reduction requirements. This paper shows monetary losses and recorded damaged/destroyed goods in agricultural sector. Data of previously recorded hazards is obtained from United Nations DesInventar Open Source Initiative database. The analysis is based on 1493 agricultural events recorded from 1981. to 2023. Data is analysed using Python programming language. It is processed with Python's DOM parser xml.dom.minidom. inside a Django web application. Visualisation of analysed data is implemented using Chart.js library.*

***Key words****: agriculture, hazard, python, damage, losses*

## 1. Introduction

The vulnerability of agricultural systems, defined as their susceptibility and limited capacity to adapt to various stressors, is becoming an increasingly important topic in the context of rapid changes in climate, markets and technologies. The agricultural sector is essential for global food security and economic stability, yet it remains inherently vulnerable to a myriad of challenges, including natural disasters, climate variability, economic fluctuations, and social disparities. Understanding and mitigating these vulnerabilities are crucial steps towards building resilient agricultural systems that can sustainably meet the growing demands of a changing world.

Aligned with the global agenda for sustainable development, particularly the Sustainable Development Goals (SDGs) (United Nations Department of Economic

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and Social Affairs, 2024) addressing vulnerabilities in agriculture is integral to achieving food security (SDG 2), promoting sustainable agriculture (SDG 12), and fostering resilient infrastructure (SDG 9). The SDGs provide a comprehensive framework for understanding the interconnectedness between agricultural vulnerabilities, environmental sustainability, and socio-economic development.

Post-Disaster Needs Assessment (PDNA) (Food and Agriculture Organization of the United Nations, 2024) frameworks provide valuable insights into the immediate and long-term impacts of disasters on agricultural sectors. By systematically evaluating damages and losses, PDNA helps quantify the extent of vulnerability and inform targeted recovery efforts. This assessment is not only pivotal in restoring agricultural productivity but also in enhancing adaptive capacities to future shocks.

In this paper, we will point out the importance of the application of information technologies (IT) in assessing the vulnerability of agricultural systems. Information technologies have the potential to transform the way we understand, measure and manage vulnerability in agriculture.

## 2. Main cause for application development

Damage in agriculture represents a complex challenge with profound socioeconomic and environmental consequences. The agricultural sector is often exposed to various risks that can threaten its productivity and sustainability.

Natural disasters such as floods, droughts, storms or fires can cause direct physical damage to crops, livestock and infrastructure, leading to losses in food production and farmers' income. In addition, pests, plant and animal diseases, and changes in market conditions present additional challenges with the potential for long-term economic losses.

Damage assessment in agriculture is necessary to quantify losses and enable timely planning and implementation of recovery measures. This assessment not only helps identify urgent support needs for farmers, but also provides a basis for developing resilience strategies that can mitigate future risks and increase the ability of agricultural systems to adapt to unexpected events.

Through a comprehensive analysis of agricultural damages, it is possible to better understand the complexity of the challenges facing farmers around the world, while providing a foundation for improving policies and practices that support the sustainability and resilience of rural communities.

Serbia has been very vulnerable to a wide range of natural hazards, including floods, landslides, droughts, and earthquakes (The World Bank Disaster Risk Management, 2021). From the total territory of the Republic of Serbia (88,848 km2), the structure of surface areas of the main land cover categories is as follows (Ministry of Construction, Transport and Infrastructure of the Republic of Serbia, 2021): agricultural land 43,113 km2, forests and forest land 38,240 km2, wetlands and water surfaces 2,377 km2, and artificial surfaces and barren land 4,757 km2. Having this in mind, it is important to recognize the risks and vulnerabilities of the land.

Serbia is focusing on improving its capacities for prevention, mitigation, and response to disasters, including the agricultural sector. However, data and evidence on damages and losses in the agricultural sector from disasters are not systematically collected and analyzed, which hinders the development of strategic measures to strengthen the sector's resilience.

Hazard specialists are equipped with knowledge on how to prepare the lands and the farmers with proper tools to overcome hazards with minimal damage, but the information available online is not readable to them. The specialists need a tool to analyze the data in order to discover how, where and why the vulnerabilities occur.

## 3. Framework of choice for analysis

Choosing the programming language for any application development is a fundamental building block. Building software is like building a house. It needs a strong foundation to be built fast, scalable, and maintainable.

The decision was made to use Python. Thanks to its popularity, it is very likely to find a ready-made solution to many experiencing problems. It's community is very strong and is constantly being developed.

One of the biggest advantages of Python are numerous libraries and frameworks. In Python, there is a library for almost anything: data visualization, machine learning, data science, complex data analysis, etc.

When it comes to frameworks, the situation is similar. They are very helpful in speeding up the development time and starting the project. There's a variety of frameworks to choose from, depending on the needs of the project: Django, Flask, Pyramid, Twisted, etc.

Python is very easily maintainable due to its resemblance to actual English. It has a clear syntax and does not require as many lines of code as Java or C to give comparable results.

Given all the advantages listed above, the decision for data analysis and visualization was to use Python's Django framework, which offers built-in database versioning. For data visualization, we chose the Chart.js library, and for XML parsing, we used Python's DOM parser, xml.dom.minidom.

## 4. Data analysis and processing

Data of previous recorded hazards is obtained from United Nations DesInventar Open Source Initiative (United Nations DesInventar Open Source Initiative) database. The data consists of 2345 records of which 1493 are agricultural events dated from March 20, 1981 to June 16, 2023.

Hazard records are in a xml file. Data is divided into six parts – lev0, regiones, eventos, causas, fichas and extension. Each of these parts has a single record under TR tag.

All municipalities are located under two tags – lev0 and regiones. Lev0 tag contains municipality code, name in native region language and name in English.

Regiones tag has the same data as lev0, but it is extended with coordinates of the municipality. Both lev0 and regiones needed to be parsed and combined since there was a mismatch in data.

Events are located under the eventos tag. Each event contains number, name in native region language and name in English.

Causes are located under the causas tag. Each cause contains name in native region language and name in English.

Recorded events are under the fichas tag. Each event has an agropecuario tag that has the value set to 1 if the event was agricultural. If the value of agropecuario tag was one, the event is parsed, otherwise it is skipped.

Each recorded event has a lot of information bound to it – municipality code, cause, losses in local currency, losses of livestock, hectares, etc. The extension tag contains additional data about each recorded event and each record in this tag is combined with each recorded event under the fichas tag.

### 4.1 Data Model

Based on the analyzed data, the model is created using 4 entities (Figure 1):

- Municipality – describes the municipality in which the event occurred,
- Cause – describes what caused the event to happen,
- Event – describes the event that can happen,
- Recorded event – describes the event that happened in detail.

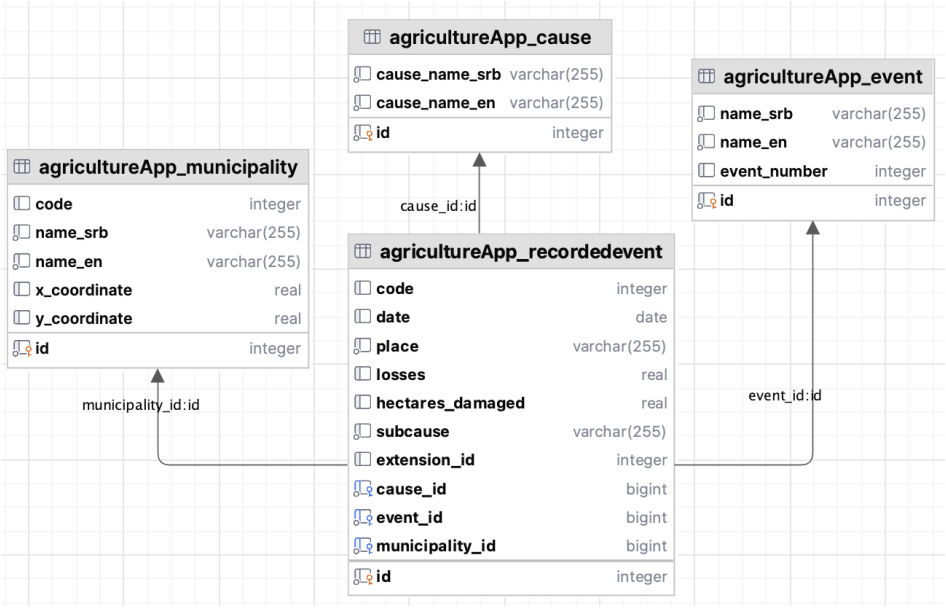


*Figure 1: Data model*

# 5. Results

All parsed data is presented in a table format, showcasing comprehensive analysis and visualization of agricultural sectors. The data includes information on both destroyed and damaged items within each sector, as well as monetary losses. Graphical representations include bar charts, pie charts, and doughnut charts. In addition, there are graphs illustrating event frequencies, event costs incurred during hazards, and declarations of emergency situations.

The Table 1 provides a clear overview of the most impactful events and their associated recorded damaged/destroyed goods and monetary losses or lack thereof.

*Table 1: Hazard statistics*

| Category | Most Impactful event | Recorded damaged/destroyed goods | Monetary Losses in RSD |
|---|---|---|---|
| **Most expensive event overall** | Flood | 409 | 374 820 519 339 |
| **Most frequent event overall** | Forest Fire | 609 | 51 088 957 |
| **Emergency situation declared** | Flood | 71 | 374 820 519 339 |
| **Crops** | Drought | 696 608 | 1 319 769 630 |
| **Livestock** | Fire | 45 792 | / |
| **Losses in hectares** | Flood | 33 301 | / |
| **Affected water sources** | Flood | 199 | / |
| **Affected agricultural assets** | Fire | 3 | / |
| **Disabled waterways** | Flood | 5 | / |
| **Agricultural losses in hectares** | Flood | 1 000 | / |
| **Forest losses in hectares** | Forest Fire | 7 189.47 | 2 050 000 |
| **Affected stock facilities** | Fire | 101 | / |

## 5.1 Visualization

Data visualization was implemented using Chart.js library. Graph used for visualization are pie, doughnut and bar. Below are given examples of the bar (Figure 2) and doughnut graphs (Figure 3).

Figure 2 shows the frequency of hazards in the Republic of Serbia during the observed period. We can conclude that the events with the highest frequency of occurrence are forest fires (609), followed by floods (409) and hailstorms (253).

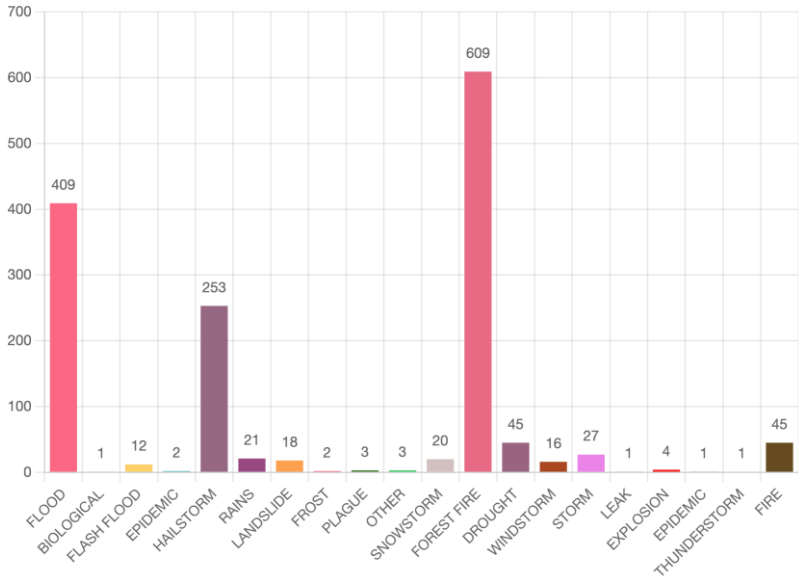


*Figure 2: Event frequencies statistics*

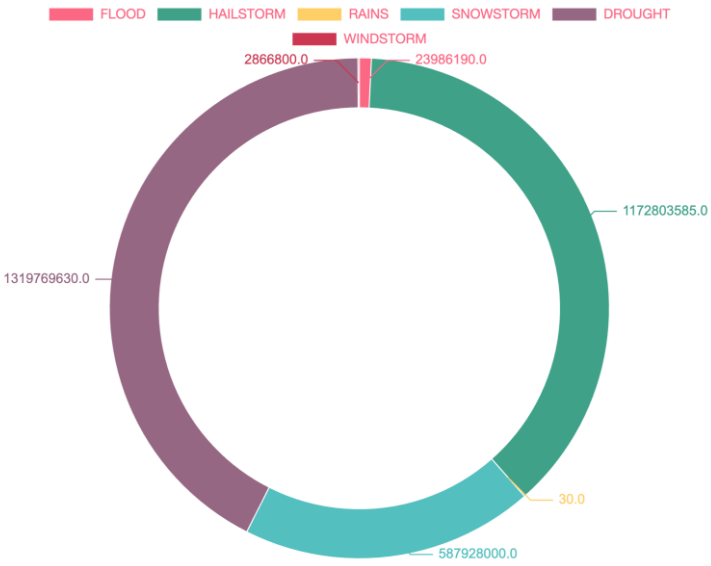


*Figure 3: Crop losses statistics*

Figure 3 shows the losses recorded in crops during the observed period. Based on the presented results, it was determined that the biggest losses in crops occurred as a result of drought (1 319 769 630 RSD), hailstorm (1 172 803 585 RSD) and snowstorm (587 928 000 RSD).

## 6. Discussion

Through comprehensive data analysis of agricultural disasters, several key insights have emerged:

- Impact Variation: Different types of disasters, such as floods, droughts, and fires, exhibit varying degrees of impact on agricultural productivity and economic stability.
- Economic Burden: The financial costs associated with agricultural disasters, both direct and indirect, underscore the need for proactive disaster management and preparedness.

Based on our findings, several recommendations can be made to enhance agricultural resilience and disaster preparedness:

- Integrated Approach: Adopting an integrated approach that combines data-driven decision-making with community engagement and local knowledge can improve disaster response effectiveness.
- Insurance and Financial Support: Enhancing access to agricultural insurance and financial support mechanisms can buffer farmers against economic losses during disasters.

## 7. Conclusion

The application of IT provides the possibility of timely identification of key factors of vulnerability such as climate change, economic fluctuations and social inequalities. Also, IT has the potential to improve communication and cooperation between different actors, enabling better risk management and more effective planning of adaptive strategies.

This study underscores the critical importance of data-driven analysis and visualization in understanding the complex dynamics of agricultural disasters. By leveraging these insights, policymakers, researchers, and agricultural stakeholders can work collaboratively to build resilient agricultural systems capable of withstanding and recovering from disasters effectively.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE IMPACT OF SUSTAINABILITY PRACTICES ON FINANCIAL PERFORMANCE: A REVIEW OF EMPIRICAL STUDIES

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***Abstract***

*This research paper provides an overview of the existing literature on the relationship between sustainability practices and financial performance. The findings suggest that sustainability initiatives can lead to enhanced financial outcomes; however, this relationship is complex and influenced by various contextual factors. Specifically, the analysis reveals that while there is evidence supporting the potential positive impact of sustainability on financial performance, as firms that effectively implement sustainability practices may experience improved market-based and accounting-based financial metrics, the existing body of literature remains fragmented, characterized by varying definitions and inconsistent metrics used to evaluate this relationship.*

***Key words****: sustainability practices, financial performance, financial metrics*

## 1. Introduction

The increasing importance of environmental and social challenges has prompted firms across various sectors to adopt sustainability practices as integral components of their business strategies. As stakeholders—including consumers, investors, and regulatory bodies—demand greater accountability and transparency regarding corporate social responsibility, the relationship between sustainability practices and financial performance has emerged as a critical area of inquiry. Recent research indicates that firms that effectively implement sustainability initiatives can experience enhanced financial outcomes, measured through both market-based variables, such as stock performance and market valuation, and accounting-based metrics, such as Return on Assets (ROA) and Return on Equity (ROE).

However, the existing body of literature remains fragmented, characterized by varying definitions and inconsistent metrics used to evaluate the relationship

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between sustainability practices and financial outcomes. This study offers an overview of existing research on sustainable development from a financial perspective and contributes to the existing body of literature by expanding our understanding of the type of the impact (whether positive, negative, or neutral) of sustainability practices and identifying the most prevalent financial performance measures used in studies examining this relationship.

## 2. Theoretical background and research questions

The relationship between corporate sustainability practices and financial performance has become a focal point of interest in academic research. The existing literature on the relationship between corporate sustainability practices and financial performance provides strong support for the notion that sustainability can lead to improved financial outcomes (Savkovic, 2024). Montabon et al. (2007) established that firms adopting robust environmental management practices exhibit improved financial metrics such as Return on Investment (ROI) and sales growth. This finding aligns with the slack resource theory and good management theory, which suggest that firms can leverage sustainability for competitive advantage (Waddock & Graves, 1997).

Further reinforcing this perspective, Ameer and Othman (2012) demonstrated that globally recognized sustainable companies outperform their less sustainable counterparts in terms of return on assets (ROA), profit before tax (PBT), and cash flow from operations. Similarly, Pan et al. (2014) found that sustainability initiatives positively impacted profits, as measured by ROA, ROE, and Earnings per Share (EPS), in a sample of Chinese mining firms. In regional contexts, Kapoor and Sandhu (2010) confirmed that Indian firms engaging in sustainability practices achieved higher returns on sales, assets, and equity, albeit with minimal effects on growth. Studies by Amouzesh et al. (2011) in Iran and Rahim (2017) in Malaysia echoed these findings, linking sustainable growth rates to improved financial indicators such as ROA and price-to-book (P/B) ratios. Recent research has explored the sectoral and temporal dimensions of the ESG-financial performance nexus. Bruna et al. (2022) found positive relationships between ESG performance and financial indicators in European companies. Industry-specific studies, such as Buallay's (2019) and La Torre et al.'s (2021) analysis of the banking and manufacturing sector, reveals contrasting effects of sustainability practices, emphasizing the need for tailored ESG strategies.

Despite the prevailing positive narrative, some studies present mixed or even negative results, highlighting the complexity of the relationship. Hussain et al. (2018) found no significant correlation between ESG parameters and financial outcomes among top-performing U.S. firms. This suggests that the financial benefits of sustainability may not be universal and can be influenced by various contextual factors. De Lucia et al. (2020), using machine learning techniques, revealed a positive but nonlinear relationship between ESG practices and financial performance in European companies. These findings underscore the importance of considering factors such as governance quality, disclosure practices, and industry-

specific characteristics when assessing the financial impact of sustainability. Mamun (2022) emphasized the positive link between transparent ESG disclosure and financial outcomes. Furthermore, some research cautions against overemphasizing sustainability. Rahi et al. (2022) noted that excessive investment in ESG initiatives could negatively affect financial performance, measured by ROE, EPS, and Return on Invested Capital (ROIC), by straining resources. Lahouel et al. (2021) found negative correlations between certain ESG activities and financial metrics. This suggests a potential trade-off between short-term profitability and long-term sustainability goals.

Kwarteng et al. (2023) emphasize the critical role of corporate governance and transparency in mediating the relationship between sustainability and financial performance, particularly in emerging economies. Their research identifies corporate governance as a significant and positive contributor to sustainability performance. Moreover, the study highlights corporate strategy as a mediating factor that influences the relationship between corporate governance and financial performance, measured by ROA and Tobin's Q. This underscores the importance of strong governance structures in optimizing the benefits of ESG initiatives.

Building on the above, the paper is guided by the following research questions:

*RQ1: What is the overall impact of sustainability practices on corporate financial performance?*

*RQ2: Which financial performance measures are most commonly used in studies examining the impact of sustainability practices on corporate financial performance?*

For the purposes of this research, the Scopus database was utilized to identify relevant studies, focusing on publications from the period 2020 to 2023. The search was conducted using the string "sustainability practices" and "financial performance", yielding a total of 98 articles. A content analysis approach was then employed to shortlist the most relevant publications from the literature. Priority was given to the most-cited articles, which were further analysed to provide insights into the relationship between sustainability practices and financial performance.

## 3. Results and discussion

The analysis presented in Table 1 illustrates the diverse impacts of sustainability practices on financial performance across different industries and regions. The studies span a period from 2020 to 2023, employing various financial performance measures such as Return on Assets, Return on Equity and Return on Sales (ROS). The review of the selected studies affirms a generally positive relationship between sustainability practices and financial performance, as reported in numerous prior works.

*Table 1: The Impact of Sustainability Practices on Financial Performance*

| Authors | Year | Performance Measure | Impact |
|---|---|---|---|
| Agoraki, M. E. K., Giaka, M., Konstantios, D., & Patsika, V. | 2023 | ROA, ROE, ROS | Positive |
| Moufty, O., Clark, E., & Al-Najjar, B. | 2021 | ROA | Positive |
| Thomas, C. J., Tuyon, J., Matahir, H., & Dixit, S. | 2021 | ROA, ROE, Tobin's Q | Positive (ROE) |
| Pham, D. C., Do, T. N. A., Doan, T. N., Nguyen, T. X. H., & Pham, T. K. Y.. | 2021 | Earnings Yield, ROA, ROE, ROCE, Tobin's Q | Positive (Except Tobin's Q) |
| Hoang, T.-H.-V., Przychodzen, W., Przychodzen, J., & Segbotangni, E. A. | 2020 | ROA, ROCE, Market to Book (MB), Price Earnings (PE) | Positive for ROA, Negative for ROCE & PE |
| Nirino, N., Miglietta, N., & Salvi, A. | 2020 | ROA, ROE, ROS | Mixed Results |
| Lassala, C., Orero-Blat, M., & Ribeiro-Navarrete, S. | 2021 | ROE | Negative |
| Indriastuti, M., & Chariri, A. | 2021 | ROA | Positive |
| Sakshi, Shashi, Cerchione, R., & Bansal, H. | 2020 | ROS, Gross Profit, Revenue Growth, Profitability Ratios, Cost Savings | Positive |
| Garcia, A. S., & Orsato, R. J. | 2020 | ROA | Positive |

A significant number of studies indicate a positive relationship between sustainability practices and Return on Assets (ROA). Notable findings from studies conducted in 2020 and 2021 highlight that firms with robust sustainability strategies tend to achieve superior returns on their assets. This is consistent with findings from Agoraki et al. (2023), Indriastuti & Chariri (2021), and Garcia & Orsato (2020), who demonstrate that sustainability efforts positively influence asset utilization efficiency.

For market-based measures, such as Market to Book Ratio (MB), Price-Earnings (PE) Ratio, and Tobin's Q, the findings are more nuanced. For instance, Hoang et al. (2020) observe that sustainability practices positively influence ROA and market valuation (MB), while the effect on Return on Capital Employed (ROCE) and PE ratio is negative or insignificant. Similarly, Thomas et al. (2021) report positive impacts on ROE but find an inconclusive result for Tobin's Q, signalling that market-based measures might be more susceptible to external market conditions and investor sentiments.

While most studies show a positive impact of sustainability practices, there are also mixed and negative findings. Lassala et al. (2021), for example, report a negative correlation between sustainability efforts and (ROE) in certain contexts, particularly when companies pursue the Sustainable Development Goals (SDGs). Similarly, Nirino et al. (2020) observe mixed results where social outcomes positively impact performance, but environmental outcomes show negligible or

negative effects depending on the specific financial metric. Several studies highlight the role of industry-specific factors in influencing the relationship between sustainability and financial performance. For example, research by Sakshi et al. (2020) on the tourism and hospitality sector identifies positive impacts across a range of financial metrics, including gross profit and revenue growth, while studies in the banking sector, such as Moufty et al. (2021), reveal more moderate positive effects, particularly regarding the economic dimension of sustainability.

The study by Agoraki et al. (2023) underscores the importance of regulatory frameworks in shaping the impact of sustainability practices. In their findings, firms in European markets benefit from positive regulatory dynamics that support the integration of sustainability, thereby enhancing their financial outcomes. This aligns with the broader trend suggesting that firms that engage with stakeholders and adhere to sustainability standards are more likely to realize financial benefits, as noted in several studies, including those by Hoang et al. (2020) and Pham et al. (2021).

The findings align with empirical insights outlined earlier, which suggest that sustainability practices can enhance financial outcomes by optimizing resource use and improving stakeholder relationships. However, the results also highlight the complexity of this relationship, underscoring the need for contextual and industry-specific analyses.

## 4. Conclusions

This study offers a comprehensive review of the existing literature on the relationship between corporate sustainability practices and financial performance. The findings suggest that sustainability initiatives can lead to enhanced financial outcomes, but the relationship is complex and influenced by various factors. While there is evidence supporting the potential positive impact of sustainability on financial performance, the existing body of literature remains fragmented, characterized by varying definitions and inconsistent metrics used to evaluate this relationship. Future research should address methodological inconsistencies and explore alternative metrics to provide a more comprehensive understanding of this critical relationship.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# OPTIMIZING FINANCIAL STRATEGIES IN INDIAN AQUACULTURE: A CASE STUDY OF WEST GODAVARI

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***Abstract***

*This paper explores financial strategies in aquaculture, focusing on the West Godavari District of Andhra Pradesh, India. Despite India's prominence in global aquaculture, the sector faces significant challenges that necessitate robust financial planning, advanced technology, and effective regulation. Adopting a qualitative research approach, this study uses in-depth interviews and structured surveys with aquaculture farm owners and finance managers to examine investment planning, cost management, financial risk mitigation, and revenue optimization. This study integrates blockchain technology with Community-Supported Aquaculture (CSA) models to enhance transparency, financial stability, and operational efficiency. Blockchain improves product traceability and trust while smart contracts reduce intermediary costs and fraud risk. The CSA model supports shared investment and risk among local communities, fostering economic resilience for farmers and building beneficial relationships. Key support for these financial strategies comes from strategic partnerships with NGOs and government agencies, alongside regulatory compliance. Increased digital literacy and training have made these technologies more accessible. Continuous feedback from stakeholders and regular audits have facilitated ongoing improvements in financial strategies. This study highlights how these integrated financial mechanisms can transform the economic landscape of India's aquaculture industry, offering sustainable advantages and serving as a replicable model for other regions and sectors. Finally, a framework combining blockchain and CSA models was presented to enhance financial strategies. This framework highlights diverse funding sources and provides decision support for financial sustainability, while addressing gaps in the literature on funding channels, capital allocation, and operational practices in the Indian aquaculture sector.*

***Key words****: Indian Aquaculture, Financial Strategies, Blockchain Technology, Community-supported Aquaculture, Economic Resilience*

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# 1. Introduction

Aquaculture is the second-largest sector in India, providing livelihoods for millions and playing a crucial role in food security. As one of the top three global fish producers (third in overall fishing and second in aquaculture), India's diverse freshwater, marine, inland, and coastal regions are vital to its fisheries sector (NFDB, 2011). The Blue Revolution significantly impacted the first phase of freshwater aquaculture development in India (De Silva, 2000). Future growth will depend on effective financial planning, technological innovation, and regulatory management (National Aquaculture Association, 2011). Inland aquaculture, particularly in regions like West Godavari in Andhra Pradesh, shows considerable promise (FAO, 2011). Despite positive developments and policy support, financial challenges persist.

This study focuses on the financial practices within the aquaculture sector of West Godavari, investigating key areas such as investment planning, cost management, financial risk mitigation, and revenue optimization (Government of Andhra Pradesh, 2022). By examining regional aquaculture practices, the study aims to identify both beneficial and challenging conditions faced by stakeholders. Effective financial strategies can help businesses achieve stable growth, minimize investment waste, manage costs, and improve revenue, which is essential for withstanding economic downturns. The study will also offer policy recommendations to enhance the financial aspects of Indian aquaculture.

# 2. Literature Review

Aquaculture, or aquafarming, encompasses the breeding and rearing of aquatic species, including activities such as stocking, feeding, and predator control (FAO, 1997). The sector has experienced significant growth, averaging 6.6% annually since 1970, driven by technological advancements and rising local and international demand (FAO, 2011). In India, inland aquaculture has become a major food source, supported by approximately 2.35 million hectares of ponds and tanks. The sector's expansion is further facilitated by innovative practices and supportive policies (NFDB, 2011). A key policy initiative is the Pradhan Mantri Matsya Sampada Yojana (PMMSY), launched in 2020, which aims to boost productivity and promote sustainable practices through increased investment and infrastructure development (Government of India, 2020). This scheme targets both beneficiary-oriented and non-beneficiary activities to enhance productivity, employment, and exports (Department of Fisheries, 2020).

India's inland fishery output has surged due to proactive policy measures, contributing significantly to global fish production (NFDB, 2021). Key growth areas include inland aquaculture, accounting for about 70% of the country's fish production, and brackish and saline aquaculture in coastal regions, where shrimp farming has seen exponential growth (FAO, 2011; NFDB, 2021). Additionally, cold-water fisheries in the Himalayan states, particularly in J&K and Ladakh, offer

potential for increased production and market expansion for niche products like trout (ICAR-DCFR, 2021).

Despite its critical role in global food security, aquaculture faces challenges, including pandemic-induced disruptions in demand, distribution, and workforce availability. Adaptive strategies and resilient practices are essential for maintaining sector stability post-pandemic (Harfoot et al., 2021; Khan, 2021). To support continued growth, aquaculture requires robust financial planning, investment in advanced technologies, and effective resource management. Adaptive financial models and alternative income streams are vital for mitigating risks and ensuring economic sustainability (Bunting, 2023). Building strong financial strategies is crucial for sustaining aquaculture's contributions to global food security and economic prosperity.

## 3. Frameworks for Financial Strategies in Aquaculture

The financial strategies model for Indian aquaculture builds on foundational works like Marketing Strategy and Management by Dibb & Simkin (2006) and Strategic Management and Business Policy by Richards (2003). These sources define key financial tactics relevant to aquaculture, focusing on funding sources, investment styles, costs, and revenues.

Funding channels include government grants, private investments, and bank loans, providing a balanced mix of stability and scalability. Investment patterns address capital allocation, reinvestment strategies, and financial planning. Operational expenses encompass feed costs, labor, and technology investments, while profitability is assessed through revenue trends, profit margins, and market demand. The projected revenue from diverse funding sources supports stability and growth. Changes in investment patterns, such as capital reprioritization and reinvestment in new technologies, help manage production costs. Financial resilience is enhanced by cold chain interventions that balance market demand, cost-effectiveness, and profitability.

Figure 1 integrates blockchain technology and Community-Supported Aquaculture models, highlighting their impact on financial strategies. This framework underscores the importance of diverse funding channels and provides decision support for achieving financial sustainability. It addresses gaps in the literature on funding channels, capital allocation efficiency, and operational practices in aquaculture, offering valuable insights for the Indian aquaculture sector.

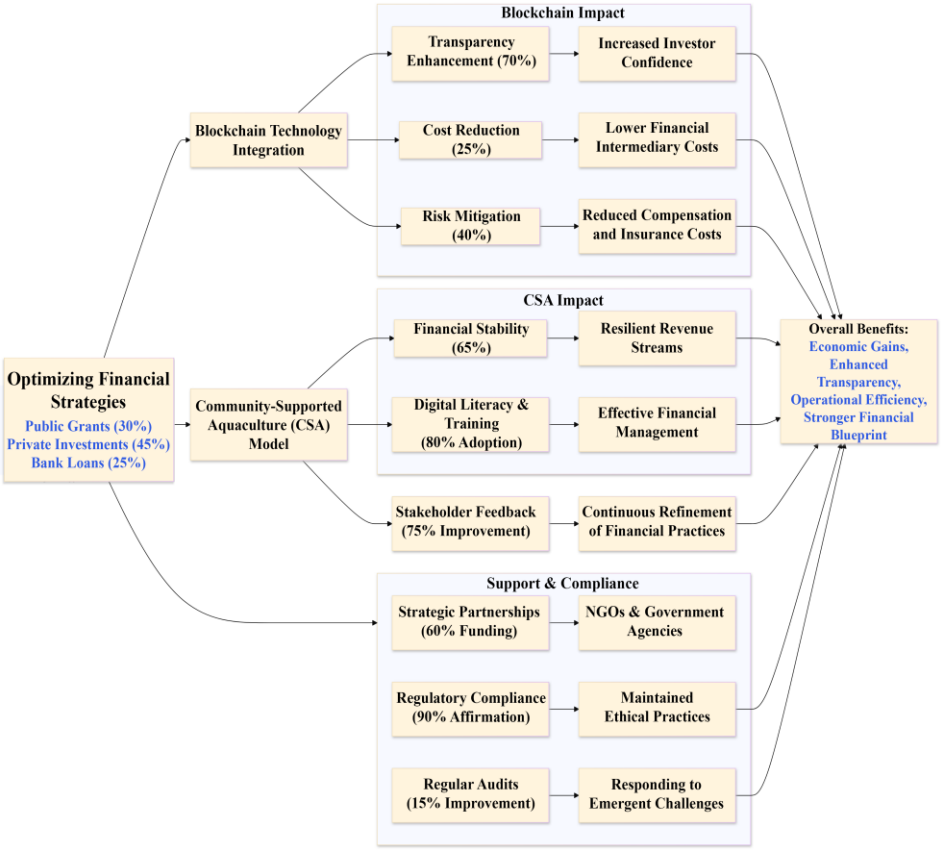


*Figure 1: Optimizing Financial Strategies in Aquaculture*
*Source: Authors*

## 4. Study Gap, Research Purpose, and Research Question

### 4.1 Study Gap

In India, the aquaculture industry is robust, particularly in Andhra Pradesh's West Godavari region, which benefits from strong policy support. Despite its global importance, there is a gap in understanding financial strategies, with the existing literature being fragmented. While there is insight into policy-driven initiatives and technological adoption, a detailed comparative analysis of funding sources is lacking. Additionally, there is insufficient exploration of investment behaviors, their impacts on operational costs, and profitability. The integration of financial technologies, such as blockchain and community-supported aquaculture models, remains underexplored. These technologies have the potential to enhance financial transparency, reduce intermediary costs, and strengthen economic resilience, particularly within local aquaculture practices.

### 4.2 Study Purposes

The objective of this study is to address gaps in understanding financial strategies within West Godavari's aquaculture sector. It will compare the effects of public grants, private investments, and bank loans on financial stability. The study aims to explore how blockchain technology and community-supported aquaculture models can enhance transparency, reduce costs, and boost investor confidence. The ultimate goal is to propose financial mechanisms that improve economic resilience and sustainability, providing policy recommendations that can be replicated to foster stable growth and development in the Indian aquaculture industry.

### 4.3 Research Question (RQ)

*How do various funding channels and financial technologies impact operational costs, profitability, and economic resilience in the aquaculture sector of West Godavari district?*

## 5. Methodology

The study employed a qualitative research approach to explore financial strategies in West Godavari's aquaculture sector, Andhra Pradesh. Fifteen experts, including aquaculture farm owners, stakeholders, finance managers, and fishery experts, were strategically recruited. Data was collected over six months through in-depth semi-structured and structured interviews. Semi-structured interviews allowed for flexible exploration of specific areas, while structured surveys provided quantitative measures.

Interviews were recorded with participants' permission, transcribed verbatim, and reviewed for accuracy. Manual coding was performed, where key text segments were annotated with initial codes. Similar codes were grouped to form overarching themes, which were refined through combining, breaking down, or discarding codes. Themes, such as "Financial Optimization," were named to reflect improvements in financial performance, transparency, operational efficiency, and investment attraction. Representative quotes illustrated key points.

Ethical considerations were strictly followed, with informed consent obtained, data anonymized, and confidentiality maintained. The study adhered to institutional review board approvals, ensuring academic and ethical standards. Data collection, transcription, and thematic analysis provided insights into aquaculture financial optimization strategies. The study highlighted the successful integration of blockchain and Community-Supported Aquaculture (CSA) models, supported by strategic partnerships and regulatory compliance. It also demonstrated how public grants, private investments, and bank loans facilitated these technologies' integration, offering a scalable model for financial sustainability that could be replicated in other regions and industries.

## 6. Study Results

As shown in Table 1, the integration of blockchain and Community-Supported Aquaculture (CSA) technology has significantly enhanced financial strategies in Indian aquaculture, as demonstrated by qualitative research in West Godavari, Andhra Pradesh. Interviews and surveys revealed that 70% of respondents noted improved transaction transparency due to blockchain technology, which also boosted investor confidence and funding. Public grants accounted for 30% of the total funding, private investments 45%, and domestic bank loans 25%. The reliance on blockchain reduced intermediary costs by 25% and financial risks, making bank loans more accessible.

*Table 1: Summary of Financial Strategy Optimization in Aquaculture*

| Aspects | Findings |
|---|---|
| Improved Transaction Transparency | 70% of respondents reported enhanced transparency due to blockchain |
| Funding Distribution | Public Grants: 30%, Private Investments: 45%, Domestic Bank Loans: 25% |
| Cost Reduction | Blockchain reduced intermediary costs by 25% |
| Risk Mitigation | Bank loans more accessible due to reduced financial risks |
| Smart Contracts | Streamlined transactions and lowered fraud-related costs |
| CSA Model Adoption | Utilized by over 65% of farmers, distributing economic risks and enhancing income resilience |
| Digital Literacy & Training | 80% of farmers benefited from digital literacy and technical training programs |
| Strategic Partnerships | NGOs and government agencies provided around 60% of the funding |
| Regulatory Compliance | 90% of participants affirmed engagement with regulatory measures |
| Stakeholder Feedback & Audits | Regular audits and feedback led to a 15% improvement in financial strategy effectiveness |
| Stakeholder Engagement | Blockchain facilitated feedback collection from 75% of stakeholders |
| Overall Impact | Enhanced operational efficiency, transparency, and security, setting a benchmark for financial planning |

*Source: Authors*

Smart contracts have streamlined transactions and lowered fraud-related costs. The CSA model, utilized by over 65% of farmers, distributed economic risks among community members, reducing financial vulnerability and enhancing income resilience. Digital literacy and technical training programs have further improved financial management, with 80% of farmers benefiting from these advancements.

Strategic partnerships with NGOs and government agencies have provided around 60% of the funding for these initiatives, covering essential operating costs and supporting project scaling. Regulatory engagement, affirmed by 90% of participants, ensures ethical practices and supports sector expansion. Regular

audits and stakeholder feedback led to a 15% improvement in financial strategy effectiveness.

Blockchain technology has facilitated feedback collection from 75% of stakeholders, refining financial practices continuously. This successful integration of blockchain within the CSA framework offers a transformative financial strategy, demonstrating increased operational efficiency, transparency, and security. The West Godavari model sets a benchmark for financial planning and sustainable practices, with significant economic impacts that can be replicated in other regions and industries.

## 7. Conclusion

Blockchain-based Community-Supported Aquaculture (CSA) represents a transformative financial strategy for the Indian aquaculture sector. This approach addresses major barriers such as transparency, financial security, and operational efficiency. Blockchain enhances supply chain transparency and reduces fraud through traceability and smart contracts, increasing consumer trust in product authenticity. The CSA model fosters community investment and risk-sharing, providing economic support for farmers through local consensus and shared initiatives.

Key elements like education and training, strategic funding, public-private partnerships, regulatory measures, and emerging feedback systems are integral to this model. It not only addresses current financial and operational challenges but also positions Indian aquaculture as a leader in innovation and sustainability by integrating blockchain technology with CSA.

This approach demonstrates that fundamental aquaculture finance principles can drive practice improvements, paving the way for smarter financial futures and impact investing within and beyond the sector. The integration of blockchain and CSA establishes a strong foundation for long-term financial viability and environmental stewardship, promoting economically driven conservation efforts.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-065 Original scientific paper

# FOSTERING STARTUP ECOSYSTEMS THROUGH JAPANESE ENTREPRENEURSHIP IN LOWER-MIDDLE-INCOME ASEAN ECONOMIES

*Masatoshi Hara*[1] *[0000-0002-5975-454X]*

***Abstract***

*This study explores the development of startup ecosystems and entrepreneurship in middle-income ASEAN countries, highlighting the crucial role of Japanese entrepreneurs. It examines how collaborations between Japanese and ASEAN startups can address the lower-middle-income trap (LMIT) and promote sustainable economic growth. The research underscores the importance of policy reforms in education, technical training, and human resource development to align efforts between Japan and ASEAN, fostering mutual benefits and enhancing ecosystem resilience. Using a qualitative mixed-method approach, the study identifies essential practices for successful partnerships, including effective mentorship and knowledge transfer, which significantly boost local startups' technological and strategic capabilities. Cultural adaptation is identified as vital for aligning with local business practices, market conditions, and regulatory environments, facilitating smoother integration and collaboration. Strategic investments and resource allocation by Japanese partners are pivotal for scaling startups, providing necessary financial and technical support. The establishment of long-term partnerships ensures sustained and mutually beneficial collaborations. The study incorporates a framework and emphasizes the need to expand it to address emerging technologies, institutional challenges, and policy recommendations, thereby enhancing its comprehensiveness and practical relevance. The findings offer valuable insights into building resilient startup ecosystems and fostering entrepreneurship in middle-income ASEAN countries, emphasizing the indispensable role of international collaboration in achieving long-term economic development and overcoming the LMIT, ultimately contributing to a more integrated and dynamic regional economy.*

***Key words****: Startup Ecosystems, Japanese Entrepreneurship, Lower-Middle-income ASEAN Economies.*

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# 1. Introduction

The ASEAN region, with its predominantly middle-income economies, is rapidly embracing digitalization, offering significant growth potential (World Bank, 2019). A major challenge is the middle-income trap (MIT), where nations struggle to move beyond middle-income status (Gill & Kharas, 2007). Japan's shift in investment priorities from developed to emerging markets, particularly ASEAN, has brought substantial capital, technology, and expertise (Oikawa & Iwasaki, 2023), which are expected to boost startup ecosystems. As these ecosystems grow, they will likely hire skilled workers and focus on cost-effective production to remain competitive. This study proposes strategies for collaboration between Japanese and ASEAN entrepreneurs, especially in lower-middle-income economies (LMIEs), emphasizing policy reforms in education, technical training, and human resource development. It also presents a framework to leverage startup ecosystems for sustainable growth and innovation.

# 2. Literature Review

## 2.1 Middle-income ASEAN's Economic Status

Since the 1960s, ASEAN economies have transitioned from primary industries to secondary and tertiary sectors, similar to the industrialization paths of Japan, South Korea, and Taiwan (Perkins, 2013). This shift has attracted multinational investments and increased foreign direct investment (FDI) (UNCTAD, 2024). Despite significant growth over the past 30 years, many Southeast Asian economies remain underdeveloped (UNCTAD, 2024; World Bank, 2024a). GNI per capita disparities are evident, with Malaysia and Thailand ranging between 7,000 and 11,000 USD, while others, notably Indonesia and the Philippines, are around 4,000 USD (World Bank, 2024a). The "Middle-Income Trap" (MIT) presents challenges for advancing to high-income status (Gill & Kharas, 2007). ASEAN can be categorized into "lower-middle-income" and "higher-middle-income" groups (Tran and Karikomi, 2019). Hara (2023) links economic development stages to MIT, highlighting the need for innovation to achieve high-income status.

## 2.2 Japanese Entrepreneurship to Foster Middle-income ASEAN Startups

The number of ASEAN startups securing over $1 million in funding grew from 652 in 2015 to 4,603 in 2023, with Singapore and Indonesia accounting for over 75% of these startups (DataIndonesia.id, 2023). LMIEs, including the Philippines, Thailand, and Vietnam, along with "Infancy" economies such as Cambodia, Lao PDR, and Myanmar, are also experiencing growth (ASEAN and UNCTAD, 2022). Malaysia and the Philippines, classified as "Fast-Growing," exceeded 300 startups in 2023, up from under 40 in 2015, while Indonesia's rise to 2,479 startups earned it "Frontier" status (ASEAN and UNCTAD, 2022; DataIndonesia.id, 2023). Japan's investment focus on emerging ASEAN markets aims to strengthen economic ties and enhance startup ecosystems through technology transfer and expertise (JETRO, 2017; Oxford

Analytica, 2017). The Japan Bank for International Cooperation (JBIC) finances startups in Indonesia and Vietnam, while Japanese entrepreneurs establish incubators and provide strategic guidance (JETRO, 2010; JIC, 2024; JICA, 2023b; Lewin et al., 1998).

### 2.3 Adaptability of Business Models in Developing Countries

Adapting business models for developing countries presents opportunities, such as creating affordable products for low-income consumers and benefiting from low-wage economies (Aagaard & Nielsen, 2021). ASEAN's middle-income economies offer growth potential, but entering lower-middle-income markets involves high costs, regulatory and administrative challenges, and cultural differences (Hara, 2024). Success requires offering low-cost products through significant R&D and cost-effective production, which may delay profitability (Verhoogen, 2023). Fair investment practices are crucial for maintaining a positive local reputation (Ismail, Halim & El-Deeb, 2023).

## 3. Study Gaps, Study Purposes, and Research Question

### 3.1 Study Gaps

Previous research has explored Japan's growing economic ties with ASEAN, focusing on technology transfer, FDI, and entrepreneurship. However, there is a lack of targeted analysis on effective collaboration strategies between Japanese and ASEAN entrepreneurs in lower-middle-income economies (LMIEs). Most studies concentrate on higher-income countries or overlook the unique challenges of LMIEs. Additionally, the long-term sustainability and scalability of Japanese-supported partnerships and startup ecosystems remain underexplored. This highlights the need for research on strategies to foster cross-border entrepreneurial collaboration in LMIEs, addressing resource sharing, market access, and cultural alignment.

### 3.2 Study Purposes

This study aims to propose strategies for effective collaboration between Japanese and ASEAN entrepreneurs in lower-middle-income economies (LMIEs). It examines how these partnerships can enhance startup development, scalability, and sustainability amid unique economic and regulatory challenges. By analyzing successful collaboration models, technology transfer, and cross-cultural practices, the study seeks to provide actionable insights for strengthening entrepreneurial ecosystems. The goal is to foster sustainable economic growth through more effective and mutually beneficial collaborations.

### 3.3 Research Question

What are the key strategies for fostering effective collaboration between Japanese and lower-middle-income ASEAN startup ecosystems, and how do these strategies enhance startup growth, scalability, and long-term sustainability?

## 4. Frameworks

The proposed framework for collaboration strategy, as shown in Figure 1, examines how key factors influence the success and sustainability of startups in lower-middle-income economies (LMIEs) through Japanese-ASEAN partnerships.

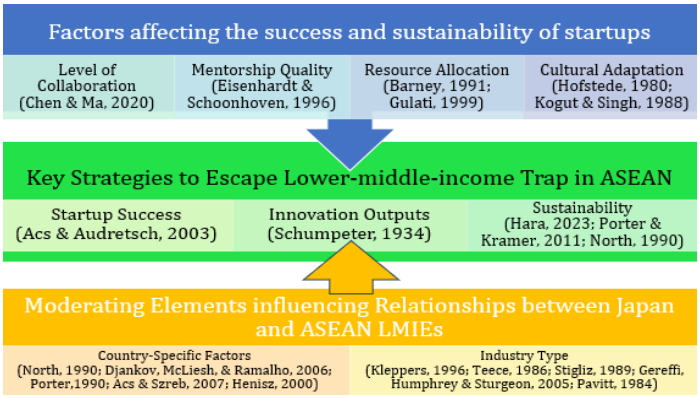


*Figure 1. A Proposed Framework for effective collaboration between Japanese and Lower-middle-income ASEAN*
*Source: Author*

The study identifies four primary independent variables: Level of Collaboration (Chen & Ma, 2020), Mentorship Quality (Eisenhardt & Schoonhoven, 1996), Resource Allocation (Barney, 1991; Gulati, 1999), and Cultural Adaptation (Hofstede, 1980; Kogut & Singh, 1988). These variables are expected to positively impact three key dependent outcomes: Startup Success (Acs & Audretsch, 2003), Innovation Outputs (Schumpeter, 1934), and Sustainability (Hara, 2023; Porter & Kramer, 2011; North, 1990). The framework also considers moderating variables, including Country-Specific Factors (North, 1990; Djankov, McLiesh, & Ramalho, 2006; Porter, 1990; Acs & Szreb, 2007; Henisz, 2000) and Industry Type (Kleppers, 1996; Teece, 1986; Stiglitz, 1989; Gereffi, Humphrey & Sturgeon, 2005; Pavitt, 1984). This framework aims to clarify how Japanese investments and collaborations influence startup ecosystems in LMIEs, highlighting effective strategies and potential challenges.

## 5. Methodology

As for the research design, this study employs a mixed-method approach, focusing exclusively on qualitative methods to analyze Japanese-ASEAN collaborations in lower-middle-income economies (LMIEs). By utilizing a convergent parallel design (CPD) (Creswell, 2014), it integrates data from case studies and document analysis to enhance research validity and provide deeper insights into collaboration dynamics and the effectiveness of Japanese-ASEAN partnerships (Harvard Catalyst, 2021; George, 2023).

Regarding data collection and sampling strategy, this study involves detailed case studies of both successful and failed Japanese-ASEAN collaborations across LMIEs (Cambodia, Indonesia, Lao PDR, Myanmar, the Philippines, and Vietnam). It utilizes literature, industry reports, and news articles to investigate aspects such as mentorship, knowledge transfer, resource allocation, and cultural challenges. Document analysis will examine reports from the past 5 to 10 years from international organizations and local ASEAN government bodies to understand funding mechanisms and collaboration models. The case studies will include 10 selected collaborations across different industries and types, aiming to identify best practices, pitfalls, and factors affecting partnership effectiveness and sustainability.

Concerning data analysis, document analysis identifies key trends and contextual factors in Japanese-LMIE ASEAN startup collaborations through reports, government documents, and industry publications. ATLAS.ti (Version 24) will be used for qualitative analysis, supporting data-grounded analysis aligned with Grounded Theory Approach (GTA) principles (Glaser & Strauss, 1967; Higuchi, 2017). This method reveals factors affecting success or failure, with findings integrated to provide a comprehensive understanding of the impact of Japanese investments on startup performance, highlighting best practices and challenges in Japanese-ASEAN partnerships.

## 6. Study Results

I analyzed 24 literature items—12 for document analysis and 12 for case studies. The review covered Japan-ASEAN relations, startup trends, culture, policy recommendations, historical developments, and current business environments. Key factors driving entrepreneurial performance in Southeast Asia include the ASEAN Guidelines and the NINJA Strategy (OECD and ASEAN Secretariat, 2020; JICA, 2023b). Japan's evolving startup ecosystem fosters mutual growth with developing countries (MRI, 2024; Flourish, 2024). Organizations such as JICA, METI, JETRO, and ERIA play crucial roles in developing startup ecosystems (METI and JETRO, 2023; Oikawa and Iwasaki, 2023). Countries, particularly the Philippines, Cambodia, and Indonesia, have enhanced their ecosystems (ADB, 2022; ADB, 2023; Gov.Ph, 2024). However, challenges such as informality, tax systems, limited financial access, and labor skill gaps affect startup success, particularly in Lao PDR and Myanmar (ADB, 2023). Vietnam and Myanmar show strong potential for expansion (EMC, 2017; ABT, 2024; Yeo, 2024). Findings are summarized in Figure 2 below.

**Institutional failures (Gr=21)** are a major barrier to Japan-ASEAN startup collaboration due to weak governance and inefficient institutions. **Market failures (Gr=21)** further impede growth by limiting access and creating ineffective innovation ecosystems. **Business environment (Gr=11)** is challenged by regulatory complexity and infrastructure gaps, complicating expansion. **Market conditions (Gr=8)**, such as competition and demand variability, restrict market entry. **Economic development (Gr=7)** influences partnership effectiveness through broader macroeconomic factors. **Long-term planning (Gr=6)** is essential for sustained collaboration, while **financial access (Gr=3)** remains a constraint

impacting innovation and growth. The analysis highlights that institutional and market failures, along with challenges in the business environment, are the most significant obstacles to Japan-ASEAN startup collaboration. To foster innovation and sustainable growth, it is essential to address these issues through improved governance, enhanced market access, and supportive business conditions.

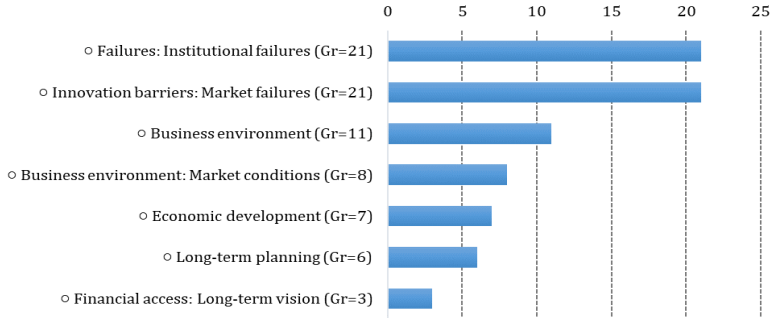


*Figure 2. ATLAS.ti Outputs through Document Analysis*
*Source: Author*

Furthermore, a review of 12 additional selected literature sources based on document analysis provides deep contextual insights into specific instances of collaboration between startups in ASEAN LMIEs and Japanese enterprises, revealing six key developments as follows.

1. **Innovation-Driven Ecosystem Support:** Japanese agencies (JETRO and JICA) promote international expansion for Japanese startups through programs, notably the Global Acceleration Hub and J-Bridge, offering financial and advisory support (JETRO, 2024).
2. **Sector-Specific Growth:** ASEAN LMIEs, particularly Vietnam and Myanmar, are rapidly expanding in fintech, healthcare, and digital services. Japanese investments include Mitsubishi's partnership with Gojek in Vietnam and support for Myanmar's fintech sector through Phandeeyar's accelerator program (Salim, 2019; TechCollective, 2024).
3. **Regional Connectivity:** JICA's projects in the Mekong region boost regional connectivity, supporting startup growth in Cambodia and Laos. Japanese enterprises are also engaging in agri-food and tech sectors in these countries (JICA, 2023a; EA, 2024).
4. **Cultural and Entrepreneurial Collaboration:** Initiatives, including the LJI SUSU events between Japan and Laos highlight the role of relationship-building in overcoming regulatory and cultural challenges, easing collaborations (LNA, 2024).
5. **Financial Innovation:** Japanese enterprises are enhancing LMIEs' financial inclusion with microfinance (e.g., AEON in Cambodia) and digital payments (e.g., Rakuten Viber in the Philippines), supporting local businesses (Phnom Penh Post, 2014; Manila Standard, 2024).

6. **Strategic Flexibility:** In Indonesia, Tokopedia's exploration of SPAC mergers and IPOs showcases Japanese investors' strategic adaptability, providing startups with growth and exit pathways (Invest Tokyo, n.a.; Jakarta Post, 2020).

## 7. Discussion and Conclusion

The qualitative mixed methods identified key practices for successful Japanese-ASEAN startup collaborations. Core elements include mentorship, knowledge transfer, and cultural adaptation, along with strategic investments from Japanese partners. These collaborations align with Japan's economic and geopolitical interests, fostering innovation, financial inclusion, and long-term cooperation in ASEAN's lower-middle-income economies.

Figure 1 illustrates factors influencing startup success and strategies for overcoming the lower-middle-income trap in ASEAN, emphasizing mentorship, collaboration, and resource allocation. Expanding this framework to include emerging technologies, institutional challenges, and policy recommendations will enhance its practical relevance. The study notes two limitations: the need for detailed analysis of institutional failures and the recommendation to incorporate field surveys and interviews for a more comprehensive approach.

In conclusion, this study explores the evolution of startup ecosystems in middle-income ASEAN countries, underscoring the significant role of Japanese entrepreneurs. Successful collaborations are driven by mentorship, knowledge transfer, cultural adaptation, strategic investments, and long-term partnerships. Enhancing the framework to incorporate emerging technologies and institutional challenges will bolster its practical application and support sustainable startup ecosystems in the region.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# SUSTAINABLE BUSINESS MANAGEMENT IN DIGITAL SOUTHEAST ASIA: JAPANESE FIRMS IN LAO PDR

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***Abstract***

*Since World War II, East Asia, including Japan, South Korea, and China, has achieved significant economic development, while many Southeast Asian economies still require further sustainable growth. Business promotion is crucial for economic development in capitalist societies, with Southeast Asia focusing on innovation and digitalization, offering unprecedented opportunities for global operations. Over recent decades, Japanese enterprises have increased foreign direct investment in Southeast Asia, fostering local market expansion and sustainable growth. This study explores the cultural and business communicative barriers hindering Japanese firms from achieving high performance and how to overcome barriers to success. This study is based on semi-structured interviews with Japanese managers leading organizations in Lao PDR. In their own words, these managers identify challenges and how they are able, or unable, to overcome them regarding staff, training, communicating, Digital Transformation, and conducting regular business. Drawing from these comments and experiences, we seek to describe best practices and strategies, prescribe some approaches that may be usable for other managers, and map the areas still requiring investigation. Effective overseas operations require network resources locally and cultural sensitivity for success in East Asia's dynamic business environment. Lao PDR, despite steady progress, faces significant challenges, including lack of resources, inequality, and inadequate infrastructure. The government is focused on sustainable development and improving digitalization, yet funding and training remain hard to resolve.*

***Key words****: Sustainable Business Management, Communication, Cultural Differences, Digital Transformation, Japanese Firms, Southeast Asia, Lao PDR.*

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# 1. Introduction

Since World War II, East Asia has seen significant economic growth, with Japan, South Korea, and China leading the way through industrialization, high-tech focus, and market reforms. In contrast, many Southeast Asian economies, though advancing, still face challenges, with Laos being one of the regions least developed. Business promotion via innovation and digitalization is crucial for growth, and Japanese companies are increasingly investing in Southeast Asia for growth as well as to drive efficiency in their businesses. Despite these efforts, Japanese firms face significant cultural and communication barriers in Laos. This study uses semi-structured interviews with Japanese managers to identify these challenges and strategies intended for improving performance in this underdeveloped country.

# 2. Literature Review

## 2.1. Economic Situation and Cross-Cultural Management in Southeast Asia

Since the 1960s, ASEAN economies have shifted from primary industries to secondary and tertiary sectors, following the industrialization models of South Korea and Taiwan (Perkins, 2013). This transition has spurred multinational investment, driven by improved business conditions and increased FDI (UNCTAD, 2024; World Bank, 2020).

However, successful operations in Southeast Asia also require cultural understanding. Key traits like respect for hierarchy, indirect communication, and relationship-building influence business interactions, from negotiations (Salacuse, 1998) to decision-making (Witt & Redding, 2008). Practices such as face-saving and adaptability are vital for cross-cultural management (Hipsher, 2010) and overcoming language barriers and fostering cultural awareness are key challenges. As globalization expands, managing cultural diversity becomes crucial for multinational enterprises (Taira & Schlunze, 2022), especially for Japanese firms adapting to local norms (Schlunze et al., 2014).

Lao PDR faces economic challenges, including currency depreciation and high inflation, with food prices up 39.5% in 2023 (ADB, 2024a). Despite these issues, growth is projected at 4.0% for 2024 and 2025, though inflation will remain high (ADB, 2024b) and challenges like weak government capacity and project delays persist (ADB, 2024a). As of June 2024, approximately 110 Japanese firms operate in Lao PDR, with 581 Japanese residents (JETRO, 2024). This is low compared to other Southeast Asian countries. To boost economic growth, Lao PDR needs to enhance its attractiveness to foreign investment, including from Japanese firms.

## 2.2. Economic Development and Digitalization in Southeast Asia

East Asia, including Japan, South Korea, Taiwan, and China, has seen significant economic growth (Perkins, 2013). In contrast, while Southeast Asia has grown over the past 30 years, many of the region's economies still need development (ADB, 2011; UNCTAD, 2024; World Bank, 2024a). The region shows a

stark GNI per capita disparity: Malaysia and Thailand have figures between 7,000 and 11,000 USD, while countries like Indonesia, Myanmar, Cambodia, Laos, Vietnam, and the Philippines report figures below 4,000 USD (World Bank, 2024a).

Gill and Kharas (2007) discuss the "middle-income trap," highlighting the challenges of transitioning to higher income levels. In Southeast Asia, economic growth is increasingly driven by digitalization, which creates opportunities (Khare et al., 2022). From 2015 to 2019, nominal GDP growth averaged 6.1%, while the Internet economy expanded by 33.0% (METI, 2020). The COVID-19 pandemic accelerated this trend, with projected annual growth of 28.2% for the Internet economy from 2019 to 2025, significantly outpacing GDP growth (Yusof Ishak Institute, 2020). This underscores the transformative potential of digitalization.

### 2.3. Digital Transformation (DT)

The concept of Digital Transformation (DT) refers to radical change in an organization's processes, culture, and thinking (Hinings et al., 2018). Firms that start with few or no digital systems can undergo DT as can firms that are born digital; DT is expected to be continuous (Kääriäinen et al., 2020). Since there are no solutions that fit all situations, firms must feel their way forward as they proceed.

### 2.4. Cross-Cultural Management

The academic study of cross-cultural management addresses concerns such as cultural knowledge transfer, inclusivity, and sustainable human resource management. These activities aim to achieve synergy (Adler & Gundersen, 2005), which fosters a firm's success rather than mere survival. A key component is knowledge transfer, typically flowing from the parent company to the subsidiary (Rhodes et al., 2008), with infrequent transfer in the opposite direction (Murakami, 2017). The transferred knowledge often involves management practices and schemas (Andreil et al., 2021). Beyond management practices, Cultural Intelligence (CQ) is crucial in cross-cultural settings (Earley & Ang, 2003).

## 3. Study Gap, Study Purpose, and Research Question

### 3.1. Study Gap and Purpose

Previous research on sustainable business management has often overlooked the cultural and communication barriers faced by Japanese firms in least-developed countries (LDCs). Lao P.D.R., an LDC in Southeast Asia with limited East Asian investment, serves as a key example. This study addresses this gap by exploring how Japanese firms can navigate these barriers to enhance their performance in such challenging environments. Specifically, it investigates the cultural and communication obstacles that hinder the performance and sustainable management of Japanese firms in LDCs, focusing on Lao P.D.R.'s underdeveloped economy. Using semi-structured interviews and questionnaires, this study provides an in-depth analysis of these challenges.

### 3.2. Research Question

*How do cultural and business communication barriers impact the performance of Japanese firms in sustainable business management in Lao PDR?*

## 4. Frameworks

Tran and Karikomi (2019) categorized ASEAN countries into "lower-middle-income" and "higher-middle-income" to examine growth challenges in inclusive development. Hara (2023) builds on Tran (2016) and Ács and Szerb (2009) by classifying economies as "Factor-driven," "Efficiency-driven," and "Innovation-driven," clarifying the link between economic development and entrepreneurial growth and its effect on GNI in the Middle-Income Trap in Southeast Asia. The World Bank (2024b) emphasized that transitioning to high-income status requires moving from "investment" to "innovation," highlighting the need for economic restructuring and social mobility. In Southeast Asia, cultural factors like hierarchy, indirect communication, and relationship-building shape business practices, with elements like face-saving, flexibility, and time orientation being key as a way of human resource management in local areas (Hipsher, 2010; Andrei and Laura, 2021). Considering these factors, a conceptual framework addressing cultural and communication barriers impacting Japanese firms in sustainable business management, particularly in less-developed countries, can be structured as illustrated in Figure 1.

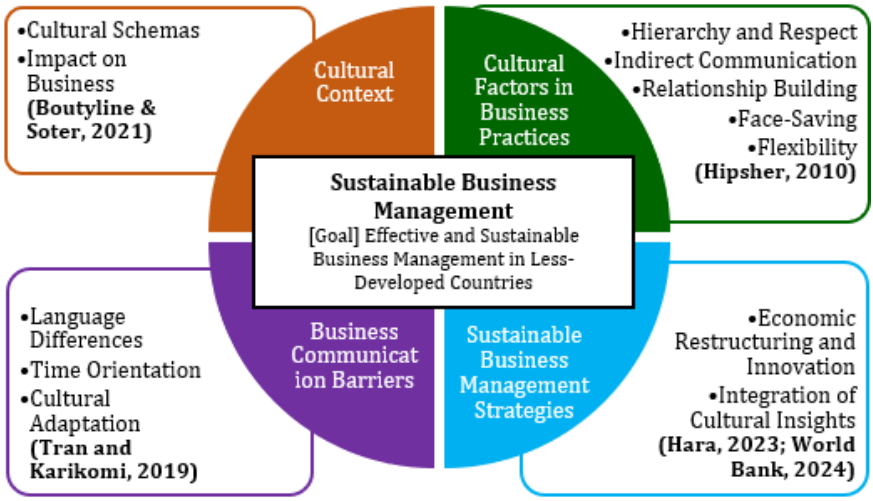


*Figure1: A Hypothetical Framework on Sustainable Cross-cultural Business Management*
*Source: Authors*

It illustrates a hypothetical framework for sustainable business management in the context of promoting economic development in LDCs. The four key factors presented— "Cultural context," "Cultural Factors in Business Practices," "Business

Communication on Barriers," and "Sustainable Business Management Strategies"—serve as major catalysts for achieving the goal of "Effective and Sustainable Business Management in Less-Developed Countries," which is central to the figure. These factors influence local business operations by potentially causing misalignments that lead to misunderstandings, deviations from local cultural expectations, communication barriers and inefficiencies, and by driving innovation while respecting the local context. This figure visually represents the various factors influencing the performance of Japanese firms in sustainable business management, highlighting the importance of cultural understanding and effective communication strategies.

## 5.Methodology

This study examines the impact of cultural and business communication barriers on the performance of Japanese firms in sustainable business management in least-developed countries, such as Lao PDR. Using a qualitative approach, semi-structured interviews were conducted with CEOs or representatives of Japanese firms operating in the region. The three firms investigated, and the time spent with them are shown in Table 1.

Participants were purposively sampled based on technology-related leadership roles (Creswell & Poth, 2017), with snowball sampling used to reach hard-to-access e-leaders through referrals. Due to geographical constraints, interviews were conducted online, recorded, transcribed, and analyzed. The interview questions were guided by a detailed research framework.

*Table 1. Case firms and data collection*

| Firm | Time | Job Title | Interview | Questionnaire | Sector |
|---|---|---|---|---|---|
| A | 75min | President | Y | Y | Construction |
| B | 85min | President | Y | Y | Education |
| C | 60min | Project Manager | Y | Y | Government |

*Source: Authors*

Thematic analysis was employed to examine the data, identifying patterns and themes within interview transcripts and open-ended responses (Braun & Clarke, 2006). This method, adaptable to various theoretical frameworks (Braun & Clarke, 2019; Guest et al., 2012), involved deductive, inductive, and hybrid approaches for coding, theme identification, and refinement. We utilized two approaches—web-based questionnaires and parallel online interviews—to ensure complete and understandable responses to the questionnaire and survey items (Creswell, 2013; Patton, 2015).

The themes revealed by the interviews and questionnaires are shown in Table 2 as follows.

*Table 2. Themes raised by interviewees*

| Main themes | Sub-themes |
|---|---|
| Alignment with HQ | Communication (Firm A, B, C); |
| Digital Transformation (DT) | Training (Firm A, B);<br>Funding (Firm B, C);<br>Low ability of staff (Firm A, B, C) |
| Business culture and practice (Cultural Schemas) | How things are done (Firm A, B, C);<br>Cultural accommodation (Firm C);<br>Teaching (Firm B, C);<br>Integration of cultures (Firm A, B);<br>Cultural adaptation (Firm B) |

*Source: Authors*

## 6. Study Findings

We surveyed three Japanese firms in Lao PDR through web-based questionnaires and online interviews in June and July 2024, focusing on DT, cultural adaptation, and economic contributions.

- Firm A (Construction) saw moderate digital impacts, with improved efficiency and fraud reduction. It positively handled financial pressures, hired a new manager, and emphasized quality control through training. Its sustainability efforts centered on profitability.
- Firm B (Education) experienced broad digital effects, enhancing product and customer management. It restructured teams, focused on cultural understanding, and struggled with sustainability. Revenue from new technologies was most successful here.
- Firm C (Government) saw limited digital impacts due to resource constraints, faced financial struggles, and made no organizational changes. It focused on staff motivation and human resource development, integrating sustainability into operations.

All firms recognized the importance of cultural understanding. Economic contributions included sales expansion (Firm A), Japanese-style education (Firm B), and human resource development (Firm C). Challenges varied, from regulatory adaptation to network strengthening, impacting their sustainable business management as explored in section 4.

## 7. Discussion and Conclusion

All firms faced challenges but found ways to address them, primarily by introducing Japanese management practices to Laos, with limited incorporation of Laotian practices. This suggests firms should more carefully consider which practices and schemas to adopt. Firm B was notably successful due to its local focus, but further research is needed to understand how firms identify and integrate local practices. All firms positively impacted local sustainability, with Firm C aligning

headquarters' goals and local stakeholders by focusing on human resource development and communication.

The framework in Figure 1 is potentially valid for addressing barriers in small markets like Lao PDR. However, the study's limitations include a small sample size, reliance on self-reported data, lack of longitudinal data, and limited exploration of external factors. Interview bias and simplified cultural interpretations may also impact the findings.

Despite its limitations, the study offers valuable insights into the cultural and communication barriers that impede Japanese firms in Lao PDR and proposes a framework for sustainable business management based on semi-structured interviews with Japanese managers.

To succeed in Lao PDR, Japanese enterprises should focus on: tailored DT, proactive financial management, and deep cultural adaptation. Investing in cultural sensitivity training, localizing operations, and fostering inclusivity will enhance relationships with local stakeholders. Balancing autonomy with effective communication between local operations and headquarters is key for strategic alignment. Contributing to local economic development and integrating sustainability practices will help build long-term market presence. Continuous strategy evaluation and adaptation are crucial for navigating the unique challenges of the Lao market.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# LEADERSHIP AS A FACTOR IN DESIGNING A FLEXIBLE COMPANY'S ORGANIZATIONAL MODEL IN DYNAMIC BUSINESS CONDITIONS

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***Abstract***

*The objective of this research is to qualitatively explore the role of leadership in designing a flexible model of organizational structure in conditions of frequent market regime-switching, tail behavior, and jumps, based on the Galbraith's Star model. Designing a flexible organization can be achieved by changes not only in the organizational structure, as previously believed, but also by changes in each of the design elements such as corporate strategy, structure, organizational culture, leadership, and human resource management. The paper focuses on understanding how to achieve organizational flexibility by changing the leadership factor, while assuming ceteris paribus. Moreover, this work attempts to gauge the contribution of leadership in the process of transforming a rigid, vertical company organization into a shallow, horizontal company organization. By adjusting the leadership input, the organization may be able to ensure stability and dynamism while being subjected to turbulent business environment.*

***Keywords****: leadership, organizational design, organic design, flexible organization, dynamic business conditions, regime-switching.*

## 1. Introduction

The topic of this research is leadership as a creation factor of a flexible organizational structure, which can take various manifestations. In the recent period (i.e., from 2020 to 2022), increased market volatility in the business environment caused modifications of companies' strategic behavior and redesigning of the existing organizational structure.

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The dynamics of structural changes in global financial markets together with the transition processes in the Republic of Serbia, imposed the necessity of company restructuring, which inevitably includes modifications of the model of corporate organizational structure and organizational design, i.e., the way the organization is managed.

Globalization and informatization are the two key characteristics of the business environment for modern organizations. This research focuses on the analysis of current rapid business changes and the organizational adaptation of companies necessary to achieve the desired flexibility and better performances. Contemporary business conditions require organizational restructuring to respond adequately to both profitable opportunities and environmental challenges.

Continuous environmental adaption is essential for organizations experiencing frequent changes in the market regime switching. It is worth emphasizing that an ideal organizational structure does not exist. However, an inadequate organizational structure subsist. Negative results may not be visible in the short term but subsequently, in the system crisis, when the negative consequences could only be eliminated by the appropriate organizational solutions, i.e., by creating an adequate organizational structure.

The transitioning process from initially expensive rigid organizational structures with numerous hierarchical levels to organizational structures with a small number of hierarchical levels is very important for modern organizations.

In conditions of of frequent market regime-switching, human resources become the key source of competitiveness and power to achieve better business results and the prerequisite for company viability and the development of modern organization. Leadership plays a significant role in aligning the rigid, vertical organization of a company.

There is no uniform definition to be followed encompassing every aspect of leadership. Leadership is a complex process that includes:

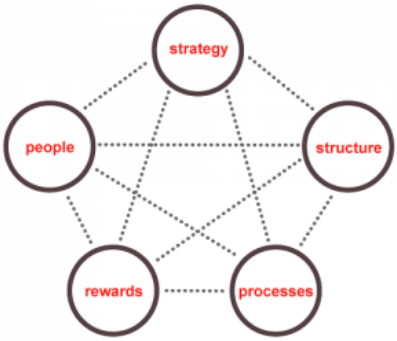
- personality variables of subordinates,
- expectations of subordinates about the leader's bahavior,
- the ability of the group to solve the problem,
- willingness of subordinates to accept responsibility. (Vlahović, 2008, p. 30).
- Some leadership definitions are the following:
- Leadership is the choice-making process in dealing with people while giving orders to influence them and the subsequent transformation of the choices into actions (Mašić, 2009, p. 405)
- Leadership is the skill of using the expertise possessed by the majority and demonstrated by the minority. It is necessary to obtain excellent results from ordinary people (Milisavljević, 1999, p.11).
- Leadership is the process of directing group members towards task accomplishment, as well as the distribution of power between leaders and members (Bošković, 2008, p. 203).

The most important components of leadership are the following:

- leadership is a process,
- leadership involves influence,
- leadership occurs in groups, and
- leadership involves common goals (Northouse, 2008, p. 7).

Leadership "primarily involves using authority to help followers handle challenges arising from a dynamic work environment and culture“ (Heifetz, 1994). Leadership is determined by numerous factors, such as company size, company structure, characteristics and behaviors of leaders and employees, environment, and organizational and national culture.

The objective of this research is to explore the role of leadership in designing a flexible model of organizational structure in conditions of frequent market regime-switching, tail behavior, and jumps, based on the Galbraith's Star model.




*Source: Galbraith, J. et al. (2002).*

The research on the influence of the leadership element in the process of designing a flexible model of enterprise organization in the dynamic changes of market regime-switching opens up many questions such as the following:

- The relationship between leadership and the organizational structure of the company
- The relationship between leadership and the business strategic goals
- The relationship between leadership and rewards
- The relationship between leadership and the organizational culture.

This analysis, however, does not aim to provide individual answers to each open question, but rather to cross-analyze the aforementioned phenomena and show how the leadership can, with fine tuning and while assuming ceteris paribus of other Galbraith's Star model elements, enable the design of a flat, flexible company organization.

The research results are derived from the author's doctoral thesis (Marković, 2023). The research conducted in the company Nectar from Bačka Palanka produced certain results, which will be presented in the next section.

### 1.1 Leadership as a factor in designing a flexible organizational model (survey)

The influence of leadership as a factor in designing a flexible model of company organization in dynamic business conditions was evaluated by conducting a survey in the company Nectar from Bačka Palanka in 2023 (Marković, 2023).

A total of 146 respondents participated in the survey, including 80 production workers, 46 middle-class managers, and 20 members of the senior management.

The results are as follows:

During the financial crisis, the respondents of all three groups, i.e., production, middle management and senior management, declared that autocratic leadership was the most desirable choice.

*Table 1: Leadership in the conditions of the financial crisis*

| | | Production | Middle management | Senior management |
|---|---|---|---|---|
| Leadership | Autocratic | 7 | 8 | 12 |
| Leadership | Democratic | 3 | 3 | 1 |
| Leadership | Liberal/Laissez-faire | 1 | 5 | 7 |

*Source: Authors*

During the health crisis (e.g., COVID-19), the respondents of all three groups, i.e., production, middle management, and senior management, declared that autocratic style of leadership was the most desirable choice.

*Table 2: Leadership in the conditions of the health crisis*

| | | Production | Middle management | Senior management |
|---|---|---|---|---|
| Leadership | Autocratic | 10 | 15 | 13.5 |
| Leadership | Democratic | 5 | 1 | 1 |
| Leadership | Liberal/Laissez-faire | 1 | 3.5 | 7.5 |

*Source: Authors*

## 2. Results

After the review of domestic and foreign literature and examples from practice, and the conducted research in a business entity, the authors conclude that a flexible organization is necessary in modern times. In this research, they relied on the Galbraith's Star model. The organizational flexibility can be achieved not only by changing the structure and strategy but also other dimensions of the design, without variations of other elements. In this case, it is the leadership. People, i.e., employees are key assets of any organization.

In this sense, the organizational flexibility is above all achieved by the creative and innovative behavior of managers and other employees (Marković, 2023).

## 3. Discussion

In dynamic business conditions, the role of the leadership phenomenon in the process of designing flexible company organizations is a great challenge for future researchers in the field of organizational design.

The questions to be asked might be the following: is the advocacy for a flexible organization justified? Can the leadership and to what extent ensure organizational flexibility without varying other elements of the Galbraith's Star model?

In this research, flexibility is proven as necessary for a company to survive in conditions of frequent market regime-switching, but to what extent should bureaucracy be rejected?

## 4. Conclusions

A new leadership and organizational culture, a new job systematization, and a new reward system are essential for implementing a flexible organizational structure.

The management of tomorrow needs to understand the importance of implementing flexible company organization. Recent business environment has changed in favor of more frequent regime switching episodes (e.g., COVID-19, cryptocurrency crash in 2022, and Russia-Ukraine war A flexible organizational structure design is directed towards enabling companies to be more adaptable to dynamic markets, i.e., to improve their perception of business opportunities and threats. By adjusting the leadership input, the organization may be able to ensure stability and dynamism while being subjected to turbulent business conditions. This research concludes that an organization's executives should understand the ever-changing nature of current markets that originates from geopolitics, intensified competition, globalization, and informatization.

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# LABOUR MARKET DYNAMICS – YOUTH MIGRATION FROM SERBIA

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***Abstract***

*Human capital is the ultimate resource of the twenty-first century. The new generations of labour force often possess competences highly valued at the labour market (IT skills, flexibility, innovation, risk taking, etc). Developed countries generally have a compelling demand for skilled labour due to shortages on their labour markets. Therefore, the movement of skilled workers outlines one of the most outstanding features of current patterns of international migration. From the second half of 20th century Serbia is well known for labour migration processes. Nowadays the phenomenon of brain drain is widespread, as significant number of highly educated, competent and innovative young people leave Serbia. Among the Serbian juvenility there is a strong desire to emigrate. The main factors influencing the decision about leaving the home country are economic factors and the quality of life. Factors which effect the decision to stay are social-emotional factors, solved housing, patriotism and sense of belonging. Youth migration have serious negative effects on the home country – it means a financial loss due to the investment in education, deficit of skilled labour force, depopulation etc. The aim of this paper is to give a literature review on the youth migration and to analyse the attitudes of young people about moving and working abroad based on field studies realized in Serbia in 2018 and 2023.*

***Key words****: labour market, migration, brain drain, Serbia.*

## 1. Introduction

Migration has played a crucial role throughout history in shaping the world as we know it today. In the current era of globalization, an increase in international migration has been evident. Mobility is more pronounced among youth than among the overall population.

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Nowadays there is a strong migration pressure from Middle East on European countries. Although it is very difficult to predict all consequences of this phenomena, migration represents one of the solutions for population decline in Danube region. On the other hand, it raises many political, social and economic questions. Highly qualified labour force from the East is looking for job opportunities in the West, starting mostly during their education and studies (Savić, 2022).

The Republic of Serbia is traditionally a country of emigration and youth mobility, usually driven by economic and political factors. Emigration is recognized as an opportunity to provide a better life for themselves and their families, seek better job opportunities and find their place in society (Šantić, 2020).

Author Icoski (2022) stresses that the repercussions of youth brain drain are major. From an economic perspective, higher-quality human capital leads to a higher level of GDP and economic health, and vice versa.The massive outflow of people in certain professions worsens the problems related to the availability and accessibility of basic services. The most critical sector is public healthcare with a huge portion of young doctors and nurses leaving the region of West Balkan. Lack of services is also evident in lower-skilled professions such as repair, maintenance, and construction, leading to higher service costs and lower quality.

The Eurostat 2019 data show that some 4000 people leave Serbia every month; most of them young people under 30, who most often cite economic reasons for leaving the country. Serbia is on the list of 50 countries with the highest migration rate, at 31st place (Ceha, 2021). At the same time in 2021, Serbia was ranked 58 out of 134 countries, according to the Global Talent Competitiveness Index. It also shows the poor capacity of Serbia to manage its talents, or to enable, grow, attract and retain them (Arandarenko, 2021).

The aim of this paper is to give a literature review on the youth migration and to analyse the attitudes of young people about moving and working abroad based on field studies realized in Serbia in 2018 and 2023.

## 2. The characteristics of the youth migration in Serbia

It is important to be aware of pull and push factors influencing the brain drain processes. Natarer & Lavrić (2022) emphasize that many contemporary studies show youth migration to be a complex set of socio-cultural (macro), familial (meso) and individual (micro) factors mutually interconnected and expressed as a motive to migrate. For example, researchers from Romania have found that although economic and cultural factors play an important role, specific family situations and prolonged transition to adulthood, together with self-perception as "would-be migrants," appear as crucial motivations for migration.

In case of Serbia the main factors influencing the decision about leaving the home country are economic factors and the quality of life. Factors which effect the decision to stay are social-emotional factors, solved housing, patriotism and sense of belonging. The pull factors that attract the Serbian population to other countries are the possibility of better incomes and bigger job opportunities, a regulated

economic system, social security, lower living costs, and good pensions at the end of working life (Krasulja, Blagojević & Radojević, 2016).

The push factors for youth brain drain in the West Balkan 6 (WB6) countries are quite diverse. The question of moving abroad is highly individual, depending on personal and societal characteristics such as education level, geographical area of origin, or employment and financial status. It is important to emphasize that if historically youth predominantly left the region for bigger salaries and better jobs, nowadays they are increasingly leaving for a higher quality of public services, education, healthcare, good governance, or environment. At the same time, financial motives remain crucial with one-third of youth wanting to leave for purely economic reasons, while 10 percent want to emigrate to pursue a better education. The EU is the most desirable destination for WB6 citizens due to geographical proximity and ongoing membership accession processes. The most important pull factor is liberal EU migration policies. (Icoski, 2022).

As medical professionals are one of the most affected by brain drain, it is interesting to analyse their motives to emigrate. Research from 2015 showed that the main pull-factors include: stable social and political environment; professional working environment favourable for training and skill-enhancement; existence of adequate medical technology for contemporary procedure; attractive wages, social and other benefits; existence of employment policies which recognize good performance. On the contrary the most important push-factors are the following: low wages; impossibility of employment; discontent with jobs; non-existence of future prospect (training and carrier development); bad working conditions (Institute of Public Health, 2015).

The research conducted in 2019 in four municipalities of Serbia analysed the intention to emigrate, an indicator of migrants' potential preferences, or more precisely, of the extent to which respondents will realize their aspirations to leave the place of permanent residence. The data showed that 42.3 percent of respondents stated that they often or very often considered leaving. The share of such responses was higher among respondents in urban areas. Being young, female, highly educated, unemployed and with migration history, they are more likely to prepare for an internal journey, but more often for an international journey. The plans and preparation for emigration in the next year were certain among 26.3 percent of the total population. However, this share was almost two times higher among young respondents: 50.4 percent in the age cohort 20-24 and 44.7 percent in the age cohort 25-29. As expected, young, predominantly male respondents, who were more educated, in the optimal fertile and working age, were the most mobile in the total population, and these categories were more likely to emigrate in the next year (Šantić, 2020).

According to the Survey of the youth population conducted by The Youth National Council in 2021, only about 11% of youth responded that they would not leave the country, while the 50% of the respondents said that they would leave although half of them were not in the planning process yet; 39% of respondents currently were not planning to leave but did not write off that possibility. The reasons to emigrate were more honourable life and better living standard and better

employment possibilities abroad. The most important reason to stay were family reasons, unwillingness to live abroad and the perception that it is good to live in Serbia. The most popular destinations are traditionally related to the Western Europe countries (63%), followed by the USA (12%) and the countries from the region – 8% (Krovna organizacija mladih Srbije, 2021).

As the brain drain is mainly connected to highly educated young people it is important to analyse the students' intention to emigrate. The *Student Migration Survey* (2018),which involved a total of 11,013 students from public and private colleges and universities, showed that a third of the respondents plan to go abroad after graduation, and as the main cause for leaving the country as many as 94.3% respondents state the reason of economic nature (impossibility of finding a job in their profession, impossibility of finding any job, poorly paid job in their profession, impossibility of professional advancement, low standard of living, poor economic situation), while the remaining 5.7% state non-economic reasons (corruption, obeying the law, etc.). According to the share of students who plan to look for better living and working conditions in other countries, the students of information and communication technologies account for the biggest segment (36.5%), followed by the students in the field of medical sciences (36.2%).

The research conducted by Cvetanović in 2022 among university students and young graduates between the age of 18 and 35 showed that largest number of respondents (29.2%) would probably leave, while 25.2% of them definitely decided to take that step. Among the respondents who planned to leave, 21% would leave the country only temporarily, and 21.3% considered that their departure would be permanent. However, the largest number (57.7%) of respondents stated that the length of the stay abroad depends on various factors, among them adaptation and professional success in another country. When it comes to the reasons for leaving, the respondents were able to offer several answers. Most often, they chose a better standard of living and then a bigger chance of finding a job in their profession, as well as studying abroad and professional training (Cvetanović, 2023).

The return of young, highly educated persons to Serbia was researched in several qualitative case studies. It was shown that such returns are complex processes, often triggering subsequent emigration due to misplaced expectations, disappointments, problems with pursuing entrepreneurial, research, scientific ideas, diploma recognition issues, unacceptance by wider social and professional communities, etc. In many cases, returns are not driven by economic reasons or political expediency, but instead by needs of belonging, memories, imagined home communities, etc. (Radonjić& Bobić, 2020).

Other than educated people, ethnic minorities are also over-represented in the migration processes (Radonjić & Bobić, 2020). An example of this is Hungary, which in 2002 became the major destination for emigrants from four municipalities from Serbia with the high share of members of the Hungarian ethnic community, directly bordering Hungary, or in its vicinity (Arandarenko, 2021). The continuous brain drain of ethnic minority students inevitably leads to the weakening and disappearance of the above-mentioned ethnic minority communities (Filipović et al., 2007).

## 3. The attitude of youth about migrations from Serbia

The last part of our paper presents the main results of a field study realized in 2018 in Kanjiža, a municipality in the north part of Vojvodina about the attitudes of young about leaving Serbia based on YOUMIG project. In the cooperation project 'YOUMIG,' funded by the INTERREG Danube transnational program, challenges of youth migration were discussed in a transnational consortium consisting of project partners from different countries from Central and Eastern Europe experiencing difficulties such as a declining population and outmigration, as well as immigration of young people, which necessitated the provision of an integration infrastructure. Project outcomes included strategies as well as pilot activities performed by local-level authorities (Gruber, 2021).

The research sample was made of young inhabitants of municipality Kanjiža between age 18 and 34. The number of interviewees was 615. The majority (341) were female, while there were 272 male interviewees, too. The great part of the sample (57%) had secondary level education, 28% owned tertiary education diploma, while 5% had only elementary education. The others were still in the process of education. As regarding the employment status of the interviewees, 51% were employed, 15% were unemployed, 9 % self-employed, 21% were still in the process of education and about 4% had other employment status.

The research result showed that about 62% of respondents did not want to leave its birthplace, but about 1/3 would like to move to a foreign country and about 5% to another municipality in Serbia. The obtained data on staying in the birthplace pointed out emotional motives. The most important factors were that there lived their family, relatives and friends, as well as they felt happy here and that they were emotionally connected to their homeland. On the other hand, 18% of respondents planned to move to a foreign country in a year. Among them 82% had realized some concrete actions towards immigration (seeking for adequate information, job search, finding housing, etc.). Among those who planned to immigrate about 55% would go alone, while about 45% with family. Only about 35% of those planning to immigrate were thinking about coming home to Serbia once. The main motives of youth immigration from the municipality of Kanjiža were economic reasons. The respondents considered that the wages in Serbia are low, the economic and political situation unstable, they could not see their future in this country and were not satisfied with the domestic standard of living and possibilities of finding an adequate workplace (Slavić, 2019).

The other field research conducted by the authors had the aim to analyse the students' current perception on their soft skills and intention to emigrate. The participants were students of Faculty of Economics in Subotica, University of Novi Sad. The on-line anonymous questionnaire was filled out by university students of all levels (bachelor, master and PhD students) from October 2022 till March 2023. The number of respondents from Serbia it was 245.

Concerning the sample overview, we have to highlight that the great majority of represents (80%) were female. The respondents' age distribution showed that the great majority (96%) of respondents was between 21 and 29 years. The two

thirds (66%) of the interviewees were master students, with college or university education, while one thirds of respondents were undergraduate students.

According to the obtained data students consider that employers expect from university graduates the following skills: communication skills, language skills, teamwork, planning and problem solving, flexibility and creativity. Students consider that for employability soft skills are very important – equally or more than hard skills – but do not think that soft skills can be learned at school and education fully prepares them for work. The data show that students think that they can mainly develop their soft skills at work or abroad (Slavić et al., 2024).

## 4. Conclusion

Youth unemployment in Serbia had been considered an important economic and social issue in recent decades. Migratory movements from Serbia are caused by various historical, social, political, eco-nomic, and demographic factors. Brain drain is still an important phenomenon leading to emigration of highly educated young people from Serbia to more developed countries. The results of various research on the position and needs of young people show that their attitudes about their future in Serbia are very negative. The emigrants are young, highly educated and skilled. This affects Serbia's labor market and overall development, as the country is losing its young and most talented professionals.

The field research realized in 2018 in Kanjiža, in one of the northernmost municipalities of Serbia, show that the majority of young people do not want to leave their birthplace, they are emotionally connected to it. But in case of economic and social circumstances they were ready to migrate and then the majority would choose to move abroad. It is important to emphasize that almost 20% of respondents planned to leave Serba in a year and they had adequately prepared that.

The results of the research on the students' perception of the importance and development of soft skills in Serbia conducted at Faculty of Economics Subotica – University of Novi Sad showed that students consider that soft skills may be only partially learned at universitiesand that they can develop their soft skills at work or abroad, so they are planning to emigrate, too.

Among young people of Serbia there is a high intention to emigrate and brain drain is significant, too. The main driver of emigration is dissatisfaction with local and country related circumstances, especially in the sphere of economic development.These facts call not only for education system reforms but also for improvements in both work legislation and the management of talented individuals which are the strategic resource for economic development.

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# CLUSTER APPROACH TO TOURISM DEVELOPMENT IN THE FAR EAST AND ARCTIC AND FORMS OF STATE SUPPORT FOR PRIVATE INVESTORS

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***Abstract***

*The problem of the cluster approach as an effective tool for long-term tourism development has been discussed for quite a long time in different countries. According to the author, a tourism cluster is a set of tourism and recreational special economic zones created with government support, located within the same territory, and crucial for the economy of that territory. The purpose of cluster formation is to create a multiplier synergetic effect in the development of the region's economy. The development of a tourism cluster inevitably impacts the entire infrastructure, including transportation, road construction, and the construction industry as a whole, as well as the development of agriculture and the food industry. Additionally, it significantly contributes to solving employment problems. Moreover, tourism clusters are drivers of a positive business reputation for a country, which can be a significant factor in attracting new investment. The relevance of the study lies in the fact that the development of tourism in territories lagging behind the national average development rate provides an opportunity to accelerate growth by attracting private investment. This is particularly important given the current sanctions pressure currently being exerted on Russia.*

***Key words:*** *cluster, tourism and recreational activity, resort, special economic zones, territories of advanced socio-economic development, gambling zones, sports tourism, agricultural tourism, Arctic zone resident.*

## 1. Introduction

Clusters are groups of organizations concentrated in a specific territory, operating in the same industry, complementing each other and strengthening the competitive advantages of the companies and the industry in which they operate.

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That is, clusters exhibit a synergistic effect and can act as multipliers of economic development. In general, clusters that are the major for a particular region (country) are included in the Development Strategies, state programs, National Projects and other state documents of strategic, long-term and medium-term planning. An example of such a document is the Strategy of tourism development in the Republic of Sakha (Yakutia) (No. 1070-r, 2020). Cluster policy allows for increasing the competitiveness of both companies and territories, as well as national competitiveness as a whole, by mobilizing all resources, including those of small enterprises. In order to provide methodological assistance to the regions on the development of clusters, the Ministry of Economic Development of Russia issued recommendations on the implementation of cluster policy (2008). These recommendations are implemented by regions, such as the government of the Arkhangelsk region, in the development of tourism and recreational cluster documents (Decree of the Government of the Arkhangelsk Oblast No. 424-pp, 2014). The technology of creation and management of tourist-recreational clusters includes the following stages: 1) Making a legal decision on the development of the tourism industry; 2) Conducting sociological surveys of residents, guests, and business entities to assess interest in the tourist and recreational development of the territory; 3) Development of a tourism and recreation passport of the territory (inventory of available resources); 4) Development of a science-based concept and program for the tourist and recreational development of the territory, based on the assessment of its potential and condition. Creating a tourism and recreational cluster development plan and, if necessary, establishing a management company to implement the development project; 5) Attracting investors and securing loans for cluster development. Leveraging public-private partnerships (PPP). Development of business plans by investors; 6) Providing training programs to manage and cater to tourist flows. The Federal Agency for the SEZ management has developed a procedure for approval of business plans for the implementation of projects for tourism and recreational activities (Order of RosOEZ No. P/0049, 2008).

The World Travel & Tourism Council states that the tourism sector provided twice as many jobs as the financial sector of the economy in 2019 (despite the fact that the financial sector accounts for 19.4% of global GDP and tourism for 6.1%). Every tenth job in the world – belongs to the tourism sector, and in total, the tourism sector provides jobs for about 313 million people. Based on the above, it can be stated that the tourism and recreation cluster creates a large number of jobs, is able to have a multiplier effect on the development of the region's economy and on solving of the employment problem.

At the same time, the tourism sector accounts for much smaller share of the economy in Russia and other post-Soviet countries compared to the global average. In 2019, the tourism sector contributed 2.8% to Russia's GDP and provided employment for 3.6% of the workforce. The 2020-2021 pandemic had a detrimental impact on the development of the tourism industry, with a decline in its share of GDP and in job creation during that period. In the light of the above, we can confidently assert that the task of tourism industry development is one of the most important strategic objectives of the state development at the present stage. In the

Russian Federation, the issues of tourism development are regulated by federal laws that establish both the procedure for providing tourist services (Federal Law of the Russian Federation No. 132-FZ, 1996) and the creation of special economic zones (hereinafter – SEZ), in which favorable regimes for the development of clusters are created (Federal Law of the Russian Federation No. 116-FZ, 2005).

## 2. Discussion

In Russia, the task of tourism development, especially domestic tourism, and the use of a cluster approach to address this issue are not up for debate.

The general approaches to the creation and development of tourism clusters have been extensively covered by Ermakova J. A. and Kholodilina Y. E. (2021), Karmanova A. E. (2021), Yakovenko D. A. (2022) and other authors.

The development of the tourism sector in the Far East has been analyzed by Grivanov R. I. and Shmatova. D. A. (2018), Mirzekhanova Z. G. (2015), Chkhotua I. Z. (2022), Yakovenko D. A. (2020) and others.

The issues and prospects of tourism development in the Arctic are discussed in the works of Grushenko E. B. and Lisunova E. A. (2021), Karmanova A. E. (2021), Prokofieva E. Y. and Lyubezna A. V. (2021), Sevastyanov D. V. (2017), Shiryaevsky D. S. (2022), Yakovchuk A. A. (2020), Yakovenko D. A., Lykov P. A., Lykov V. A. and Burdanova N. V. (2024), and many other authors.

At the same time, the factors influencing investment attraction in the context of domestic tourism development, particularly in light of political and economic sanctions are understudied. Based on the analysis of the issues considered by various authors, the problem that became the subject of this study was selected.

## 3. Materials and methods

After analyzing the perspectives in the scientific community regarding the problems of tourism development and the multiplier effects of investment in the tourism industry on regional economies and employment issues, the author believes that the issues of both the incentives for investing in a particular industry and the effectiveness of investment and multiplier effects have not yet been sufficiently studied. There has been no comparative analysis of the new forms of support that emerged before the introduction of massive sanctions imposed by Western countries on Russia and during the period of these sanctions. In this regard, the author set out to analyze and evaluate the effectiveness of the proposed benefits and preferences using methods such as cross-sectional analysis and the comparison of various statistical data. The objects of the study are two macro-regions: the Far East and the Arctic. The subject of the study is the indicators of investment dynamics.

## 4. Results

There is no unified classification of tourism clusters, the author proposes the following classification:

*Table 1: Classification of tourism clusters (compiled by author)*

| No. | Purpose of tourism cluster | Category of tourism cluster |
|---|---|---|
| 1 | Recreational and health improving, medical | Resort |
| 2 | Sports and extreme adventure | Alpine skiing |
| | | Mountaineering |
| | | Water sports (kayaks, etc.) |
| 3 | Cultural and educational, event and festival | |
| 4 | Religious and pilgrimage | |
| 5 | Beach and water (cruise) | Beach vacation |
| | | Sea (ocean) cruises |
| | | River cruises |
| 6 | Gambling zones | Gambling zones |
| 7 | Scientific and educational, professional and business | Congress and exhibition activities |
| 8 | Agricultural and gastronomy cluster | Wine industry |
| | | Cognac and other production |
| | | Cheesemaking |
| | | Regional cuisines of the country |
| | | Ecotourism |
| 9 | Hunting and fishing | Sport fishing |
| | | Hunting |
| | | Photo hunt |
| | | Safari |
| 10 | Historical and ethnographic | |

In the USSR, the first sprouts of tourism clusters emerged. For example, the classic clusters were the following:

*Table 2: Popular tourist areas in the USSR (compiled by author)*

| Name | Territories included | Category |
|---|---|---|
| Golden Ring | Moscow, Moscow Oblast, Vladimir Oblast, Yaroslavl Oblast, Kostroma Oblast, Ivanovo Oblast, Tver Oblast | Historical tourism |
| Caucasian mineral waters | Stavropol Krai, Kabardino-Balkarian Republic | Spa |
| River cruises on the Volga River | Astrakhan Oblast, Volgograd Oblast, Saratov Oblast, Samara Oblast, Ulyanovsk Oblast, Republic of Tatarstan, Nizhny Novgorod Oblast, Kostroma Oblast, Yaroslavl Oblast, Tver Oblast | Historical, water tourism |

For a long time, several Russian territories, including the Far East and the Arctic, have experienced disruptive trends in their development: the permanent population has been declining, and the dependence of these macro- regions on financial support from the federal budget has been increasing.

During the Soviet era, thermal springs in the Yelizovsky district of Kamchatka, located in the immediate vicinity of the airport and the city of Petropavlovsk-Kamchatsky, were developed into resorts and health spas. The ski center

"Moroznaya" was built in 1975, in close proximity to the center of the region. Kamchatka is also known for its rhodon springs and volcanoes. The region has two geyser valleys. Therefore, the foundation of the tourism cluster of the region has been formed quite a long time ago.

The second promising center for the creation of a large tourism cluster has emerged in Primorsky Krai. In order to attract new investors and tourists, one of the gambling zones authorized in Russia was established in Primorsky Krai in 2009 (Decree of the Government of the Russian Federation No. 376, 2007; Order of the Government of the Russian Federation No. 1213-r, 2009).

A tourism cluster is planned for development on the Kola Peninsula (Murmansk Oblast), combining in one project opportunities for sports, industrial, expedition, historical and cruise tourism. The cluster is well located in relation to the federal centers. Its proximity to St. Petersburg and Moscow, as well as a wide range of opportunities for tourism development, from Arctic and nature tourism to a variety of winter sports and entertainment, may be a good opportunity to replicate the success of the nearest Scandinavian counterparts.

The Eastern Economic Forum, held on the initiative of the President of the Russian Federation since 2015, has created prerequisites for the development of scientific and educational, professional and business cluster.

The Government of the Russian Federation allocates subsidies for the development of tourism clusters and the creation of infrastructure for the development of tourism. In particular, in 2024 such subsidies are being received in the studied regions by Kamchatka Krai (in the amount of 1,362,065.4 thousand rubles) and Primorsky Krai (in the amount of 486.9 thousand rubles) (Order of the Government of the Russian Federation No. 1355, 2024).

The state subsidizes flights to the Far East, as a result, the cost of air travel from the central regions of Russia to the Far East and back in 2024 amounts to 25-30 thousand rubles.

In order to support businesses and attract investors the following measures are being taken:

- in the Far East and, partially, in the Arctic, federal legislation established tax and other benefits. Preferential regimes were introduced: resident of the Territory of Advanced Socio-Economic Development (hereinafter - TASED) (Federal Law, No. 473-FZ, 2014) and resident of the Free Port of Vladivostok (hereinafter - FPV) (Federal Law, No. 212-FZ, 2015)
- in the Arctic in 2020, benefits were established for investors: residents of the Arctic zone of Russia (hereinafter - RAZR) (Federal Law, No. 193-FZ, 2020)

The Laws of 2014-2015 (No. 473-FZ; No. 212-FZ) established both customs privileges (for the residents of FPV) and state obligations to create infrastructure for investors (roads, water supply, heating, electricity, etc. (for residents of TASED).

The Law of 2020. (No. 193-FZ) does not provide for budget expenditures on the development of production infrastructure. These costs are intended to be covered by the RAZRs on their own. Therefore, in addition to substantial tax

benefits, the law provides RAZD with a subsidy from the federal budget, which amounts to up to 20% of the actual costs of project implementation.

*Table 3: TASED investors implementing tourism projects (compiled by author)*

| Federal subject of the Russian Federation | TASED | Residents (tourism) | Investment (thousands of rubles) | | Jobs created | |
|---|---|---|---|---|---|---|
| | | | Planned | Actual (01.01.2024) | Planned | Actual (01.01.2024) |
| **Sakhalin Oblast** | Gorny vozduh | 17 | 15 850 196,7 | 5 525 380,2 | 1 177 | 471 |
| | Kurily | 2 | 1 406 415,0 | 427 849,8 | 120 | 24 |
| **Republic of Buryatia** | Buryatia | 2 | 1 802 260,0 | 78 477,4 | 157 | 34 |
| **Zabaykalsky Krai** | Zabaykalye | 1 | 188 949,0 | 24 573,7 | 228 | 233 |
| **Primorsky Krai** | Primorye | 2 | 27 004 025,3 | 6 465,0 | 1 216 | 1 |
| | Bolshoi kamen | 2 | 1 435 040,0 | 78 477,4 | 125 | 20 |
| **Khabarovsk Oblast** | Khabarovsk | 3 | 1 577 600,0 | 1 238 517,7 | 179 | 149 |
| **Republic of Sakha (Yakutia)** | Yakutia | 5 | 1 591 316,0 | 16 832,5 | 136 | 7 |
| **Kamchatka Oblast** | Kamchatka | 46 | 46 750 027,8 | 4 958 710,3 | 2 826 | 665 |
| **Chukotka Autonomous District** | Chukotka | 2 | 10 750,0 | 700,0 | 6 | 1 |
| **Magadan Oblast** | no | 0 | 0 | 0 | 0 | 0 |
| **Jewish Autonomous Oblast** | no | 0 | 0 | 0 | 0 | 0 |
| **Amur Oblast** | Amurskaya | 0 | 0 | 0 | 0 | 0 |

As can be seen from the table, most of the federal subjects of the Far Eastern Federal District have territories attractive for tourism development.

Of the 25 major investment projects being implemented (with private investment of more than 0.5 billion rubles) in the TASED territories, the decision to implement 9 projects was made after the introduction of massive sanctions against Russia:

*Table 4: The largest investment projects in the TASED in the tourism sector, developed after 01.03.2022 (compiled by author)*

| Federal subject of the Russian Federation | Investor and Investment Project | Implementation start date | Investment planned (thousands of rubles) |
|---|---|---|---|
| **Primorsky Krai** | OOO «VOSTOK PARK RESORTS»:<br>Theme amusement park with a resort and hotel complex | 20.09.2023 | 26 773 600,0 |
| **Sakhalin Oblast** | OOO «Soyuz»:<br>Construction of a high-end hotel complex operated by an international operator | 19.06.2023 | 2 250 799,8 |
| | OOO «ARHIPELAG ONEKOTAN»:<br>Tourist complex on the Kuril Islands | 29.06.2022 | 748 470,0 |
| | OOO «LIGO GOSTEPRIIMSTVO»:<br>Hotel complex, Yuzhno-Sakhalinsk | 22.08.2022 | 1 540 760,0 |

| Federal subject of the Russian Federation | Investor and Investment Project | Implementation start date | Investment planned (thousands of rubles) |
|---|---|---|---|
| | ООО «OTEL EBEKO»: Hotel 3* in Severo-Kurilsk on Paramushir Island | 01.07.2022 | 1 224 860,0 |
| | ООО «Golf»: Year-round golf club with developed sports and residential infrastructure in Yuzhno-Sakhalinsk | 08.04.2022 | 2 841 588,0 |
| **Kamchatka Krai** | ООО «YUMIR»: Recreation center | 17.05.2023 | 510 000,0 |
| | ООО «GREEN FLOW KAMCHATKA»: Construction project of hotel, thermal complex and healing Center "Green Flow Kamchatka" | 06.09.2022 | 1 856 000,0 |

Thus, out of 97.6 billion rubles of private investment in the tourism industry within the TASED, more than 40 billion rubles were attracted after the imposition of sanctions.

*Table 5: FPV investors implementing tourism projects (compiled by author)*

| Federal subject of the Russian Federation | FPV residents (tourism) | Investment (thousands of rubles) | | Jobs created | |
|---|---|---|---|---|---|
| | | Planned | Actual (01.01.2024) | Planned | Actual (01.01.2024) |
| **Sakhalin Oblast** | 6 | 839 721,0 | 106 938,0 | 178 | 47 |
| **Khabarovsk Oblast** | 1 | 182 028,0 | 0 | 29 | 2 |
| **Kamchatka Oblast** | 18 | 7 791 578,1 | 6 999 692,0 | 542 | 396 |
| **Primorsky Krai** | 182 | 65 962 438,9 | 22 921 199,5 | 7 537 | 1 477 |

The situation in the FPVs is similar to that of the TASED in terms of investment attraction dynamics.

Over the past 10 years, during the preferential regimes for tourism development in the Far East, private projects worth more than 172 billion rubles have been attracted. The leaders in attracting private investments are Primorsky Krai (54.5% of all private funds attracted to the tourism industry), Kamchatka Krai (31.6%), and Sakhalin Oblast (10.5%).

Investors are being attracted to the AZRF at a rapid pace. All of them were attracted after the introduction of sanctions. Over the past 3 years, investments worth almost 42 billion rubles have been attracted. The leader in attracting investments in the Arctic is the Murmansk Oblast, which secured 87.8% of all investments in tourism development.

*Table 6: AZRF investors implementing projects in the tourism sector (compiled by author)*

| Federal subject of the Russian Federation | AZRF residents | | Investment (thousands of rubles) | | Jobs created | |
|---|---|---|---|---|---|---|
| | | | Planned | Actual (01.01.2024) | Planned | Actual (01.01.2024) |
| **Arkhangelsk Oblast** | total | 197 | 117 231 880,6 | | 6 597 | |
| | including tourism | 20 | 1 341 995,5 | 211 633,0 | 532 | 237 |
| **Murmansk Oblast** | total | 212 | 163 987 064,4 | | 7 056 | |
| | including tourism | 66 | 36 730 229,3 | 6 538 922,4 | 1 051 | 210 |
| **Krasnoyarsk Krai** | total | 31 | 37 571 869,9 | | 1 749 | |
| | including tourism | 7 | 851 047,0 | 82 082,9 | 169 | 16 |
| **Republic of Karelia** | total | 65 | 97 992 769,5 | | 2 360 | |
| | including tourism | 17 | 1 486 080,0 | 978 268,6 | 178 | 82 |
| **Komi Republic** | total | 31 | 2 002 496,5 | | 829 | |
| | including tourism | 1 | 1 856,5 | 0 | 1 | 0 |
| **Republic of Sakha (Yakutia)** | total | 16 | 5 472 501,5 | | 658 | |
| | including tourism | 0 | 0 | 0 | 0 | 0 |
| **Yamalo-Nenets Autonomous Okrug** | total | 99 | 29 321 508,0 | | 2 369 | |
| | including tourism | 8 | 1 155 279,2 | 32 142,4 | 128 | 0 |
| **Nenets Autonomous Okrug** | total | 11 | 295 102 322,4 | | 80 | |
| | including tourism | 3 | 216 860,0 | 48 964,1 | 20 | 23 |
| **Chukotka Autonomous Okrug** | total | 21 | 166 319 986,2 | | 2 291 | |
| | including tourism | 2 | 55 518,4 | 29 082,8 | 73 | 73 |

## 5. Conclusions

Despite the pressure from sanctions, tourism clusters in the Russian Far East and the Arctic are successfully developing. Government support measures have a multiplier effect. In the period following the introduction of Western sanctions, the volume of private investment in the tourism industry has increased by 1.5 to 2 times. For every ruble of state investment and preferences, private investors invest from 5 to 10 rubles. Thus, domestic tourism in Russia has received new incentives for development. Today, it is safe to say that significant tourism clusters have been formed in the Far East and the Arctic, such as Primorye (gambling, resort, congress, and business activities), Gorny Vozdukh (sports), Kurils (water), Yakutia (historical and ethnographic), Kamchatka (sports, resort), and Murmansk Oblast (hunting and fishing), and others.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# WORKPLACE 3.0: DECODING SERBIAN MILLENNIAL GENERATION'S WORK BEHAVIOR

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***Abstract***

*The largest living cohort, the millennial generation, stands at the zenith of its intellectual and physical prowess, dominating the global labor market. Millennials' behavior in the work environment diverges markedly from previous generations' behavior, as it is shaped by unique economic, political, and socio-cultural contexts. Accustomed to "living uncertainty", this generation often neglects organizational togetherness and actively pursues only personal career growth. (Un)expectedly, this has led to a quite controversial work reputation. Stereotyped as disloyal, reliant on constant guidance, with a lack of initiative, having commitment issues, and appearing to be self-centered, millennials are perceived as "challenging" employees. Conducted research endeavors to offer a profound exploration of the millennial generation's workplace attitudes and behavior, addressing notable knowledge gaps in current (national) labor market literature. The desk method, along with the extensive literature synthesis, provides insight into the complexities of millennials' organizational loyalty and work ethic, commitment and satisfaction, and advances the general scientific conversation surrounding the mentioned labor market participants' behavior in Serbia. The research results indicate that millennials are a generation notably distinct from all that preceded it, possessing both strengths and weaknesses that can be debated, but also the generation that undeniably presents the most highly skilled employee group that till today entered the labor market. Expectations are that research will benefit HR managers of public/private organizations in Serbia who have integrated millennials into their work teams. By utilizing research conclusions, organization executives may adeptly identify and timely address negative attitudes and detrimental work behavior among millennial personnel.*

***Key words:*** *generation Y, workplace behavior, HR management, organizational dynamics, systematic literature review.*

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"My career will be one of choice, not one chosen out of desperation. It will align who I am with what I do."
*– Millennial Survey respondent (PricewaterhouseCoopers, 2011)*

## 1. Introductory considerations

The integration of four distinct generations (baby boomers, generation X, millennials, and generation Z) into cohesive, high-performing work teams seems like an unattainable achievement for modern HR managers. As the most prevalent in today's workforce, the millennial generation (also known as "generation Y"), determines the global employment landscape – possesses the dual potential to either stabilize or disrupt organizational dynamics (Kovačević & Labrović, 2018). As the predeceasing generations approach retirement, the path for the career advancement of millennials opens. It is expected they become the backbone of the organization, not merely due to their numerical prevalence but also because of their critical expertise, authority, and high standards of work quality. As authors Tirta and Enrika (2020) argue, millennials will rise to the highest levels of management within the next decade, taking over organizations from the current leaders. This evolution marks a transition from Workplace 2.0, characterized by generation X's distinct work practices and technological adeptness, to the emerging Workplace 3.0. For today's HR managers, the challenge is to navigate this change. To future-proof their organizations, managers must address the complexities of engaging millennials by revitalizing their work culture, improving their intergenerational coexistence, anticipating and mitigating job dissatisfaction, and ensuring they remain a motivated and valuable labor force.

The conducted research aims to integrate current literature findings and establish a knowledgeable position of millennials in the domain of the national labor market. The research will minutely examine ("decode") specifics of millennial generation behavior and attitudes in the work environment, as well as how they are seen in relevant studies of (primarily) Serbian researchers. The study will concentrate on the main characteristics of this working cohort, and contribute to a more detailed insight into their work attitudes, perceptions, and short/long-term expectations. Research methods that will be integrated include desk research along with extensive literature synthesis (assaying theories of psychology, available social and statistical data, and industry research knowledge). The main research hypothesis posits that the millennial generation is notably distinct from all that preceded it, possessing both strengths and weaknesses that can be debated, but also the generation that undeniably presents the most highly skilled/educated employee group that till today entered the labor market.

## 2. Insights into the Serbian millennial generation's characteristics

Millennials have unique character traits that differentiate them from preceding generations (Perkasa & Purwanto, 2024; Buzza, 2017; Deal et al., 2010; Hershatter & Epstein, 2010). This generation (individuals born between 1980 and 2000) is recognized for their enhanced focus on ethics, politics, and environmental concerns, along with higher education levels and digital skills in comparison to earlier generations (PricewaterhouseCoopers, 2011; DeVaney, 2015). Some sources (Jelača & Golubović, 2024; DeVaney, 2015) suggest that this generation can be divided into two subcategories, older millennials (born between 1980 and 1990, in certain sources referred to as "xennials" or "bridge millennials") and younger millennials (born between 1991 and 2000, in some sources labeled as a micro generation, "zillennials"). For research purposes, the observed time frame often includes and so-called "cuspers" – individuals born near the end of one generation or the beginning of another (Kolnhofer-Derecskei et al., 2017). These time spans will also be relevant to this research context.

Known by various other names, including "nexters", "nextus generation", "net generation", "generation ME", "echo boomers", "trophy kids", "look at me generation", "internet generation", "digital natives", "txt generation", "generation.com", "boomerang generation", or "Peter Pan generation", millennials dominated 50 percent of the global workforce population in 2020 (projections suggest that by 2025, this demographic will comprise almost 75 percent of the global labor force) (PricewaterhouseCoopers, 2011; Ivanović & Ivančević, 2019; Kovačević & Labrović, 2018; Kolnhofer-Derecskei et al., 2017; Tirta & Enrika, 2020; Myers & Sadaghiani, 2010; Todorović & Pavićević, 2016).

In the national context, as per data (population estimates) released by the Statistical Office of the Republic of Serbia (2024), by the end of December 31, 2023, the millennial generation comprised 1,698,532 individuals, accounting for 25.7% of the total population within mentioned country's borders. Information from the aforementioned agency regarding registered employment showed that a total of 1,170,544 Serbian millennials were registered as employed in 2023, representing 49.6% of all national labor market workers. Of the total number of employed millennials, men outnumbered women, with 604,071 men and 566,473 women.

Certain bodies of research (Kovačević & Labrović, 2018; Ivanović & Ivančević, 2019; Gajić et al., 2019) indicate that Serbian millennials exhibit many general characteristics with their peers in other countries. As recognized in the (inter)national literature, factors that shaped the millennial generation worldwide (and are transcribed to the national context), are related to the technology boom (the reason millennials mostly are technology-addicted and technology-savvy), open borders (they are characterized as open-minded), globalization, and the certain changes in the education system at the beginning of the millennium (Kolnhofer-Derecskei et al., 2017; Buzza, 2017; Arras-Djabi et al., 2024). Having been raised in a context of plentiful resources (the "want it" and "want it now"

generation), ensuring their fundamental requirements are satisfied, millennials instinctively lean towards satisfying what Maslow referred to as "higher needs" (love and belonging through social relationships, family bonds, and community, striving for esteem through recognition, respect, and a sense of importance) (Cattermole, 2018; Kolnhofer-Derecskei et al., 2017). This leaves a lasting impression on their work ethic, too.

Millennials, unlike earlier generational cohorts, frequently encounter delayed traditional milestones of adulthood. Many millennials are postponing the start of their careers until their early twenties. Additionally, due to the high expenses related to living costs and university fees, they often encounter obstacles in attaining homeownership until they reach their thirties. Consequently, a significant number of individuals are residing with their parents for notedly extended periods of time compared to previous generations (Cattermole, 2018). This phenomenon is partly explained by the fact that this generation was raised by so-called "helicopter parents" (the excessively involved "boomer" parents) who closely monitored them (Kolnhofer-Derecskei et al., 2017). In the work environment, this also reflects on their functional work relationship with older colleagues, creating additional tasks for HR managers (Myers & Sadaghiani, 2010). As can be surmised, millennials demonstrate all the splendor and despair of the society in which they matured, evoking a sense of fascination among researchers.

## 3. Findings on the Serbian millennial generation's work behavior

The literature summary that follows will allow readers to conveniently identify patterns and draw conclusions about the behavior of a typical (Serbian) millennial. This generational cohort's behavior in the work environment will be presented through the prism of positive and negative characteristics they have developed, which will thereafter be put in an adequate context in order to detailly clarify their position.

**Positive traits of Serbian millennials.** Millennials became known for their abundance of higher education qualifications, making them a highly preferred workforce. They favor a horizontal organizational culture and general social awareness, simultaneously seeking to align with the positive core values of their employing organization (Cattermole, 2018; Forastero et al., 2018). As not interested in just doing a job, they aim to make a meaningful impact, contribute to the community, and be an integral part of an organization with a strong corporate culture that provides unique workplace experiences (Cattermole, 2018; Hershatter & Epstein, 2010; Todorović & Pavićević, 2016). Their workplace attributes include optimism, determination, courage, self-confidence, creativity, multitasking capabilities, focus on accomplishment, as well as the presence of ethical principles (Anitha & Aruna, 2016; Myers & Sadaghiani, 2010). This cohort is also frequently characterized as self-educated, energetic yet traditional, task-oriented, and adapted to a "constantly faced with pressure" state of affairs. Another defining trait is the

willingness and motivation of this generation to work flexibly, anytime and anywhere (Đurović et al., 2023).

This age group exhibits a progressive tendency towards collaboration, cooperativity, synergistic decision-making environment and teamwork, contrasting with previous generations (e.g. generation X, which typically prioritized independence, power, and authority/dominance). They value meaningful work, job security and work-life balance more than financial compensation distinguishing them from traditionalists, baby boomers, and generation X (even though their anticipations for remuneration with bonuses, and intrinsic rewards – feedback, recognition, respect, and development – are greatly increased). In a word, millennials are diligent employees who prioritize leisure/free time over work more than earlier generations (Buzza, 2017; Gajić et al., 2019; Nabawanuka & Ekmekcioglu, 2022; Frye et al., 2020; Cattermole, 2018; PricewaterhouseCoopers, 2011), and by their work-related expectations (existence of two-sided, beneficial exchange relationship between organization and employees) support positions of Social Exchange Theory and Psychological Contract Theory (Jolović & Berber, 2023).

**Negative traits of Serbian millennials.** Millennial workers' behavior frequently strays from conventional standards, characterized by genuine actions and unorthodox work beliefs. Millennials are often stereotyped as disloyal to their employers (reputed as employees who frequently change jobs – "the generation that always has updated their resumes") and are labeled as too informal in their work demeanor (Cattermole, 2018; Myers & Sadaghiani, 2010). Their propensity for job-hopping (evidenced by Cattermole's (2018) finding that 6 out of 10 millennials in every moment are seeking new job prospects) contributes to their role of "workplace instability culprits". Despite being recognized as the most educated/skilled generation in history, due to unprecedented levels of college enrolment and completion, millennials often face criticism for perceived deficiencies in general knowledge (Deal et al., 2010).

Compared to older generations, millennials may appear more reliant on guidance on what to do, as well as on feedback for performance improvement. Also, they sometimes exhibit behaviors that may be perceived as pretentious, expecting special treatment and exemptions from established workplace norms (Buzza, 2017; Đurović et al., 2023; Ivanović & Ivančević, 2019; Tirta & Enrika, 2020). They hold high work and career expectations, anticipating rapid progression within the first 18 to 24 months of employment (regardless of performance), paired with substantially higher expectations for job benefits (e.g. salary increases) (Kovačević & Labrović, 2018; Cattermole, 2018).

Common work-related perceptions about millennials involve and a variety of negative traits such as laziness, lack of initiative, commitment issues at work, disrespect of authority, difficulty in maintaining focus, distractedness, inadequate preparation for the workplace, neediness, apathy, lack of etiquette, arrogance, abrasiveness, lack of temperance, impatience, narcissism and self-centeredness (Stewart et al., 2017; Deal et al., 2010; Arras-Djabi et al., 2024). To conclude, millennials are a generation that has an attenuated sense of organizational

camaraderie, is more inclined to change jobs, is intermittently dissatisfied, and in general less committed to the organization it belongs to.

## 4. Concluding considerations

Millennials are distinguished by their uniqueness. This characteristic is shaped by distinct economic, political, and socio-cultural circumstances in which this generation matured, educated, and entered the labor market. As it recognized a notable gap in the existing academic literature on the complexities of the millennial generation's behavior in workplace environments in Balkan countries, particularly Serbia, this research devoted itself to investigating that issue.

Fragmentary, the study aimed to provide guidance and establish the consciousness of HR managers in Serbia's public and private organizations that have embraced the millennial generation into their workforce. Overall, the research findings were intended to aid all stakeholders engaged in the business sector with this age cohort worldwide, by equipping them with insights to recognize and address detrimental work attitudes and behaviors prevalent among millennials, given their significant impact on both organizational and national welfare.

Workplace behavior perceptions commonly held about millennials that encompass a spectrum of (un)favorable characteristics were presented in detail in the main part of the study. It is concluded that millennials' loyalty and work ethic, commitment, and satisfaction within current organizations are declining; that this age cohort often places personal career growth above organizational unity and togetherness; as well as that, consequently, their negative work-related behaviors bloom, work instability prospers, and dissatisfaction and turnover rates soar.

Comprehension of this generation's mindset by superiors is pivotal in effective managing and securing organizational well-being. To effectively utilize millennials in the workplace, it is primarily important to establish a clear connection between their job expectations and the resulting rewards. Millennial employees need to have a clear understanding of what rewards, opportunities, and development they can expect from the organization, including the timeframe for these benefits. In the same way, it must be clearly outlined what is anticipated of them, how they should behave at work, what qualities they must possess and nurture. As this becomes fulfilled, a particular challenge faced by an organization is in making millennials feel valued as contributors in a thriving company that upholds ethical standards, with self-conscious significance and fulfillment of their particular roles (by bringing personal ideas into action, team brainstorming and problem-solving, with possibilities for specialization, and basis for positive community changes). The presented recommendations should "alert" HR managers to comprehend that only by addressing these issues promptly they can prevent potential disruption to organizational stability in the near future.

Building on the previously stated premises, the main research hypothesis which claimed that the millennial generation is notably distinct from all that preceded it, having its own set of strengths and weaknesses, has been validated.

Given that the pivotal organizational goal is forming more stable and productive work teams, and considering that this generation's representatives are the largest segment in the (national) labor market on the present day, it is essential that both theoretical and practical research attention stay focused on this age cohort.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# SUSTAINABLE DEVELOPMENT EFFICIENCY OF EUROPEAN COUNTRIES

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***Abstract***

*This paper assesses the efficiency of 44 European countries based on the values of indicators of the Sustainable Development Index (SDI). The objective of the research is to evaluate the success of European countries in implementing sustainable practices. Data Envelopment Analysis (DEA) is used to analyze sustainable development efficiency of the observed countries. DEA is a non-parametric technique based on linear programming that measures the relative performance of organizational units, particularly in comparisons with multiple inputs and outputs. DEA offers benchmark units, which is crucial for improving the practices of inefficient units. The analysis includes target values for inputs/outputs, indicating the extent to which inefficient units need to adjust their inputs/outputs to achieve efficiency. For this analysis, six indicators are divided into two inputs and four outputs, and model used input orientation. A comparative analysis was also conducted between the real values of the SDI and the efficiency indices provided by DEA, including a comparison of the rankings of countries. The results indicate that countries with lower input values tend to rank better, regardless of their output levels. Furthermore, it is recommended to set constraints on the maximum predicted output values.*

***Key words:*** *Sustainable Development, Efficiency, Data Envelopment Analysis, Sustainable Development Index*

## 1. Introduction

The future of planet Earth and civilization depends on the impact humans have on it. The importance of clean air, drinking water and healthy soil is becoming increasingly evident, as the rising number of diseases caused by pollution grows and the threat of their depletion looms. For all these reasons, a Sustainable Development

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(SD) initiative has been launched, aiming to reduce the exploitation of non-renewable energy sources, protect the environment, decrease unemployment, improve living standards, reduce inequality among people and, in general, save the planet for the future generations.

Performance monitoring plays a crucial role in ensuring the timely implementation of both organizational and national strategies. Establishing and utilizing an effective performance evaluation system contributes to optimizing decision-making processes and enhancing the competitiveness of countries.

The objective of this study is to assess the efficiency of 44 European countries in implementing SD practices. To evaluate SD performance, the study will examine the Sustainable Development Index (SDI). Initially, the components that contribute to the assessment of the Index and its outcomes will be analyzed, followed by an evaluation of alternative methods for measuring performance. In this study, Data Envelopment Analysis (DEA) will be used to assess the efficiency index. DEA facilitates the comparison of entities (in this case, countries), identifies how inefficient some countries are, outlines ways to improve their efficiency and highlights which countries exhibit the best practices.

The aim of this paper is to address the following research questions: 1) How is SD measured? 2) Can DEA be used to measure SD, and which model is suitable for this purpose? 3) Are there any differences between the results obtained through the DEA method and the SDI, and if so, what are they?

The paper is structured into five chapters. Following the introduction, a literature review is provided, discussing previous work in the field of performance measurement and the application of the DEA method, highlighting the gaps for further research. The third chapter presents the DEA method, and the model used, along with the data and SD indicators. The fourth section focuses on the presentation of results and discussion. Finally, the conclusion is provided, along with suggestions for future research directions.

### 1.1 Literature review

There are no universally accepted sets of indicators for measuring SD due to varying terminology and differing interpretations of the concept of SD (Parris & Kates, 2003).

The United Nations Commission on SD developed a list of 134 indicators covering the economic, social, and institutional aspects of SD. This list was later reduced to 58 indicators, intended to be universal for all countries. However, it was subsequently announced that these indicators could be used by countries on a voluntary basis at the national level and could be adapted to their specific conditions (Parris & Kates, 2003).

Moran et al. (2008) argue that indicators must reflect changes in quality of life and demonstrate whether these changes are in line with the planet's ecological boundaries. They propose the Human Development Index (HDI) for measuring human development and the Ecological Footprint as an indicator of sustainable consumption for ecological sustainability. The HDI can range from 0 to 1, with a

consensus agreeing that a value of 0.8 represents the threshold between medium and high human development. For citizens od countries that have reached this level of human development, any lower score does not indicate an adequate standard of living (Moran et al, 2008).

The Ecological Footprint measures how much human activity utilizes the regenerative capacities of the biosphere. By comparing the Ecological Footprint (national per capita) with the biocapacity (global per capita), an indicator is derived that measures the minimum number of planets equivalent to Earth that would be required to support the current population if the consumption level of a given country were universal. If the ratio of Earth-equivalents is greater than 1, it means that ecological resources are being consumed faster than they can regenerate. A ratio of ≤ 1 is the necessary minimum for sustainability (Moran et al, 2008).

Unfortunately, if constraints are set requiring that the HDI should be ≥ 0.8 and the Ecological Footprint to biocapacity ratio ≤ 1, no country would meet both criteria, even though these are the two minimum thresholds for sustainability. There are countries that fulfil one of these two conditions, but they are few in the world.

There are approaches that view sustainability through the goals to be achieved, which is more common, and those that take an opposite perspective, defining and measuring indicators to be avoided (e.g. overuse of marginal lands, landscape damage due to large projects, etc.).

The best example of this is the U.S. Central Intelligence Agency's (CIA) State Failure Task Force. From 127 indicators of state failure, they narrowed the list down to 75 indicators, covering social, economic, political and environmental aspects. The most effective model used indicators for infant mortality, trade openness and the level of democracy. States are at a higher risk of failure if their first parameter is above, and the second below, the median for given year, combined with partial democracy (Parris & Kates, 2003).

### 1.2 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric method that uses linear programming to assess the relative performance of organizational units with multiple inputs and outputs, making direct comparison difficult (Boussofiane et al., 1991). DEA is data-driven and does not require assumptions about the production function's form. It measures each unit's efficiency and offers insights to improve performance. Applications include identifying benchmarks, setting targets, monitoring efficiency changes, and resource allocation (Boussofiane et al., 1991).

DEA evaluates the relative efficiency of Decision-Making Units (DMUs), with an efficiency index of 1 indicating relative efficiency and values below 1 signalling inefficiency. A key challenge lies in determining appropriate weights for inputs and outputs, often allowing DMUs to assign their own weights to maximize efficiency, which introduces subjectivity (Boussofiane et al., 1991).

Initially applied to non-profit organizations, DEA now extends to profit-oriented sectors and comparisons within homogeneous groups like hospitals and schools (Bowlin, 1998). Examples include Smith's (1990) study of 47

pharmaceutical companies, Salinas-Jiménez and Smith's (1996) analysis of healthcare efficiency, and Miliotis' (1992) assessment of Greek power distribution. Markovits-Somogyi (2011) reviewed DEA in transportation, while Zhou et al. (2018) explored DEA applications in sustainability, highlighting three approaches: traditional models, models treating undesirable outputs as inputs, and models using weak disposability of technology. DEA's flexibility allows it to address diverse efficiency challenges, with room for further research at the international level.

The next section introduces the DEA model applied in this analysis.

### 1.1.1 DEA model with constant return to scale (CRS)

The model developed by the creators of the DEA method, Charnes, Cooper and Rhodes, known as the CCR ratio model, is a constant return to scale (CRS) model (Charnes et al., 1978). Under this assumption, changes in input scale cause proportional changes in outputs. This means that if inputs increase by a certain percentage, outputs will increase by the same percentage, and vice versa. The CCR ratio model calculates overall technical efficiency, which encompasses both pure technical and scale efficiency, accounting for the effects of operational size (Savić, 2016).

In the model, the objective is to maximize relative efficiency (hk), which is calculated as the ratio of the weighted sum of outputs to the weighted sum of inputs. The value of hk indicates whether the DMU is relatively efficient or not. If the value is equal to 1, the unit is relatively efficient. If the value of hk falls between 0 and 1, the DMU is relatively inefficient, and this value shows the percentage by which inputs need to be reduced to achieve efficiency.

For the analysis, input orientation was applied, meaning the goal is to minimize inputs while maintaining the same level of outputs.

## 2. Methodology

According to the SDI, the efficiency of 44 European countries was analyzed in this study. The data for SDI spans 11 years, from 2009 to 2019, and was sourced from the SDI website (SDG, n.d). The data for Serbia excludes information on Kosovo and Metohija. The structure of the Sustainable Development Index is shown on Figure 1. The details on methodology and calculations are described in the official report (SDI, n.d).

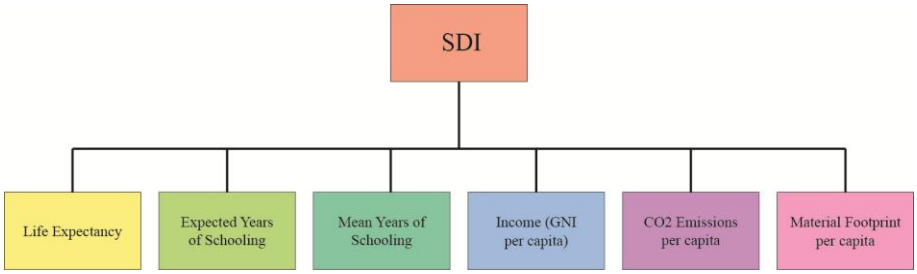


*Figure 1: SDI Structure*

The indicators used as inputs in the model were $CO_2$ emissions per capita and the Material Footprint per capita. The output indicators included: Life Expectancy, Expected Years of Schooling, Mean Years of Schooling and Income per capita.

Initially, a nonlinear model was developed and subsequently transformed into a linear model using Charnes-Cooper transformations. The key difference between the two models is that the linear model maximizes the weighted sum of outputs, while the weighted sum of inputs is constrained to equal 1. These represent two primal models. However, practical experience has demonstrated that the number of DMUs should be significantly greater than the total number of inputs and outputs, leading to the resolution of the dual CCR model. The mathematical model utilized for the analysis is given in Savić (2016, p. 24, model M3.3).

## 3. Results and Discussion

It is notable that year after year, the values of all indicators have been increasing. The minimum values for $CO_2$ emissions per capita have risen from 0.62 to 1.08, with a decrease in 2014 to the lowest recorded value of 0.18 tons. The minimum values for Material Footprint per capita range from 0.73 to 5.57 tons, with a slight decline in 2014. These values were achieved by Moldova. The maximum values for inputs range from 13.88 to 16.77 tons of $CO_2$ and from 34.82 to 38.08 tons of Material Footprint per capita. Interestingly, these values were recorded by the most environmentally conscious nations, Finland and Norway. Moldova had the lowest income per capita, while Switzerland had the highest, which is reflected in life expectancy, as Swiss citizen have the longest life expectancy.

Of the 44 countries, Moldova was the only one considered efficient during the first four years, and Kazakhstan was the least efficient country. In 2013, alongside Moldova, Russia also achieved efficiency, having previously been in 33rd place the year before, but with significant fluctuations in its positioning overall. Throughout the remaining years of the analyzed period, Serbia and Montenegro alternated as the least efficient countries. From 2014, Azerbaijan also achieved efficiency, and from 2015 Ireland joined the ranks of efficient countries. These four countries remained in these positions until the end of 2017. In the final year, Moldova, Ireland and Azerbaijan had the highest efficiency indices. Thus, throughout all 11 years,

Moldova consistently held the top position, primarily due to its exceptionally low values for input indicators. The change in rankings is shown on Figure 2.

Efficiency indices were significantly lower during the first two years compared to the subsequent years. Excluding the efficient countries, the efficiency scores for 2009 ranged from 0.1162 for Kazakhstan to 0.3937 for Switzerland, while in the final year, the lowest score was 0.3408 for Serbia and the highest was 0.9596 for Malta. In the first year, $CO_2$ emissions and income per capita had the greatest impact on the efficiency scores. Over time, the impact of $CO_2$ emissions gradually decreased, while the significance of the material footprint increased and then diminished again. The results show a trend of increasing influence from expected years of schooling and a decreasing significance of income per capita. Life expectancy and the average number of years of schooling were almost entirely neglected and rarely influenced efficiency scores. Therefore, for future research, it would be advisable to introduce certain constraints for these factors.

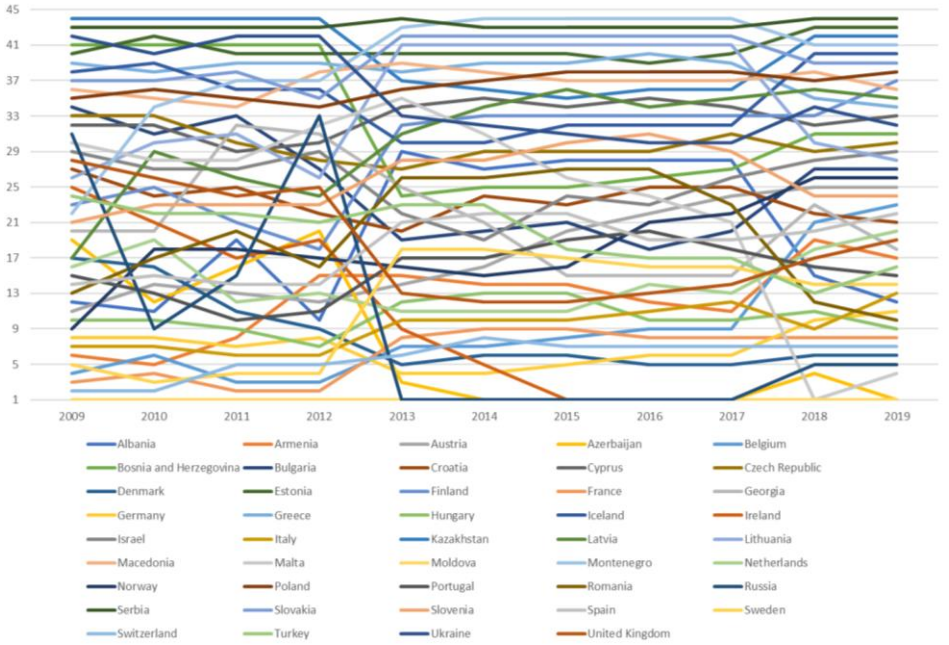


*Figure 2: Change in rankings*

It is evident that the efficiency indices according to the SDI are significantly lower than those produced by the CCR model in 2009. The range of the SDI values spand from 0.263 for Greece to 0.8 for Armenia, while in the constant returns to scale model (CCR), the lowest efficiency index was 0.1162 for Kazakhstan, and Moldova had an index of 1. The rankings for these countries were relatively consistent across both indices. According to the SDI, Moldova was ranked 11$^{th}$. In Europe in 2009, Armenia had the highest SDI, while it was ranked 6$^{th}$ in the CCR

model. However, there were also surprises and significant ranking discrepancies. For example, Ukraine ranked 7th according to the SDI but was 42nd according to the CCR model. Similarly, Switzerland, Sweden and Norway, which the CCR model ranked in the top 10, were among the lowest-ranked countries that year.

In the final year, Iceland recorded the lowest value in the SDI, which was also reflected in its ranking, placing it 40th in the model. Its index value was 0.178, the lowest real value in the observed period. The highest value was achieved by Georgia, with a score of 0.823, although it ranked 18th in the model. The largest discrepancy is observed with Ireland, which ranked first in the DEA model, but only 32nd according to the SDI. Comparison of SDI and CCR model for 2019 year is shown on Figure 3. From the previous analysis, it can be concluded that there are significant discrepancies between the results obtained using the DEA Solver software and the data from the official SDI website. The main reason for this discrepancy lies in the non-compensatory nature of the Index, due to the formula used for its calculation. The SDI does not allow negative results from one sub-index to be compensated by positive results from another.

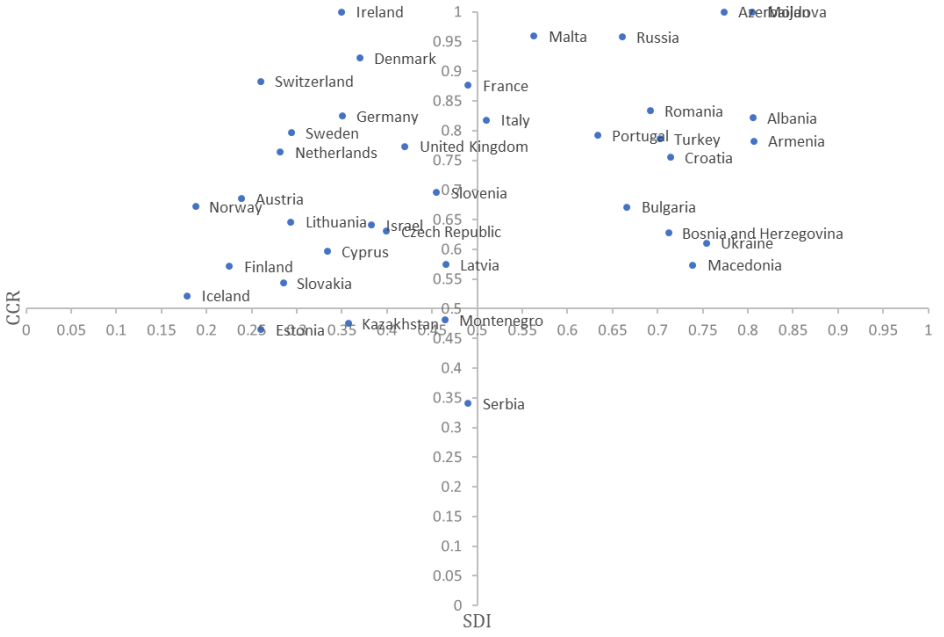


*Figure 3: Comparison of SDI and CCR model – 2019*

## 4. Conclusions

Performance measurement is an interesting and undoubtedly important area for all organizations, markets, regions, and countries, as well as the nonprofit sector. Based on achieved performance, it is possible to guide future efforts and, if necessary, adjust management policies to achieve desired goals.

In this paper, data from the Sustainable Development Index, spanning from 2009 to 2019, was used to evaluate European countries. Based on six factors, an efficiency index was calculated for each country, with Moldova standing out due to its undisputed efficiency, driven by the lowest input indicator values. A comparison with the actual SDI was made, where Switzerland and the Scandinavian countries showed the most significant differences in rankings, suggesting that further research into the environmental and social policies of these nations could be beneficial. The DEA model can be used for measuring sustainable development, but it is advisable to use original measurements rather than pre-constructed ratio indices.

It is assumed that updated data would provide a completely different picture of the observed countries. Additionally, the selection of factors greatly influences the obtained results. In future research, it is expected that introducing different indicators or altering the orientation of the same indicators would yield different outcomes, potentially leading to significantly varied insights on the same topic.

For future research in this field, it is recommended to use a constrained model, or a modification of this model, that allows for the setting of target values.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-072 Original scientific paper

# ECONOMICS OF HEALTHCARE IN NEUROSURGERY: COST EFFICIENCY AND FUNDING ANALYSIS IN THE MODERN HEALTH SYSTEM

*Jagoš Golubović*[1] *[0000-0001-5524-246X]*, *Andrea Ivanišević*[2] *[0000-0003-3342-7257]*

***Abstract***

*Neurosurgery is a highly specialized branch of medicine that incurs exceptionally high costs and requires complex planning and financing strategies. This study investigates the key factors affecting the successful operation of neurosurgical institutions, including the formalization of planning processes, the stability of financing, the efficiency of implementation, staff resistance to planning, and the role of control and evaluation.*

*A global quantitative survey was conducted among neurosurgeons worldwide. The survey included 48 questions divided into thematic sections focusing on planning, implementation, financing, and control of business plans in neurosurgical institutions.*

*The results showed that the formalization of planning processes is prevalent in most neurosurgical institutions, positively impacting business success. Financial stability emerged as a crucial factor in successful plan implementation, while resistance to planning posed a significant obstacle. Institutions that regularly performed control and evaluation of their business plans achieved better results. The formalization of planning, stable financing, detailed control, and resistance management are critical for the successful operation of neurosurgical institutions. These strategies enable more efficient resource management, cost reduction, and high-quality patient care.*

***Keywords:*** *neurosurgery, health economics, planning, financing, cost efficiency, resistance*

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# 1. Introduction

Neurosurgery, as a highly specialized medical field, requires significant financial resources due to the complex and high-cost nature of the procedures and equipment involved. The economics of healthcare in neurosurgery encompasses multiple factors, including resource allocation, cost control, and financial sustainability, which play a pivotal role in ensuring the efficient operation of neurosurgical institutions.

This paper aims to investigate the economic aspects of neurosurgery by focusing on the formalization of planning processes, financial stability, resistance to business planning, and the role of control and evaluation in improving cost efficiency. Furthermore, this study highlights the need for optimized business models to address the unique challenges faced by neurosurgical institutions.

## 1.1 Methods

This research was conducted as a global quantitative study using a structured survey targeting neurosurgeons from different parts of the world. The survey consisted of 48 questions divided into several thematic sections, including planning, implementation, financing, and control of business plans. The participants were asked to evaluate the level of formalization in their planning processes, the stability of financing, the efficiency of business plan implementation, and any resistance encountered from staff members.

The data was statistically analyzed using SPSS software to identify patterns and correlations between the variables, particularly focusing on the role of financial stability and staff engagement in the successful implementation of business plans.

# 2. Results

The key findings of the study are as follows:

Formalization of Planning Processes: The results showed that 73% of the surveyed neurosurgical institutions employed formalized written procedures in their planning processes, which positively impacted their operational success. Institutions with formalized procedures demonstrated better efficiency in resource allocation and a higher rate of achieving their business objectives.

Financial Stability: The study revealed that institutions with stable financial resources had a significantly higher success rate in implementing their business plans (70%) compared to institutions facing unstable financial conditions (30%). Stable funding allowed these institutions to plan more effectively, reduce unexpected costs, and maintain consistent operational performance.

Resistance to Planning: Staff resistance to the planning process was identified as a major barrier to successful plan implementation. Institutions that reported high levels of staff resistance showed lower success rates (42%) compared to those with moderate or low resistance (65% and 78%, respectively). Resistance was often

linked to a lack of communication and insufficient involvement of staff in the planning stages.

Control and Evaluation: Institutions that conducted regular control and evaluation of their business plans achieved 76% success in meeting their goals. Regular evaluations allowed for timely identification of issues and course corrections, contributing to the overall success of the institutions.

## 3. Discussion

The results of this study underline the critical role of formalized planning processes, stable financing, and regular evaluation in the successful management of neurosurgical institutions.

Formalization of Planning: Neurosurgical institutions that adopted formalized planning structures experienced better operational outcomes due to clear guidelines and consistent processes. Formalization ensures that all staff members understand their roles and responsibilities, thereby reducing confusion and enhancing overall efficiency. This finding supports the hypothesis that formalized planning processes lead to greater success in neurosurgical management.

Financial Stability: Financial stability emerged as a key determinant of successful plan implementation. Institutions with stable funding were better equipped to allocate resources effectively and manage long-term projects, while those with unstable funding struggled with unpredictability and reduced efficiency. The results reinforce the hypothesis that stable financing significantly impacts the success of neurosurgical business plans.

Resistance to Planning: Resistance among staff members was found to hinder the execution of business plans. This resistance often stemmed from perceptions of planning as a bureaucratic process disconnected from daily operations. Addressing this issue through improved communication and greater staff involvement in the planning process can significantly reduce resistance and improve plan implementation. This aligns with the hypothesis that reducing staff resistance leads to better operational outcomes.

Control and Evaluation: Institutions that regularly evaluated their business plans were able to identify problems early and adjust their strategies accordingly, leading to higher success rates. The findings confirm the hypothesis that regular control and evaluation are essential for the successful operation of neurosurgical institutions.

## 4. Conclusions

This study highlights several critical factors for the successful operation of neurosurgical institutions. Formalized planning processes, stable financial support, and regular control and evaluation are essential for achieving business objectives and maintaining operational efficiency. Additionally, managing staff resistance to

planning through improved communication and engagement is crucial for the smooth implementation of business strategies.

Neurosurgical institutions that integrate these strategies into their operations can expect improved resource management, reduced costs, and higher-quality patient care. Future research should focus on developing specific interventions to address resistance to planning and further refine the financial models used in neurosurgery to ensure long-term sustainability.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# SOCIO-ECONOMIC ANALYSIS AND EVALUATION OF THE CHOSEN VARIANT FOR LAND RECLAMATION DESIGN

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***Abstract***

*The economic analysis was conducted using an incremental approach, comparing the economic costs and benefits of the project over a 30-year analysis period, which is the same as used in the financial analysis. The analysis was carried out at constant prices using a social discount rate of 3%. The financial costs of the project were used as a basis for estimating its economic costs, by correcting the component of unskilled labor and investment and operational costs with shadow prices that take into account the level of current distortions between domestic and import-export market prices through conversion factors. The economic evaluation of the project included the calculation of the economic costs of the project as well as the assessment of the economic benefits. After presenting the total economic costs and total economic benefits, the economic cash flow is discounted and the economic parameters are calculated.The abstract should summarize the paper's contents in brief, approximately 250 words. This paper explores the consequences of working abroad in the country of emigration by comparing the sociodemographic characteristics of two waves of emigrants: those who migrated in the second half of the 20th century and those who left at the beginning of the 21st century. The analysis encompasses two spheres – the private and social realms, considering both positive and negative aspects.*

*Key words: land reclamation, socio-economic analysis, financial feasibility.*

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# 1. Introduction

Over the past few decades, the complexity of financial decisions has increased significantly, thus highlighting the need to develop efficient analysis techniques for financial decision-making in different fields. Therefore, it is essential to identify methods for comparing various design assumptions to determine the one with the least impact. Land degradation is becoming a major constraint for food production and threatening future growth and development of the country. In fact, it is observed that environmental degradation is reaching irreversible levels (desertification) Reclamation of Salt-Affected Soils: Micro-Economic Issues and Policies 621 in some regions, especially in arid and semi-arid tracts. On the other hand, the replacement costs (in terms of enhanced input use, abatement and conservation costs), are mounting and would make a dent in the national income if these costs are taken into account (Reddy 2003).

Construction projects carry financial and economic risks (Xenidis & Angelides, 2005; Vaynshtok, 2017; Jiao, 2021). These risks have the potential to influence the success of projects in terms of time, cost, and quality (Perera et al., 2014). Turner (2014) points out that incomplete or inaccurate cost estimation is a high-impact risk factor in financial risk management. Managing financial and economic risks is essential to minimize project losses (Akomea-Frimpong et al, 2022). Financial and economic risks, particularly those involving land reclamation, are critical considerations in construction projects.

While the discourse on financial and economic risks in construction projects provides a global overview of the challenges in infrastructure development, the situation in Vojvodina, Serbia, presents a unique case study that illustrates these challenges on a micro scale. In Vojvodina, the combination of environmental threats, such as frequent flooding, and the existing aging infrastructure for land reclamation exemplifies the critical need for a nuanced approach to financial risk management tailored to local conditions. The region's reliance on an extensive network of pumping stations for agricultural productivity, which is now in dire need of modernization, underscores the importance of accurately estimating costs and managing financial risk. This is particularly pressing, as the region seeks to balance technological upgrades with sustainable agricultural practices. Thus, the general principles of financial risk management in construction projects find a specific and urgent application in the context of Vojvodina's land reclamation efforts, highlighting the need for a comprehensive multicriteria financial analysis.

In Vojvodina, approximately 50% of the area has been historically threatened by floods from rivers flowing through this region, internal waters, and high groundwater levels. Through the regulation of river courses, flood defenses, and drainage, these areas have been transformed into fertile fields. As of 2005, 92% of Vojvodina’s territory could be utilized for agricultural purposes (Xenidis & Angelides, 2005). However, such systems require continuous maintenance and modernization, making financial analysis a pivotal factor in assessing the feasibility of these projects. Previous studies have highlighted the importance of financial risk

management in the construction sector, with incomplete or inaccurate cost estimations being identified as significant risk factors.

Given the increasing complexity of financial decisions, this study presents a multicriteria analysis to assess the financial feasibility of various design options for land reclamation in AP Vojvodina, Serbia. This analysis, based on data from 104 pumping stations, aimed to determine the optimal design variant by evaluating both economic and technical criteria. The optimal functioning of pumping stations is necessary for the effective protection of agricultural and urban areas within land reclamation systems, whose water regimes are managed by the aforementioned pumping stations.

The pumping stations that were the subjects of the study were located in a relatively wide area; therefore, the analysis of their condition and operation was carried out according to their affiliation with the land reclamation system.

Most pumping stations are technologically obsolete and problematic for maintenance, and as such, require the replacement of old parts and equipment. Today, in light of climate change and adaptation measures, the need for energy saving, increased energy efficiency, and environmental protection, it is necessary to reconstruct and modernize the existing facilities and equipment of pumping stations.

Economic profitability analysis deals with the question of the extent to which the project is valuable to society. It is worth investing in a project if its economic benefit, for a given area, is greater than the expected benefit of other alternative solutions.

The purpose of the economic evaluation is to determine the viability of the project in terms of its value to society, not from a financial aspect. The national government invests its limited resources to contribute to the improvement of the living standards of the people of the country. Government resources include taxes collected by the people and distributed by the Government to activities or projects for the benefit of the nation. State investments, therefore, must be efficient, effective and valid.

The main objective of the economic analysis is to assess the contribution of the proposed project to future improvements in social and economic well-being compared to resource costs. Thus, economic analysis deals with the question of whether the benefits of the project exceed the costs of the project.

Economic analysis is a systematic approach to determining the optimal use of scarce resources in achieving a specific goal within certain assumptions and constraints. The analysis takes into account the opportunity costs of the resources used and attempts to measure in monetary terms the private and social costs and benefits of the project to the community.

## 2. The economic flow of the project

The cumulative discounted economic flow of the project becomes positive in the tenth year, while the Economic Net Present Value (ENPV) for the life of the project of 30 years is € 324.973.641.

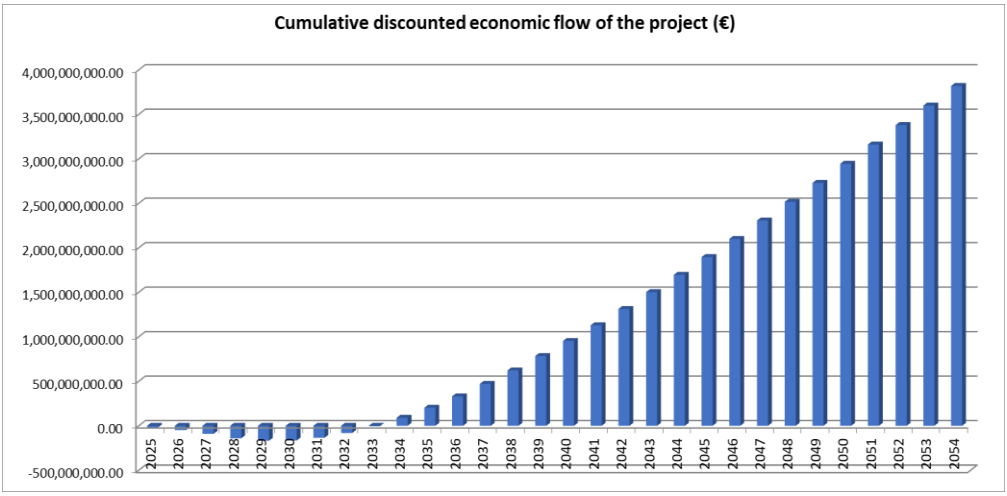


*Figure 1: Cumulative discounted economic flow of the project (€)*

## 3. Economic cost-benefit analysis

Economic profitability analysis deals with the question of the extent to which the project is valuable to society. It is worth investing in a project if its economic benefit, for a given area, is greater than the expected benefit of other alternative solutions.

The purpose of the economic evaluation is to determine the viability of the project in terms of its value to society, not from a financial aspect.

In the case of imported products and services, there is no conversion because it is assumed that the international market is more liberalized than the domestic one. A standard conversion factor that measures the average difference between domestic and world prices is applied to other prices (Table 1).

*Table 1: Calculation of the standard conversion factor*

| | | | |
|---|---|---|---|
| M | Import 2021 | 25.697.100.000 | € |
| H | Export 2021 | 19.627.500.000 | € |
| TM | Customs 2021 | 502.127.660 | € |
| **SCF=(M+H)/(M+H+TM)** | | **0,989** | |

Since no special wage distortions are foreseen for employees belonging to the 'qualified' categories, the standard conversion factor is applied.

With an unemployment rate of 9.1%, contributions of 35.1%, the participation of unskilled labor of 50%, and the participation of labor costs of 50% in investments and 17.1% in operating costs, the stated financial costs of the project will be corrected for the shadow labor cost, i.e. applying a coefficient in the amount of 95.4% for investments, i.e. 96.8% for operating costs.

*Table 2. Calculation of correction factors CAPEX and OPEX*

| | |
|---|---|
| Discount rate | 3,0% |
| Regional unemployment rate (SN) | 9,1% |
| Taxes and contributions on earnings (PD) | 35,1% |
| Shadow wage rate factor, unskilled labor SNRS = (1-SN)*(1-PD) | 59,0% |
| Participation of unskilled labor UNRS | 50,0% |
| Total, earnings in shadow SOP = (1-UNRS)+(UNRS*SNRS) | 79,5% |
| Share of labor costs in CAPEX, RSI | 17,1% |
| Participation of labor costs in OPEX, RSOT | 10,1% |
| CAPEX cost factor, FKI=1-RSI*(1-SOP) | 96,5% |
| Cost factor OPEX, FKOT=1-RSOT*(1-SOP) | 97,9% |
| Correction factor CAPEX, FKI*SCF | 95,4% |
| Correction factor OPEX, FKOT*SCF | 96,8% |
| Discount rate | 0,989 |

*Links:*

| | |
|---|---|
| Unemployment rate | https://www.stat.gov.rs/sr-latn/oblasti/trziste-rada/anketa-o-radnoj-snazi/ |
| Taxes and contributions on wages | https://porezionline.rs/statistika.php?cID=889 |

## 4. Socio-economic assessment of profitability and efficiency

The economic analysis is performed from the point of view of the whole society and its goal is to assess the impact of the project on the well-being of the population and the community.

Economic analysis is performed on the basis of information obtained from financial analysis. Furthermore, in order to move from the perspective of the project owner to the perspective of the whole society, three main updates of the financial flows are made:

1. Introduction of externalities,
2. Fiscal corrections,
3. Conversion from market to calculation prices.

The results of the socio-economic analysis are shown in Table 34.

*Table 3. Profitability results of economic and social analysis*

| Parameter | Economic internal rate of return (EIRR) | Economic net present value (ENPV) € | Discounted payback period (years) | B/C Analysis |
|---|---|---|---|---|
| Results of economic analysis | 31% | 324.973.641 | 7 | 2,69 |

## 3. Conclusion

Summary evaluation of the validity of the investment and The financial and economic analysis was carried out in accordance with the Law on the Construction, the Rulebook on the Scope and Content of the Justification Study and the Feasibility Study, with the simultaneous use of recommendations and methodology in accordance with the European Commission's Guide to Cost-Benefit Analysis of Investment Projects Economic appraisal tool for Cohesion policy 2014-2020.

The economic-financial analysis should show whether the project and its implementation are justified from a social-macro aspect and a financial-micro aspect. The data used refer to the prices of works and equipment based on technical solutions from the project.

A detailed economic and financial analysis was conducted, and it covered all aspects of the profitability, efficiency and financial feasibility of the Project.

## Acknowledgments

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# INTEGRATION OF RISK ASSESSMENT INTO FINANCIAL MODELS IN ORDER TO MAKE MORE SUCCESSFUL DECISIONS

*Ksenija Krmpot*[1], *Ranko Bojanić*[2] *[0000-0002-9217-3296]*

***Abstract***

*This paper explores the importance of integrating risk into financial models to improve the decision-making process. Through the analysis of various methods such as Monte Carlo simulations, stress testing and scenario modeling, the paper shows how the integration of risks enables more accurate forecasts and better management of uncertainties. Examples from practice, such as the experiences of global financial institutions and corporations, illustrate how by applying these techniques companies can reduce losses and optimize financial performance. The paper further analyzes the challenges and limitations that arise when implementing these models. In conclusion, it is emphasized that the integration of risks is crucial for making sustainable and informed financial decisions in the modern business environment.*

***Key words:*** *risk integration, financial models, decision-making, risk management and assessment, business stability, financial performance.*

## Introduction

Financial models are tools used in the world of finance in order to make decisions, plan and predict future financial results. These models are mathematical representations of real financial situations and are used for risk analysis and assessment, asset evaluations, financial flow planning and strategic decision-making. Decision-making can be defined as the process of choosing between two or more possibilities, with the aim of achieving a certain goal or solving a problem. Managers are faced with the decision-making process every day. Sometimes these decisions are routine and simple, while other decisions require time, information and analysis. The common elements that can be recognized in all decision-making

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situations are the following: decision goal, alternative decisions, constraints, decision results and decision selection criteria. Financial modeling and managerial decision-making are two interconnected processes that play a key role in the successful management of organizations. While financial modeling provides tools and methodologies for analyzing and forecasting financial results, managerial decision-making uses that data to make strategic decisions that shape the future of the organization. The combination of these two aspects creates a strong foundation for rational and informed decision-making which minimizes risk and maximizes value for the organization.

### 1.1 Review of basic financial models

The Capital Asset Pricing Model is one of the most well-known and widely used models for estimating the expected return on financial assets in relation to their risk. Developed in the 1960s, the CAPM model is based on the assumption that there is a linear relationship between risk and return. The basic assumption is that investors demand additional return as compensation for taking on additional risk. The basic idea of the CAPM model is that risk can be divided into two parts: systematic risk (market risk) and unsystematic risk (specific to a particular company). The CAPM focuses on systematic risk, represented by the beta coefficient, because it is assumed that unsystematic risk can be eliminated by portfolio diversification. The CAPM is extremely important in estimating the cost of capital and in the process of making investment decisions. However, its basic assumptions - such as the rationality of investors and perfect markets - are often criticized in the real world, where markets can be inefficient and information may be incomplete.

The Arbitrage Pricing Theory (APT) is a more complex model that offers an alternative to the CAPM model. Developed by Stephen Ross, the APT extends the concept of evaluating expected returns against multiple independent factors rather than just one factor (as in the CAPM model). This theory assumes that the return on an asset is the result of the influence of several macroeconomic factors, and that differences in prices can be used for arbitrage (making a risk-free profit). The APT is more flexible than the CAPM because it allows for the inclusion of more economic and market determinants in the analysis, thus obtaining a more accurate picture of expected returns and risks. Unlike the CAPM, the APT does not depend on the market portfolio and allows for variability in the factors used, making it applicable in different market conditions. Nevertheless, the APT model is sensitive to factor selection and requires a significant amount of data for quality implementation.

The Black-Scholes model is one of the most well-known models for estimating the value of options and other derivative instruments. Developed by Fisher Black, Myron Scholes and Robert Merton, this model won the Nobel Prize for its significant contribution to financial theory. The main application of the Black-Scholes model is to estimate the price of call and put options.

The Black-Scholes model rests on several important assumptions, such as market efficiency, continuity of trading, and normal distribution of returns. Although these assumptions are often idealized, the model is extremely successful

in practice and has become the standard for option valuation. Today, the Black-Scholes model is used in a wide range of financial products and instruments, including options on stocks, commodities and currencies.

### 1.2 Definition and types of risk

Risk represents the possibility that actual results deviate from expected outcomes. In a financial context, risk includes uncertainty about future events that may affect the results of investments, financial projections or business decisions. Risk in finance represents the possibility that the actual results deviate from the expected ones [9]. Basically, risk implies uncertainty that affects the possibility of achieving the expected results, whether they are positive or negative. Understanding the different types of risk and their characteristics is crucial for effective management of financial resources and for making informed decisions.
Basic types of risk:

- Market risk
- Loan risk
- Operational risk
- Legal risk
- Political risk

Risk quantification methods:

- Variance
- Standard deviation
- Value at Risk (VaR)
- Conditional Value at Risk (CVaR)
- Simulations and stress tests

## 2. The analysis and evaluation of existing methods

1. The Scenario Analysis Methods - Scenario analysis is one of the most commonly used approaches in risk assessment. It involves creating different scenarios that represent possible future outcomes based on variations in key factors such as interest rates, asset prices or macroeconomic indicators. This method allows financial analysts to understand the potential implications on financial results under different conditions.
2. Monte Carlo simulations - Monte Carlo simulations represent a more advanced approach to risk integration that involves randomly generating a large number of scenarios based on probability distributions of key parameters. This method enables a quantitative assessment of risk and the generation of a distribution of possible financial outcomes.
3. Stress testing - Stress testing involves assessing the impact of extreme but realistic conditions on financial results, such as significant market

corrections or macroeconomic crises. This method is often used in financial institutions to assess capital adequacy and liquidity.

4. Value at Risk (VaR) model - The VaR model estimates the maximum possible loss on an investment portfolio in a certain period of time at a certain level of confidence. This method is standard in risk assessment and is widely applied in banking and investment institutions.
5. Loan risk models - Loan risk models are used to estimate the probability that debtors will not fulfil their obligations. The KMV model, for example, estimates the probability of bankruptcy of companies based on market capitalization and volatility.

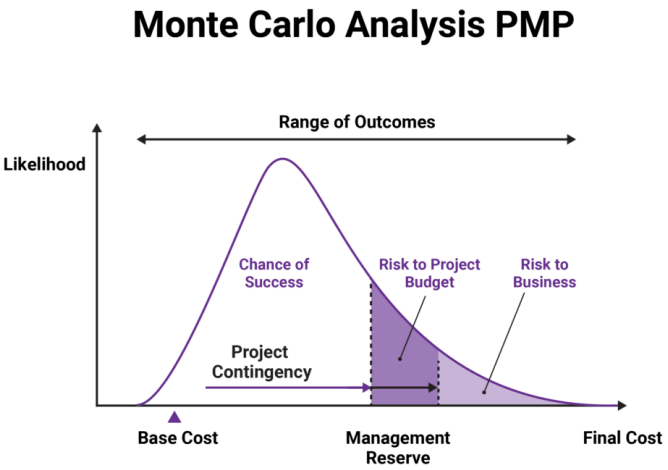
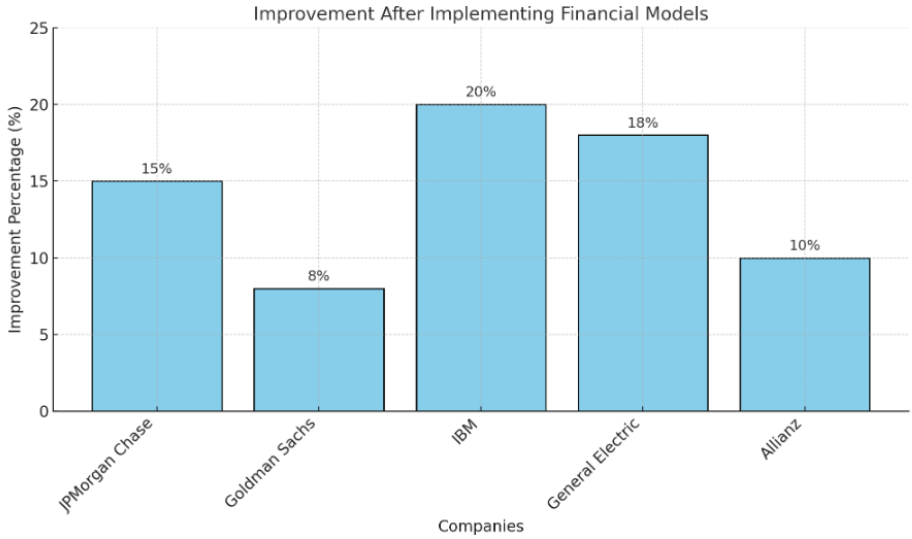


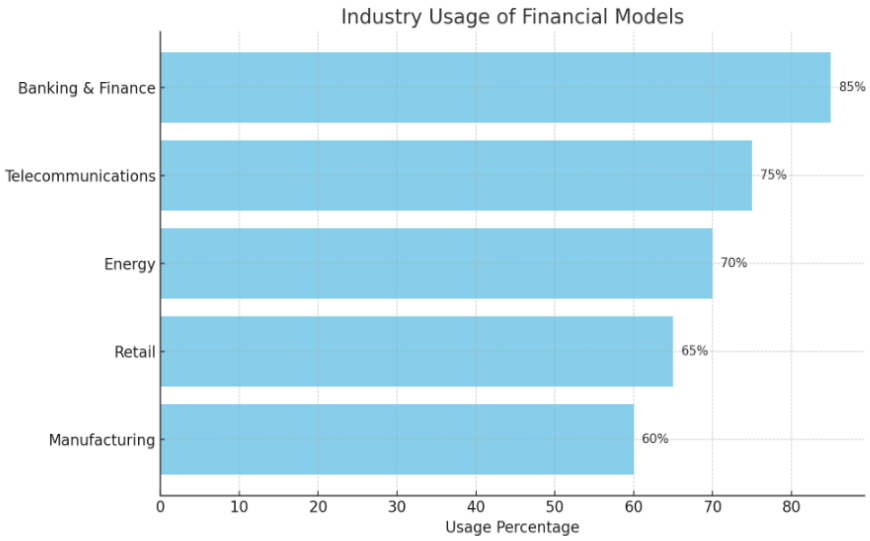

*Figure 1 - Monte Carlo diagram*

| **Company** | **Type of financial model** | **Advantages after implementation** |
|---|---|---|
| JPMorgan Chase | Stress testing and Value-at-Risk (VaR) models | Increased ability to manage market risks, reduced risk exposure by 15%, improved regulatory compliance and increased investor confidence by 10%.companies based on market capitalization and volatility. |
| Goldman Sachs | Monte Carlo simulation | Optimization of asset allocation led to an 8% increase in yield, with a 12% reduction in risk of loss. Increased stability in volatile market conditions. |
| IBM | Stochastic model for currency risk management | Reduced sensitivity to exchange rate fluctuations by 20%, enabling long-term planning of financial flows with greater precision. |

## 3. Advantages and challenges of integrating risk into financial models

The integration of risk into financial models is a key component for improving the decision-making process, as it enables a more accurate assessment of potential losses and benefits. This approach provides significant benefits, such as better predicting of volatility and reducing risk exposure, thereby improving business stability. However, there are challenges such as complexity of implementation and high costs associated with the application of advanced risk assessment methods. Companies often face the need for skilled staff and technological resources to successfully integrate risk into their models. Consideration of the benefits and challenges of integrating risk into financial models is necessary to create effective strategies that will encourage better risk management and facilitate decision-making under uncertain conditions.






## 4. Practical application and future recommendations

Best practices in risk integration into financial models involve the development and implementation of systematic approaches that ensure comprehensive risk management in line with business goals and strategies. Companies should implement detailed risk management strategies that include clear and measurable objectives, but also operational plans that determine responsibilities and procedures for identifying, assessing and managing risks. Integrating risk into financial models can have a significant impact on company performance. We herewith consider three specific examples that illustrate how companies have successfully implemented risk management in their models, including comparing the situation before and after the implementation of these strategies, with an emphasis on quantitative and qualitative aspects.

The first example is JP Morgan Chase, one of the largest and most famous financial institutions in the world. Before integrating advanced risk management methods, the company experienced serious problems during the 2008 financial crisis. During that period, JP Morgan Chase suffered losses estimated at around $30 billion due to lack of adequate monitoring and risk management. After they soon applied advanced techniques such as Monte Carlo simulations and stress testing, the situation changed significantly. Monte Carlo simulations allowed the company to evaluate a large number of possible scenarios and variants of market conditions, which led to a significant improvement in the identification and management of risks. The reports show that risk losses have been reduced by 40% in the period from 2010 to 2020, which has contributed to the stabilization of the company and the improvement of its profitable performance. Additionally, improved methods

helped JP Morgan Chase maintain its market positions and provide better customer service, leading to an increase in market share and revenue growth of approximately 15% over the same period.

The second example is Goldman Sachs, which before 2012 had significant problems with credit risk management and macroeconomic factors. During this period, the company was exposed to high risks due to market volatility and ineffective management methods. By applying new tools such as advanced data analysis and machine learning techniques, Goldman Sachs has been able to significantly improve its forecasting and risk management capabilities. Machine learning and analytical methods have enabled the company to process large amounts of data and identify risks with greater precision. These changes led to a reduction in credit losses by approximately 25% between 2013 and 2018. The company also reported improvements in portfolio management, which led to an increase in return on investment (ROI) of around 20% over the same period. These changes helped Goldman Sachs maintain stability and a competitive edge in the market.

The third example is General Electric (GE), which before 2015 had problems with operational risk management due to its large and diverse business portfolio. Before implementing the new risk management models, GE was experiencing significant losses due to ineffective procedures in various sectors. After integrating techniques such as stress testing and scenario analysis, the company achieved significant results. Stress testing allowed GE to assess how different extreme scenarios could affect their business, while scenario analysis helped identify and manage potential risks. As a result of these measures, GE was able to reduce operating costs by about 20% and increase its profitability by 15% in the period from 2016 to 2020. The company also improved its operational processes and strategic planning, which contributed to greater stability and greater ability to adapt to market conditions.

This paper aims to contribute to the understanding of how the integration of risk in financial models can influence financial practice and future research. The implementation of advanced risk management methods, such as Monte Carlo simulations, stress testing and machine learning techniques, has shown the potential to significantly improve the accuracy of forecasting and risk management (Glasserman, 2004; Danielsson, 2011). Financial institutions which have adopted such approaches, such as Morgan Stanley, Bank of America and Merrill Lynch, have shown improved results in financial risk management and significantly reduced volatility in their portfolios (Jorion, 2007). Future research should focus on developing and refining risk integration tools and techniques. Researching new technological innovations and their impact on risk management can lead to new discoveries in the field of financial analytics and may help develop more comprehensive models for forecasting and risk management (Choi & Kim, 2019). Also, it is important to consider how regulatory changes and new standards can affect the application of advanced models and technological solutions in financial institutions.

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# ADVANCED MANUFACTURING AND TECHNOLOGY

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# INFLUENCE OF LASER WELDING SPEED ON WELD WIDTH, PENETRATION, REINFORCEMENT AND HEAT AFFECTED ZONE

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***Abstract***

*Laser welding is an emerging eco-friendly technology that has a significant potential in industrial applications. Compared to arc welding, laser welding is quicker, more efficient, less energy demanding, more user friendly, while the cost of the equipment has dropped in recent years. In this paper, an attempt was made to determine the dimensions of the weld, weld metal and heat affected zone in order to better understand phenomenons that occur in the process. It was found that the increasing in welding speed has a strong influence on the penetration, reinforcement and heat affected zone, while the width of the weld was not affected. Furthermore, in some specimens, gas inclusions or pores were observed within the weld. There is a strong tendency of the gases to escape, which is evident from the apparent underfill defect in some specimens, that was followed by crystallisation.*

***Key words:*** *sustainable welding, laser welding, weld dimensions, welding speed.*

## 1. Introduction

Welding is a joining process that utilises heat and/or pressure. The most widely used welding processes are fusion processes that impart melting to the base material, making the welding relatively quick and productive, while maintaining a low cost of the equipment. However, there are numerous drawbacks to this principle, beginning with problems related to overheating, microstructural changes like segregation, heat affected zone, distorsion, etc. Of these, the most widely used

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are processes that utilise arc welding heat sources like shielded metal arc welding (SMAW), gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW). However, recently, laser heat sources emerged in the welding technology (Messler, 2004). Laser welding joins materials using a concentrated heat source from a laser beam, enabling precise, deep welds at high speeds. It accommodates various materials (metals, polymers, ceramics composites) and thicknesses ranging from 0.01 mm to 50 mm plates (Science, 2013) (Antolić, 2016). Laser welding's narrow weld zone suits thin sheets and small parts. While not replacing traditional methods, laser tech offers efficiency in difficult-to-work materials and high-speed applications. Its uses span industries like machinery, automotive, electronics, non-metallic sectors, and medicine (Gostimirović, 2012). Laser welding is concentrated, so it applies less heat. This leads to smaller weld zones and less material consumption. Laser welding has some advantages for the environment. Reduced heat input and quicker processing lead to lower energy usage. They also result in a smaller carbon footprint. A more sustainable production process benefits from decreased post-processing waste and consumable usage (S3Dht).

In this paper, an attempt was made to determine the influence of welding speed on weld dimensions, to better understand the effect of laser beam on structural steel.

## 2. Experimental part

The material selected for testing was S355 steel. The samples were plates of rectangular shape with dimensions of 150 x 50 x 3mm, cut by laser. The chemical composition of the material is provided in the Table 1.

*Table 1. Chemical composition of the S355 steel*

| %C | %Si | %Mn | %P | %S | %Cr | %Ni | %Mo | %Fe |
|---|---|---|---|---|---|---|---|---|
| 0.16 | 0.31 | 0.78 | 0.014 | 0.015 | 0.63 | 0.15 | 0.03 | balance |

Steel S355 belongs to the group of structural steels. The application of this group of steels is very extensive because they provide an excellent combination of good weldability, strength and toughness. Structural steels are highly adaptable to various purposes and are often the first choice in engineering practice.

Before welding, samples underwent visual inspection, dimension measurement, and impurity removal with abrasive cloth. A degreasing agent wipes were used to remove chemical contaminants. This preparation is vital to prevent impurities from affecting laser beam absorption and lowering weld quality. To conserve material, passes were made parallel within one sample instead of changing for each parameter variation. Laser welding's concentrated energy input minimally impacts the surrounding material, so parallel passes didn't affect adjacent ones. Welding, or to be more accurate, laser remelting was done by the following equipment:

1. Welding Machine: Gweike LW1500H with a 1500W laser power and AU3TECH-HW970 welding head.

2. Welding Table: 1000mm x 2000mm, equipped with perforated steel plates for effective sample clamping.
3. Welding Tractor: GECKO Battery tractor for linear welding, offering movement of the welding head with various welding speeds in both directions.
4. Clamps and Hand Tools: Various tools secure and manipulate workpieces during welding.
5. Protective Gear: Includes a welding mask and gloves for operator safety, providing shielding from irradiation and heat. Masks protect against UV and infrared radiation, while gloves guard against heat and splatter. Proper gear ensures safety in laser welding.

*Figure 1. Experimental setup: a) welding tractor; b) welding device*

The HW970 welding head was securely mounted on the welding tractor, ensuring stability during the process. After conducting trial passes to align the movement direction, the welding process commenced with the following parameters:

- Laser Power: 1500W,
- Beam Width: 3 mm
- Material Distance from Nozzle Tip: 5 mm
- Shielding Gas: Argon
- Gas Flow Rate: 20 l/min
- Welding Speed: 20-110 cm/min
- Pre- and post-time: 100 ms
- Laser Mode: Continuous

The passes were conducted consecutively with variations in the tractor movement speed following this sequence: 20, 25, 30, 40, 50, 60, 70, 80, 90, 100 cm/min. A total of 10 passes were executed, Figure 2.

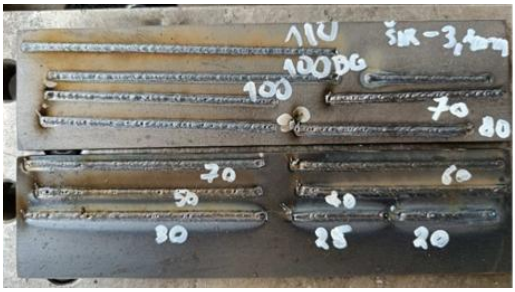


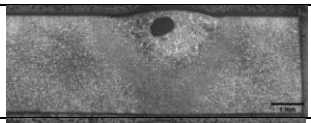

*Figure 2. Welding/remelting passes*

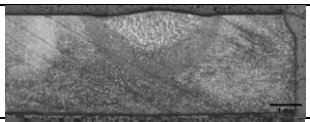
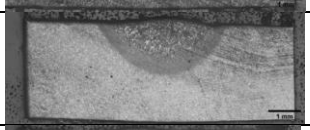
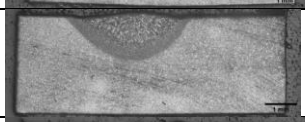
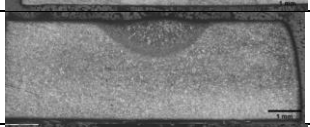
Struers-Discotom device was used for cutting the segments from the plates, with intensive water cooling to prevent heat-induced changes in microstructure. Samples were subsequently encapsulated using a STEUERS Prontopress device, shaping them into discs with melted polyethylene granules as a filler. Finally, each sample was engraved with a number. After wards, samples were ground for microscopy by Struers-Knuth Rotor device (with SiC abrasive papers) and finally polished with a Struers DP-U2 using diamond suspensions. Surface chemical etching is then applied to reveal the microstructure, by Nital (3% $HNO_3$ in ethanol). Welds were examined by Leeitz Orthoplan light microscope with a camera and measurement scale to study weld dimensions.

## 3. Results and discussion

Panoramic photographs of the cross-section of the welded joint are provided in Table 2. In Samples 1, 6 and 10, welding defects were observed, in form of gas inclusion/porosity (Sample 1), underfill as a result of gas inclusion collapse (Sample 6) and both (Sample 10). Usually, porosity is the result of solidification kinetics, where quick crystallisation occurs and the gas becomes trapped within the material. Underfill is in this case also related to porosity, where the gas from the pore escapes from the weld metal, which is followed by the immediate solidification.

*Table 2. Weld macro images*

| Sample number | Welding speed | Picture |
|---|---|---|
| 1. | 20 cm/min |  |
| 2. | 25 cm/min | |

| Sample number | Welding speed | Picture |
|---|---|---|
| 3. | 30 cm/min |  |
| 4. | 40 cm/min |  |
| 5. | 50 cm/min |  |
| 6. | 60 cm/min | |
| 7. | 70 cm/min |  |
| 8. | 80 cm/min | |
| 9. | 90 cm/min | |
| 10. | 100 cm/min | |

The measurement results of the width, penetration depth, reinforcement, and heat-affected zone width of the welded joint samples are provided in Figures 3 - 6.

The table clearly shows a tendency of decreasing certain characteristic dimensions with increasing welding speed. Based on the table, diagrams have been created to visualize, or rather, to simplify the observation of dimension changes.

The width of the welded joint increases up to a speed of 40 cm/min, then decreases until the final speed of 100 cm/min, when the width increases to approximately the initial value. Nevertheless, the differences are fairly small. The range of measured dimensions indicates that the welding speed does not have a direct impact on the width of the welded joint, as no consistent pattern can be found.

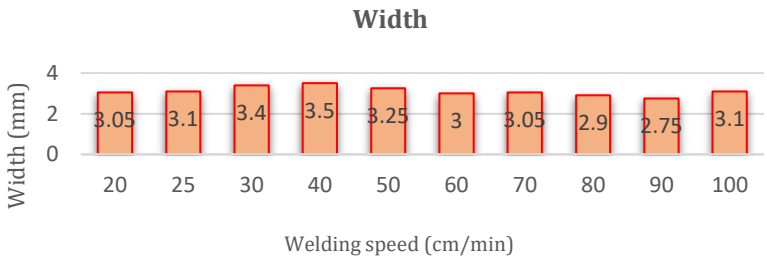



*Figure 3. Weld width vs welding speed*

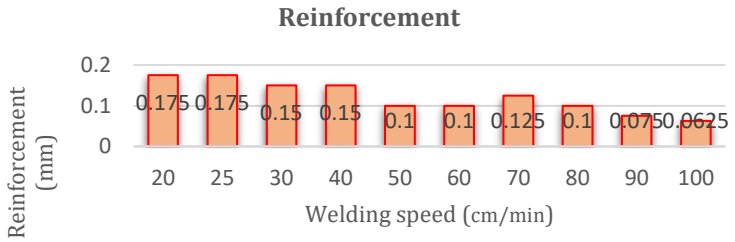



*Figure 4. Weld reinforcement vs welding speed*

The values of the reinforcement were obtained as the average measurement in several different positions. A decrease in the reinforcement is noticeable with increasing welding speed. Based on the results shown in Figure 4, it can be noted that there are pores on samples 1 and 10, likely due to the penetration of shielding gas or even atmospheric gases. Samples 6 and 10 exhibit surface depressions as a result of gas escaping to the surface, which certainly affects the reinforcement.

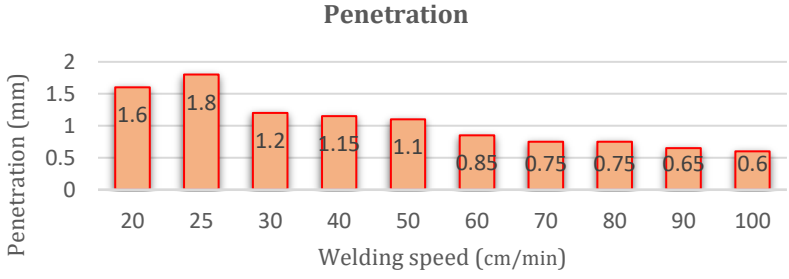



*Figure 5. Penetration vs welding speed*

The penetration decreases as welding speed increases, as with the reinforcement, however, penetration exhibits a wider range of dimensions. For example, there is a 1.2 mm difference in fusion zone depth between sample 2 at 25

cm/min and sample 10 at 100 cm/min. The reason for the smaller penetration in sample 1 compared to sample 2 is unclear, possibly due to a pore inside the weld on this particular section that was tested.

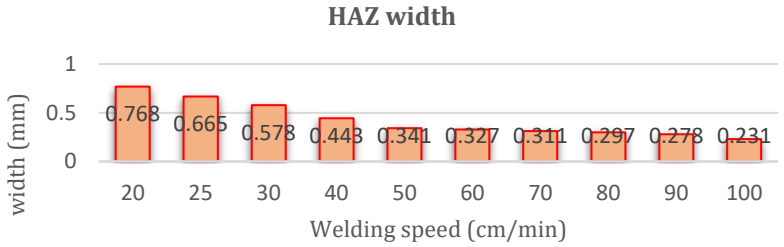



*Figure 6. HAZ width vs welding speed*

The widest HAZ was obtained in sample 1 at 20 cm/min. Speed increases lead to a steep decrease until 50 cm/min, with further increases gradually reducing the HAZ width. Analysis suggests the HAZ width correlates with heat input, with speed having a significant effect.

## 4. Conclusions

Laser welding offers versatility and adaptability across various applications, boasting simplicity, high productivity, and precision compared to conventional methods. Its high power density allows for swift welding speeds, affecting a small area around the joint with minimal base material deformations, ideal for thin materials. Operator training is notably fast, vital given the shortage of skilled welders. However, high initial and upkeep costs pose challenges. Yet, ongoing advancements promise a more cost-effective alternative to traditional methods. To fully implement laser welding, understanding the influence on parameters is crucial.

Analysis of results reveals a clear link between welding speed and joint dimensions, which can be summarized as follows:

- Speed notably impacts fusion and heat-affected zones, causing a decrease in dimensions.
- Reinforcement shows deviations but generally decreases with higher welding speed.
- The effect of welding speed on weld width remains inconclusive based on this experiment, suggesting no direct influence.

Porosity has a significant impact on the quality and weld dimensions. Although pores, that is, gas inclusions have a strong tendency to escape the weld metal, the quick and subsequent crystallization causes the occurence of underfill in the weld metal.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CYBERSECURITY IN INDUSTRIAL INTERNET OF THINGS AND COLLABORATIVE ROBOTS: INDUSTRY 5.0 PERSPECTIVE

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***Abstract***

*Industry 5.0 is leading important transformative changes in today's world. Through human-centric, sustainable, and resilient practices, these changes are answering challenges identified on a global level. In the manufacturing sector, the shift from technology-oriented production to people-oriented production is being made. Industry 5.0 enhances the importance of people, their role in Industrial Internet of Things, and working in a symbiosis with Collaborative Robots. These practices require obtaining sensitive data, which makes strengthening and maintaining firms' Cybersecurity measures necessary. In order to show how Cybersecurity pervades Industrial Internet of Things and Collaborative Robots, authors of this paper have applied the PRISMA framework. The main findings of this paper show how Cybersecurity is used in Industrial Internet of Things and Collaborative Robots from the Industry 5.0 perspective.*

***Key words:*** *Industry 5.0, Cybersecurity, Industrial Internet of Things, Collaborative Robots.*

## 1. Introduction

Digital technologies have emerged in the scope of the Industry 4.0 strategy, which was initiated in 2011 (Lasi et al., 2014). Ever since, digitalisation and digital transformation are changing the ways of doing business, resulting in the creation of digital product-service systems (Rakic et al., 2023; Vuckovic et al., 2022). As digital technologies of the Fourth industrial revolution, cybersecurity, industrial internet of things (IIoT), and collaborative robots (cobots) are intertwined with an aim to

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ensure a proper functioning of cyber-physical systems (Komosar et al., 2024; Lezzi et al., 2018). However, with the introduction of Industry 5.0, human-cyber-physical systems have appeared (Chen et al., 2021). The human factor in the human-cyber-physical systems resembles main Industry 5.0 pillars – human-centricity, sustainability, and resilience (Chen et al., 2021; Slavic et al., 2024). When compared with Industry 4.0 which is identified as a technology-driven strategy, Industry 5.0 is identified as a value-driven strategy (Crnobrnja et al., 2023; Golovianko et al., 2023). In other words, Industry 5.0 goes beyond firms' needs and tends towards answering societal needs on a global level (Slavic et al., 2024).

In this paper, a systematic literature review is conducted with an aim to investigate the use of Cybersecurity in (Industrial) Internet of Things and Collaborative Robots from the Industry 5.0 perspective. Consequently, authors propose following research questions:

**RQ1:** How are Cybersecurity and Internet of Things intertwined in the context of Industry 5.0?

**RQ2:** How are Cybersecurity and Collaborative Robots intertwined in the context of Industry 5.0?

To answer the research questions, the paper is structured in the following way: Section 2 gives an overview of the research methodology, Section 3 consists of a review of extracted research, Section 4 includes a discussion on the given topic, and Section 5 concludes the paper.

## 2. Research methodology

In this paper, a systematic literature review (SLR) was conducted to investigate the use of Cybersecurity in (Industrial) Internet of Things and Collaborative Robots in the context of Industry 5.0. Aim of this study is to identify and interpret recent literature in the mentioned field. Preferred Reporting Items for Systematic reviews and Meta-Analyses, also known as the PRISMA framework was used in this study. The PRISMA framework consists of three stages: (1) identification, (2) screening, and (3) inclusion. Figure 1 shows a PRISMA flow chart which resembles phases of this SLR study.

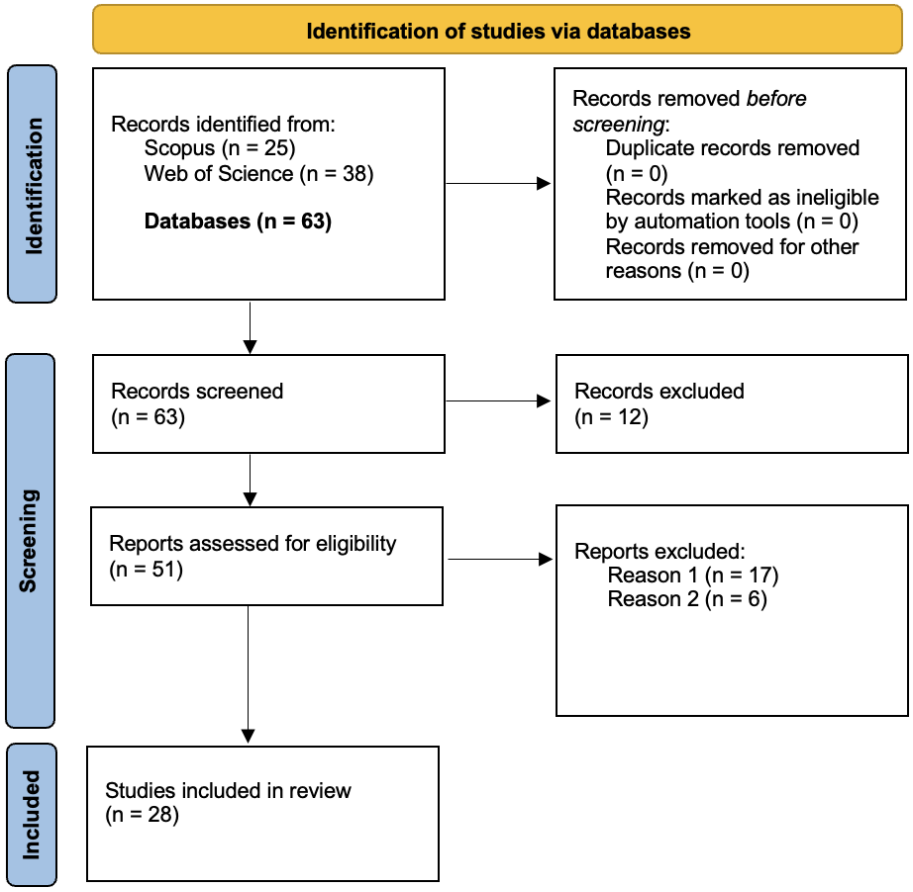


*Figure 1: PRISMA flow diagram presenting the results of the systematic research*

This SLR study was conducted in September 2024. Data collection and screening were done in the Scopus and Web of Science databases using the following research string for researching titles, abstracts, and keywords: "cybersecurity" AND "internet of things" OR "collaborative robots" AND "Industry 5.0". This research string gathered 106 results. Only conference papers and articles written since 2020 were further included in the SLR, resulting in 63 records for further screening. After the screening process, 12 records were excluded due to inaccessibility. Next, 51 reports were assessed for eligibility – 17 were excluded after examining the titles (Reason 1), and 6 were excluded after examining the abstracts (Reason 2). Finally, 28 studies were included in the systematic literature review.

## 3. Review of extracted research

As Internet of Things represents a network of interconnected systems, software, data storage, and services, it also represents a target for cyberattacks due to sensitive and important data it storages (Ahmed et al., 2023; Alkhudaydi et al., 2023). With the transition to Industry 5.0 and enhanced collaboration between humans and robots, more personal data is included (Nelufule et al., 2024). Additionally, educating the end-users of these systems about potential threats plays a crucial role in maintaining responsible usage and cybersecurity practices (Ganji & Afshan, 2024). By introducing regular staff training, cybersecurity awareness increases, and the impact of cyberattacks on performance, intellectual capital, and organisational knowledge minimises (Corallo et al., 2022).

Cybersecurity attack, threats, and vulnerabilities which are found in IoT environments are Denial of Service (DoS), Distributed Denial of Service (DDoS), malicious, ransomware, blackhole, sinkhole, reconnaissance, and wormhole attacks (Abdullahi et al., 2022). Methodologies for predicting these attacks are usually based on artificial intelligence and deep learning/machine learning, and blockchain (Alrowais et al., 2023; Mughaid et al., 2024; Rudenko et al., 2022; Tariq et al., 2023). Industrial machines and devices are particularly vulnerable to cyberattacks due to their design which emphasizes functionality rather than security (Alnajim et al., 2023). The vulnerability increases as the dependence on technology grows (Díaz, 2022). To encounter this risk, cybersecurity models tailored specifically for Industry 5.0 connectivity needs are designed (Babbar et al., 2024).

However, Internet of Things has proven to be useful in different fields, such as medicine (Internet of Medical Things), and manufacturing (Industrial Internet of Things) (Casarosa, 2024; Corallo et al., 2022). The use of IoT systems in medicine implies gathering very sensitive data needed for patients' survival, which should be organised according to legal frameworks (Casarosa, 2024). Nonetheless, there are several security certifications schemes which address cybersecurity issues in the IoT environment (Matheu et al., 2019, 2021). Except for fulfilling the security certification schemes requirements, when designing cybersecurity solutions, design guidelines should be followed as well (Boukerche & Coutinho, 2021).

Open-source tools and materials are important for understanding how Internet of Things and collaborative robots work – testbeds which provide simulations of these technologies represent a great source for education and research in these fields (Thom et al., 2021). Also, as working with collaborative robots requires trust, including employees in simulations strengthens the relationship one has with the cobot (Liao et al., 2023). Since cobots do not require any safety net between the machine and the human, the whole network of connected smart objects needs to be both safe and secure (Raimundo & Rosário, 2022).

# 4. Discussion

## 4.1. Cybersecurity and Internet of Things

In the context of Industry 5.0 and the connectivity between suppliers, employees, consumers, and technologies it provides, cybersecurity attacks represent a great threat to any digitalised business. Education and research play an important role when defining preventive and corrective strategies in the scope of cybersecurity. Through employee training, cybersecurity awareness is increased, and firm's human-centricity and resilience are strengthened. Additionally, new employee profiles, such as Cybersecurity Professional, are introduced in companies with an aim to focus on cybersecurity attacks, threats, and vulnerabilities.

Internet of Things gathers and stores big amounts of data, some of it being sensitive and personal, especially when IoT is applied in the health sector. Additionally, leading automotive companies use mandatory established cybersecurity implementation in development and manufacturing of products such as airbag systems, and breakes. In order to keep the data secure, different cybersecurity methods are developed. Also, cybersecurity certifications schemes and legal frameworks are designed with an aim to keep the Internet of Things systems as secure as possible.

Accordingly, the answer to **RQ1:** *How are Cybersecurity and Internet of Things intertwined in the context of Industry 5.0?* is that *Cybersecurity and Internet of Things are intertwined in a way which prioritizes keeping personal data safe, and emphasizes the importance of employee education and training*.

## 4.2. Cybersecurity and Collaborative Robots

Compared to industrial robots, collaborative robots require a higher level of human-machine interaction. This represents a challenge, due to the fear many employees have when faced with collaborative robots which have an anthropomorphistic design. The new human-machine interaction requires further digital forensic analyses. When integrated with artificial intelligence, collaborative robots can predict the way a certain employee will perform its tasks. Due to the close collaboration, the workspace needs to be both safe and secure.

In the context of collaborative robots, which represent one of smart objects which are connected through the Internet of Things, cybersecurity secures the data about human-robot interaction and tasks they have performed together.

Correspondingly, the answer to **RQ2:** *How are Cybersecurity and Collaborative Robots intertwined in the context of Industry 5.0?* is that *Cybersecurity and Collaborative Robots are intertwined in a way that secures the data and IT systems which represent the "machine" part in human-machine interaction*.

## 5. Conclusions

This manuscript has investigated the connection between Cybersecurity and Internet of Things, and Cybersecurity and Collaborative Robots, both from the perspective of Industry 5.0. The research was done using the PRISMA framework for conducting a systematic literature review. The study included 28 papers from Scopus and Web of Science databases.

With an aim to contribute to Industry 5.0 practices through a human-centric use of digital technologies, more specifically Internet of Things, Collaborative Robots, and Cybersecurity, companies should invest in developing organisational knowledge related to these fields through education, research, and training. Except for gaining and sharing knowledge inside the company, this data should also be secured. Additionally, next to security stands safety, important for maintaining employees' health and well-being.

The transition to Industry 5.0 implies a human-centric, sustainable, and resilient approach towards doing business. In Internet of Things environments and human-robot collaborations, cybersecurity prioritizes minimising risks and addressing attack, threats, and vulnerabilities associated with data and IT systems. Also, education and training of employees, as well as designing new employee profiles contributes to strengthening cybersecurity in the whole Internet of Things network.

Future research on the given topic should include other scientific databases, such as Science Direct or MDPI. Additionally, case studies which include investigating best practices regarding cybersecurity methodologies in IoT and collaborative robots should be conducted.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE FUTURE OF AGRICULTURAL SPRAYING: AI AND UAVS FOR SMART AND SUSTAINABLE PRACTICES

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***Abstract***

*Unmanned Aerial Vehicles (UAVs), commonly known as drones, paired with advanced artificial intelligence (AI) systems, are poised to transform agricultural spraying practices. Traditional spraying methods often face challenges in efficiency, precision, and environmental impact. UAVs equipped with AI-powered vision systems offer the potential to revolutionize crop protection by enabling targeted pesticide and fertilizer application, optimized flight paths, and real-time condition monitoring. AI algorithms analyze image and sensor data to detect pests, diseases, and nutrient deficiencies with remarkable accuracy. This precision targeting allows for a significant reduction in chemical usage, minimizing environmental impact and costs. Moreover, AI-controlled drones can operate autonomously, covering vast fields quickly and safely, even in challenging terrain. This study explores the cutting-edge advancements in UAV technology and AI for agricultural spraying. It highlights their potential to increase agricultural yields, improve resource management, and promote sustainable farming practices. Further research on regulatory frameworks, cost-effectiveness, and data privacy will be crucial in realizing the full potential of this transformative technology.*

***Key words:*** *UAVs, drones, precision agriculture, artificial intelligence, crop spraying, sustainability*

## 1. Introduction

The agricultural sector has witnessed significant transformations over the years, from the mechanized agriculture revolution in the early 20th century to the

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Green Revolution in the 1960s, which led to a substantial increase in food production. The latest revolution in agriculture is precision agriculture, which leverages advanced technologies such as GPS, satellite imaging, and data analytics to optimize crop yields and reduce environmental impact. Precision agriculture is crucial in addressing the growing global demand for food, as it enables farmers to manage their fields more efficiently and effectively, thereby increasing productivity while minimizing waste and environmental degradation. The need for precision agriculture is particularly pressing in the face of climate change, population growth, and the need for sustainable agricultural practices. As noted by Abobatta (2021), precision agriculture is essential for sustainable development and reducing poverty, especially in developing countries. The integration of precision agriculture tools and technologies is vital for ensuring a food-secure future and meeting the challenges posed by the increasing global demand for food (Mogili & Deepak, 2018).

Unmanned Aerial Vehicles (UAVs, drones) have emerged as a promising technology for various applications, including precision agriculture (Mogili & Deepak, 2018). Remote sensing is a powerful tool for monitoring crop health and detecting potential problems, such as pests, diseases, and nutrient deficiencies (Liaghat & Balasundram, 2010). UAVs equipped with AI-powered vision systems offer a solution to these challenges by enabling targeted pesticide and fertilizer application, optimized flight paths, and real-time condition monitoring (Kamilaris et al., 2017). AI algorithms can analyze image and sensor data to detect pests, diseases, and nutrient deficiencies with remarkable accuracy, allowing for precision targeting and a significant reduction in chemical usage (Kerkech et al., 2020). This precision targeting not only minimizes environmental impact but also reduces costs associated with excessive chemical application (Kouadio et al., 2023).

The integration of UAVs with advanced artificial intelligence (AI) systems has the potential to revolutionize agricultural spraying practices, addressing the challenges faced by traditional methods (Kouadio et al., 2023). Traditional spraying techniques often struggle with efficiency, precision, and environmental impact, leading to the overuse of pesticides and fertilizers (Giles, 2016). Moreover, AI-controlled drones can operate autonomously, covering vast fields quickly and safely, even in challenging terrain (Mogili & Deepak, 2018). This capability is particularly advantageous in areas with limited accessibility or where manual spraying is impractical (Kamilaris et al., 2017). Drones can also be used for aerial photography, providing detailed maps of fields and enabling farmers to assess crop conditions and identify problem areas (Giles, 2016).

As the agricultural landscape continues to evolve, producers are looking for new and exciting ways to increase their yields while also conserving resources and limiting their environmental impact. Drones and AI offer a promising solution, with the potential to transform every aspect of crop production from planting to harvest. By leveraging these cutting-edge technologies, farmers can optimize their operations, reduce costs, and promote sustainable farming practices (Kouadio et al., 2023).

This research contributes to the advancement of using drones and AI in agriculture in several key ways: crop protection, specialized payloads, optimizing operations, increasing yields, transforming crop production. In summary, this research highlights the transformative potential of drones and AI in revolutionizing modern agriculture, from enhancing crop protection to optimizing operations and promoting sustainability. These studies demonstrate the potential of computer vision in detecting weeds, pests, and diseases in crops. By using machine learning algorithms to analyze images, farmers can quickly and accurately identify potential issues and take action to prevent them from spreading.

## 2. Remote sensing

### 2.1 Soil Mapping

Remote sensing techniques can be used to map soil properties, such as texture, organic matter content, and nutrient levels, which are crucial for site-specific management (Surendran et al., 2024). Satellite-based remote sensing, such as Landsat and MODIS, can provide large-scale soil maps at relatively low cost (Shikha et al., 2007). Aerial-based remote sensing, using sensors mounted on aircraft or UAVs, can provide higher-resolution soil maps with more detailed information on spatial variability within fields (Stöcker et al., 2017).

### 2.2 Crop Monitoring

Remote sensing is a powerful tool for monitoring crop health and detecting potential problems, such as pests, diseases, and nutrient deficiencies (Liaghat & Balasundram, 2010). Multispectral and hyperspectral sensors can capture data across a wide range of wavelengths, allowing for the detection of subtle changes in plant reflectance that may indicate stress or disease (Adam et al., 2010). Thermal sensors can also be used to detect water stress in crops, enabling more efficient irrigation management (Schellberg et al., 2008).

### 2.4 Detecting weeds, pests and diseases

Computer vision has been increasingly used in agriculture to detect weeds, pests, and diseases. This technology uses machine learning algorithms to analyze images of crops and identify potential issues. Here are some recent studies on the use of computer vision in detecting weeds, pests, and diseases. Multispectral imaging has emerged as a powerful tool for detecting and monitoring weeds, pests, and diseases in precision agriculture. By providing valuable data on the spatial distribution of these threats, multispectral cameras can guide targeted interventions and optimize the use of herbicides and pesticides. Multispectral cameras can be used to detect, and map weed infestations in crop fields by exploiting differences in spectral reflectance between weeds and crops (Goel et al., 2003). Weeds often have distinct leaf pigments, canopy structure, and growth habits that

result in unique spectral signatures that can be detected by multispectral sensors (Peña et al., 2013). By analysing multispectral data, algorithms can be developed to automatically identify, and map weed patches, enabling targeted application of herbicides and reducing the need for blanket spraying (Slaughter et al., 2008). Weed Detection: Computer vision can be used to detect weeds in crops by analyzing images of the field. This can be done using traditional image processing techniques or deep learning algorithms. For example, a study published in 2023 used a convolutional neural network (CNN) to detect weeds in corn fields with an accuracy of 95% (Chithambarathanu, 2023).

The latest advancements in multispectral camera technology for disease detection in precision agriculture are based on improved spectral resolution. Newer multispectral cameras are able to capture data in more spectral bands, providing more detailed information on plant reflectance and allowing for better discrimination between healthy and diseased plants (Mahlein et al., 2012). Higher resolution multispectral sensors, including those mounted on UAVs, can provide detailed maps of crop health at the individual plant level, enabling early detection of disease outbreaks (Peña et al., 2013). Combining multispectral data with thermal imaging allows for the detection of changes in leaf temperature associated with certain diseases, further improving diagnostic accuracy (Calderón et al., 2013).

Several machine learning algorithms can be trained on multispectral data to automatically identify disease symptoms in crops. **Convolutional Neural Networks** (CNNs): CNNs are a type of deep learning algorithm that can effectively process and classify multispectral images. A study used a CNN to detect weeds in corn fields from multispectral images with 95% accuracy. **You Only Look Once (YOLO)**: YOLO is a real-time object detection system that can be trained on multispectral datasets. Researchers trained YOLO v3 from scratch to detect objects in multispectral images, achieving an overall mean average precision (mAP) of 46.4%. **Support Vector Machines (SVMs**): SVMs are a traditional machine learning algorithm that can be used for multispectral image classification. SVMs are good at handling two-class problems and are easy to implement. **Linear Discriminant Analysis (LDA)**: LDA is a supervised dimensionality reduction technique that can be used for multispectral image classification. LDA is easy to implement but may lead to overfitting. **Random Forest**: Random Forest is an ensemble learning method that can be used for multispectral image classification. It is robust to overfitting and can handle high-dimensional data (Zeng et al., 2021).

These algorithms can be trained on multispectral datasets containing images of healthy and diseased crops. The models can then be used to automatically identify disease symptoms in new multispectral images, helping farmers detect and manage crop diseases more efficiently. Also, Hyperspectral cameras that capture data in hundreds of narrow spectral bands are becoming more affordable and accessible, providing even more detailed information on plant health and disease status (Mahlein et al., 2012). Low-cost multispectral sensors are being developed for use with smartphones and handheld devices, allowing farmers to quickly assess crop health in the field (Delalieux et al., 2007). Integrating multispectral data with other

sources of information, such as weather data and historical disease records, can improve disease forecasting models and guide more targeted interventions (Sankaran et al., 2010). These advancements in multispectral camera technology, combined with improved data analysis capabilities, are making it easier and more cost-effective for farmers to detect and manage crop weeds, pests and diseases, reducing the need for broad-spectrum pesticide applications and promoting more sustainable agriculture.

## 3. UAV spraying

The effectiveness of UAV spraying is influenced by various factors, including droplet size, flight altitude, flight speed, and environmental conditions (Liu et al., 2022; Wang et al., 2018; Qin et al., 2018). Spray quality, characterized by droplet coverage and drift potential, is a critical aspect that requires attention to balance between coverage and drift risk (Dengeru et al., 2022). The size of droplets generated by UAVs and ground-based machinery plays a crucial role in spray quality, with smaller droplets having a higher risk of drift but better coverage (Yallappa et al., 2017; Ling et al., 2018).

In challenging environments such as orchards and tall trees, the application of UAV spraying becomes essential for achieving higher spray penetration and effectiveness (He, 2018). The optimization of UAV spraying techniques is vital for ensuring precise and effective pesticide application in modern commercial crop protection systems. Understanding the impact of downwash airflow on spray distribution and deposition is crucial for improving the uniformity and efficiency of multi-rotor UAV spraying (Boukhalfa et al., 2014).

The integration of remote sensing data with variable-rate application systems in precision agriculture requires careful coordination and data management (Schellberg et al., 2008). Satellite-based remote sensing may face limitations such as spatial resolution constraints and cloud cover issues, while aerial-based remote sensing can be impacted by weather conditions and flight schedules (Ehsani & Maja, 2013). Additionally, the use of UAVs for remote sensing in agriculture may be subject to regulatory and legal considerations, including airspace restrictions and privacy concerns (Stöcker et al., 2017).

Variable-rate application systems, which adjust input levels based on spatial and temporal variability within fields, can be guided by remote sensing data to ensure that inputs are applied where and when they are most needed (Schellberg et al., 2008). This approach can lead to significant savings in input costs and reduced environmental impact.

In conclusion, the evaluation of UAV spraying in precision agriculture underscores the need for continuous research and development to enhance the effectiveness, efficiency, and environmental sustainability of this technology. By addressing key factors influencing spray quality and deployment challenges, UAV spraying can significantly contribute to modern agricultural practices.

## 4. Benefits of Remote Sensing in Precision Agriculture

Remote sensing has been increasingly integrated into precision agriculture to enhance crop management and minimize environmental impacts. The benefits of remote sensing in precision agriculture include real-time crop monitoring, which provides data on crop health, soil conditions, water status, and yield, enabling farmers to make informed decisions about variable rate applications within fields (PointOneNav, 2024). This leads to improved crop yield by identifying areas of stress or growth, allowing farmers to optimize inputs like seeds, fertilizer, and water, resulting in higher yields and better-quality produce (Sangeetha et al., 2024). Additionally, precision agriculture reduces the need for pesticides and excessive fertilizer use, thereby preserving soil quality and promoting a healthier ecosystem (Sangeetha et al., 2024). Remote sensing also helps farmers optimize resource use by applying site-specific management practices, minimizing waste, and maximizing efficiency (Surendran et al., 2024). Furthermore, the integration of remote sensing data with other technologies like GPS, GIS, and machine learning enables farmers to make more informed decisions about crop management, reducing the farm's dependence on weather conditions (Ohio State University, 2017).

Remote sensing technology can automate many tasks, such as crop monitoring and data analysis, freeing up farmers to focus on more strategic and high-value activities (Ehsani & Maja, 2013). By optimizing crop management practices and reducing waste, remote sensing in precision agriculture can contribute to a more sustainable and environmentally friendly agricultural system (Khanal et al., 2020). Remote sensing data can help farmers identify areas of stress and optimize resource allocation, leading to reduced water and fertilizer usage (Schellberg et al., 2008). By identifying and addressing potential issues early on, remote sensing in precision agriculture can help farmers achieve higher crop yields and improve overall agricultural productivity (Sishodia et al., 2020). This technology can reduce the need for manual data collection and analysis, saving farmers time and resources (Giles, 2016). Remote sensing data can be used to create detailed maps of crop and soil variability, enabling farmers to implement site-specific management practices and optimize agronomic inputs (Liaghat & Balasundram, 2010). It can detect early signs of disease and pest infestations, enabling farmers to take targeted actions and reduce the need for chemical pesticides and fungicides (Ennouri et al., 2020).

Artificial intelligence (AI) is also being increasingly used in precision agriculture to analyze large amounts of data from remote sensing and other sources. AI algorithms can identify patterns and anomalies in the data, enabling farmers to predict and prevent crop diseases, pests, and other issues (Sangeetha et al., 2024). AI can also optimize crop yields by identifying the most effective irrigation and fertilization strategies, reducing waste and environmental impact (Surendran et al., 2024). Moreover, AI-powered decision support systems can provide farmers with personalized recommendations for crop management, taking into account factors like weather, soil type, and crop variety (PointOneNav, 2024). These AI-powered

systems can significantly improve the efficiency and effectiveness of precision agriculture, enabling farmers to make data-driven decisions and achieve better outcomes.

## 5. Challenges and Limitations

While remote sensing offers numerous benefits in precision agriculture, there are also challenges and limitations to its widespread adoption, including: high initial investment costs, specialized expertise, data integration, spatial and temporal resolution, regulatory and legal considerations. The acquisition of remote sensing equipment and the development of data processing and analysis capabilities can require significant initial investments (Ehsani & Maja, 2013). Effectively using remote sensing in precision agriculture requires specialized expertise in data acquisition, processing, and interpretation, which may not be readily available in all farming communities (Adam et al., 2010). Integrating remote sensing data with other precision agriculture technologies, such as variable-rate application systems, requires careful coordination and data management (Schellberg et al., 2008). Satellite-based remote sensing may be limited by spatial resolution, cloud cover, and revisit frequency, while aerial-based remote sensing can be affected by weather conditions and flight schedules (Ehsani & Maja, 2013). The use of UAVs for remote sensing in agriculture may be subject to regulatory and legal considerations, such as airspace restrictions and privacy concerns (Stöcker et al., 2017). These challenges highlight the need for careful consideration of the potential benefits and limitations of AI in drone technology for agriculture, as well as the importance of addressing these hurdles to ensure effective and sustainable adoption.

## 6. Conclusions

UAV spraying has emerged as a powerful tool in precision agriculture, enabling farmers to optimize crop yields, reduce input costs, and promote sustainable farming practices. By providing valuable data on soil properties, crop health, and input needs, remote sensing can guide targeted interventions and optimize resource use efficiency. The integration of remote sensing with other precision agriculture technologies, such as variable-rate application systems, can further enhance the effectiveness of these practices.

However, the widespread adoption of remote sensing in precision agriculture faces challenges, including high initial investment costs, the need for specialized expertise, and the integration of data from various sources. Addressing these challenges will require collaboration among farmers, researchers, and technology providers to develop more accessible and user-friendly remote sensing solutions.

As precision agriculture continues to evolve, UAV sprayers will play an increasingly important role in enhancing crop production, improving resource use efficiency, and promoting sustainable farming practices through the use of artificial intelligence (AI) in agriculture drones as it revolutionizes farming practices.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# MAPPING THE INTERSECTION OF CYBERSECURITY AND INDUSTRY 5.0: A BIBLIOMETRIC ANALYSIS

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***Abstract***

*Industry 5.0 is a human-centric strategy that emphasizes the collaboration between humans and advanced technologies. On the other hand, cybersecurity is fundamentally oriented towards protecting people and their interactions with these technologies, especially within the framework of Industry 5.0. The increasing digitization and reliance on technology emerge in the development and implementation of cybersecurity concepts, measures, and implementations. This paper includes the intersection of Industry 5.0 and cybersecurity, focusing on their integration and the resulting research. It identifies the most influential authors and key areas of research, highlights essential keywords, and examines the most productive countries in the field of cybersecurity within Industry 5.0.*

***Key words:*** *cybersecurity, Industry 5.0, cyber threats, digital transformation, bibliometric analysis*

## 1. Introduction

In 2015 the term Industry 5.0 was introduced as a new strategy that relies on three main concepts: human-centricity, sustainability, and resilience (Rada & Schaller, 2024; Slavic, 2023). The concept of Industry 5.0 can be understood from multiple perspectives and defined in various ways, depending on the source. Leng et al. (Leng et al., 2022) distinguish between EU proposal-based, human-machine collaboration-based, and intelligent cutting-edge technology-based definitions. At its core, Industry 5.0 places humans at the center, focusing on their role in utilizing and interacting with advanced technologies such as artificial intelligence (AI),

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digitalization, blockchain, and IoT in different industries such as automotive (Crnobrnja et al., 2023; Rakic et al., 2023; Slavic et al., 2024).

The use of AI in human-oriented industries broadens the range of cutting-edge technologies available, making the implementation of cybersecurity essential. With a variety of cybersecurity threats, using AI to support cybersecurity can reduce the risks of damage scenarios by implementing the most innovative cybersecurity solutions. (Komosar et al., 2024).

To investigate current trends in the field of cybersecurity in Industry 5.0 this research covers a bibliometric analysis approach. Currently, there is a lack of bibliometric analysis that can address this research field. The aim of this paper is to synthesize current research in a bibliometric manner as a direction for further investigations. To conduct precise research, the authors declared research questions as follows:

1. RQ1: Which authors have contributed the most in this field?
2. RQ2: Which journals have the most published papers in this field?
3. RQ3: Which countries have the biggest production of papers in this field?
4. RQ4: Which keywords were the most used in the papers?

The paper is defined as follows: after the introduction the methodology is presented, followed by the results and discussion. At the end of the paper, the conclusion is provided with future direction and the limitations of the study.

## 2. Methodology

In this paper standard research framework for bibliometric analysis is provided. The authors selected Scopus as one of the most relevant databases for research. The initial step involved conducting a research query. After various combinations, the final query was: TITLE-ABS-KEY ( cyber security OR cybersecurity OR cyber-sec* ) AND TITLE-ABS-KEY ( industry 5.0 OR industry 5* OR 5th industrial revolution OR fifth industrial revolution ) AND PUBYEAR > 2018 AND PUBYEAR < 2025. The total number of 94 is taken for analysis.

Software R studio (rstudio-2024-.04.2-764) including biblioshiny() is used to run analysis and obtain results. Additionally, VOSViewer is used to visualize the results.

## 3. Results and Discussion

To systematically present the results, the research questions and their corresponding answers will be addressed separately in sub-sections.

### 3.1 The authors who contributed the most

To answer RQ1, three aspects are taken into consideration: the number of published papers, the number of citations, and production over time. Table 1 presents an overview of the authors that contributed the most. All the authors have

an equal number of published papers – 2. In 2022, a total of 10 papers were published, increasing to 35 in 2023 and surpassing 40 in 2024. This significant growth highlights the rising importance of cybersecurity in Industry 5.0 as a critical area for development. On the other hand, considering the duration of productivity, Das AK has the longest active period in this field, followed by Mikolajewski. Bakkar, Nelufule, and Pal each have a one-year production period.

*Table 1: Number of published papers per author*

| Number | Author | Number of published papers | Production period |
|---|---|---|---|
| **1** | Bakkar MN. | 2 | 2023 |
| **2** | Das AK. | 2 | 2022-2024 |
| **3** | Mikolajewski D. | 2 | 2023-2024 |
| **4** | Nelufule N. | 2 | 2024 |
| **5** | Pal S. | 2 | 2024 |

Furthermore, Table 2 presents authors with the highest cite score per paper on a global level. The paper (Javed et al., 2022) has the highest score of citations – 268. One of the most popular topics in the most cited papers is blockchain, cryptography incorporated into operations, and supply chain management. For example, in the (Raja Santhi & Muthuswamy, 2022) Blockchain and cryptography are integrated and investigated in supply chain management with a total number of 132 citations. Additionally, in (Kumar & Mallipeddi, 2022) investigates the same topic expanding it with operations management with a score of 45 citations. Furthermore, in (Mourtzis et al., 2023) also focus on integrating blockchain in the era of the industrial metaverse with a 62-citation score.

While on the other hand Wang et al. (Wang et al., 2022) focus on data security storage mechanisms based on blockchain in IoT with 44 citations. Dhirani et al. (Dhirani et al., 2023) investigate ethical dilemmas and privacy issues in emerging technologies with 64 citations.

*Table 2: Highest citation score by paper*

| Number | Author | Number of citations |
|---|---|---|
| **1** | Javed AR. | 268 |
| **2** | Raja Santhi A. | 132 |
| **3** | Dhirani LL. | 64 |
| **4** | Mourtzis D. | 62 |
| **5** | Kumar S. | 45 |

### 3.2 The most relevant journals

To answer RQ2, the number of published papers in specific journals is taken into consideration. Table 3 presents the most relevant journals. In the first place, there is IEEE Transactions on Consumer Electronics with 5 published papers. On the other hand, the rest of the journals – Electronics, IEEE Access, IEEE Open Journal of the Communications Society, and Sensors have the same number of published papers – 3.

*Table 3: Number of published papers per journal*

| Number | Journal | Number of published papers |
|---|---|---|
| **1** | IEEE Transactions on Consumer Electronics | 5 |
| **2** | Electronics (Switzerland) | 3 |
| **3** | IEEE Access | 3 |
| **4** | IEEE Open Journal of the Communications Society | 3 |
| **5** | Sensors | 3 |

On the other hand, it is also H-index taken into consideration. The full overview is presented in Table 4. The highest H-index is IEEE Transactions on Consumer Electronics followed by Sensors with H-index 3. The IEEE Open Journal of the Communications Society has a value of 2 for the H-index, and the Electronics (Switzerland) and IEEE Access have an H-index of 1.

Additionally, the G-index is also the highest in the case of IEEE Transactions on Consumer Electronics with a score of 5 followed by a score of 3 for Electronics (Switzerland) and Sensors/ Furthermore, the highest M-index is obligated for IEEE Transactions on Consumer Electronics and IEEE Open Journal of the Communications Society.

*Table 4: Different indexes by journals with the highest number of published papers*

| Number | Journal | H-index | G-index | M-index |
|---|---|---|---|---|
| **1** | IEEE Transactions on Consumer Electronics | 4 | 5 | 2 |
| **2** | Electronics (Switzerland) | 1 | 3 | 0.5 |
| **3** | IEEE Access | 1 | 1 | 0.5 |
| **4** | IEEE Open Journal of the Communications Society | 2 | 2 | 2 |
| **5** | Sensors | 3 | 3 | 1.5 |

### 3.3 Countries with the highest score of production

To address RQ3, Figure 1 illustrates the countries that have contributed publications in this field. India leads, followed by the USA. In third place is the UK, while Ukraine ranks fourth. Spain rounds out the top five.

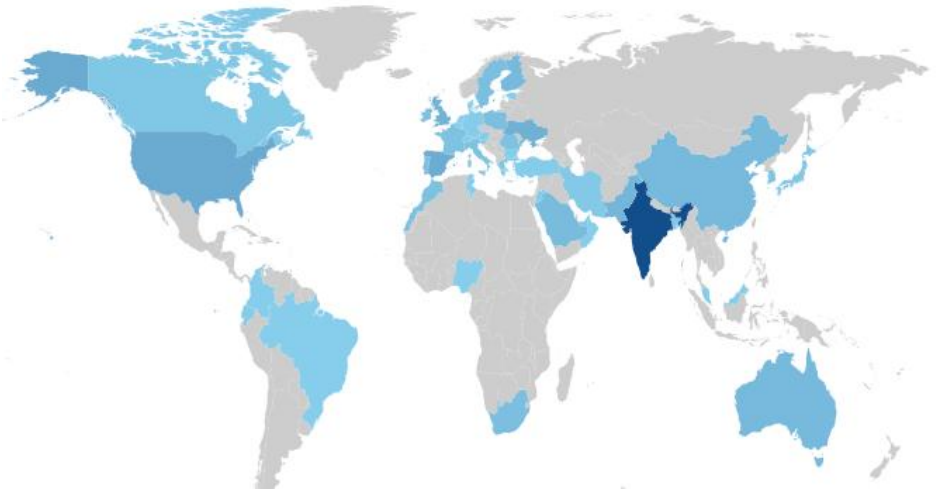

*Figure 1. Overview of published papers per country*

To take other factors into account, Table 5 provides an overview of the papers published in these countries over the past period. This result demonstrates the growing popularity of this topic in recent years. In relation to RQ3 and RQ1, there is a clear trend of expanding research in this area, particularly with the integration of cybersecurity into Industry 5.0.

*Table 5: Overview of production per country over the years*

| Year | India | UK | USA | Spain | Ukraine |
|---|---|---|---|---|---|
| **2022** | 9 | 1 | 2 | - | - |
| **2023** | 44 | 13 | 9 | 3 | 9 |
| **2024** | 76 | 16 | 21 | 20 | 17 |

Furthermore, one of the main factors that can be considered for contribution is the cite score. Table 6 presents the citation scores for the five most cited countries. Australia ranks first with 290 citations, followed by India with 186. Ireland has 72 citations, Greece 62, and the USA completes the top five with 49 citations.

Table 6: Overview of most cited countries

| Number | Country | Number of citations | Average citations |
|---|---|---|---|
| **1** | Australia | 290 | 96.7 |
| **2** | India | 186 | 15.5 |
| **3** | Ireland | 72 | 36 |
| **4** | Greece | 62 | 62 |
| **5** | USA | 49 | 16.3 |

### 3.4 The most used keywords

To identify the answer to RQ4, Figure 2 illustrates the most used keywords and the correlation between them. The most frequently used keyword is 'cybersecurity,' appearing 37 times. The second most common keyword is 'Industry 5.0,' with 27 occurrences. Additionally, the term 'Internet of Things' appears in 24 papers, followed closely by 'cyber security,' which occurs 22 times. Furthermore, the term 'network security' represents another cluster in Figure 2, with 18 occurrences, followed by 'Industry 4.0,' which appears 16 times.

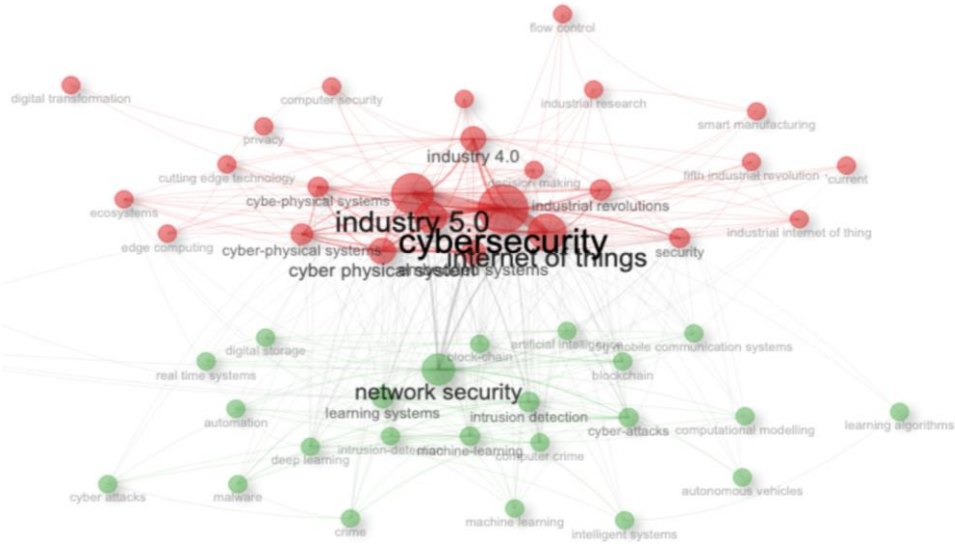


*Figure 2. Correlation between keywords*

## 3. Conclusion

This paper presents a bibliometric analysis of the development of cybersecurity within the framework of Industry 5.0. Through its approach, Industry 5.0 enhances the possibility of human interaction with the latest technologies, creating ideal conditions for the development of cybersecurity, not only for individuals but for entire industries (e.g., the automotive sector). Four research questions were proposed, and the analysis enabled the synthesis of the obtained results. Based on the results and discussion, the following conclusions were drawn:

- Interest in the development of this field has grown over the years. Regarding this trend, it can be expected to expand this field.
- The authors with the highest number of publications and citations focus on the use of blockchain and cryptographic concepts, integrating them into operations and supply chain management.

- The most frequently used keywords relate to cybersecurity and Industry 5.0, where a challenge is observed in the unification of different terms.
- The journal with the highest number of papers in relation to the number of citations is IEEE Transactions on Consumer Electronics.
- The country with the most success in this field is India, based on both the number of published papers and the number of citations.

Future research directions are expected to develop in this area, particularly in specific branches of cybersecurity (e.g., network security). The limitation of this study lies in the database used; future research offers the opportunity to expand the scope of scientific databases.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ONE SOLUTION OF LOW-COST LORA BASED IOT MODULAR CONTROL DEVICE

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***Abstract***

*This paper aims to improve a low-cost modular control device based on the IoT concept by integrating long-range LoRa communication technology. The LoRa communication technology enables the use of a modular control device in areas without implemented Internet and Wi-Fi infrastructure.*

***Key words:*** *LoRa, IoT, modular, control device.*

## 1. Introduction

The Internet of Things (IoT) is a concept that connects physical devices, objects, and systems to the Internet, allowing them to collect, exchange, and process data without the need for human intervention (Stankovski et al., 2020, 2021; Tarjan et al., 2020; Tegeltija et al., 2022, 2023). The key idea of IoT is to create a network of smart devices that can analyze and modify the collected data to optimize performance, improve efficiency, and provide users with personalized services. This includes many devices, from smartphones, sensors, home appliances, cars, and industrial equipment and infrastructure. IoT devices are equipped with processing units, sensors, actuators, and communication interfaces, which enable mutual communication and interaction with the environment via the Internet. The processor unit manages the operation of the entire IoT device. With the help of sensors, the IoT device becomes aware of its surroundings and collects data. The processing unit processes the data collected from the sensor. Based on the results of e-data processing, the IoT device influences its environment through actuators or

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forwards data to other IoT devices or systems through the communication interface. IoT has wide applications in various sectors, in industrial and non-industrial systems. In households, it enables the development of smart houses where devices such as lights, locks, and thermostats communicate with the user via applications. In agriculture, smart irrigation systems optimize water use based on weather conditions. In industry, IoT helps monitor and maintain equipment in real-time, reducing costs and increasing productivity. For the implementation of the Internet of Things concept to be possible, it is necessary to provide Internet access to every device. This is easily feasible in urban areas with a developed and implemented communication infrastructure such as Wi-Fi networks, mobile phone networks, etc. In some regions, there is no implemented communication infrastructure, or it is of poor quality.

This paper aims to improve a low-cost modular control device based on the IoT concept realized in previous research by integrating long-range LoRa communication technology. This technology enables the use of a modular control device in areas without implemented Internet and Wi-Fi infrastructure.

## 2. Proposed solution

To realize this paper, a modular control device based on the IoT concept realized in previous research was used (Tegeltija et al., 2023). This modular control device is based on the ESP32 platform (Espressif, 2024). The ESP32 platform provided several advantages. First of all, the developed device was simple. It had a large number of built-in functionalities. It can be easily programmed using the Arduino IDE development environment. Ultimately, the device's price was very low and acceptable to many users. The disadvantage of this device was that the ESP32 platform allowed connecting to the Internet only via a Wi-Fi network. This means that this modular control device requires the existence of a Wi-Fi infrastructure to communicate with other devices and systems. To eliminate this shortcoming and improve the device, the LoRa communication interface was chosen.

## 3. LoRaWAN: the possibilities of LPWAN

LPWAN (Low-Power Wide-Area Network) is a category of wireless network technologies designed for long-term IoT applications that require low power consumption and the transmission of small amounts of data over long distance (Raza et al., 2017). These technologies allow devices to be connected across wide geographic areas with minimal power requirements. They are ideal for sensors and other IoT devices that run on batteries and communicate intermittently. The application of LPWAN technology is wide and can be found in Smart City Applications, Personal loT Applications, Home Automation & Safety, Smart Grid & Smart Metering, Industrial Assets Monitoring, Logistics, Critical Infrastructure Monitoring, Agriculture and Wildlife Monitoring & Tracking (Raza et al., 2017). The key features of LPWAN are (Tarjan, Tejić, Tegeltija, et al., 2018): low power

consumption, long-range (2-20 km) low data transfer rate (in the range of a few kilobits per second), low costs (unlicensed bands). Among the most used LPWAN technologies are (Tarjan, Tejić, Dragičević, et al., 2018): LoRaWAN (Long Range Wide Area Network), Sigfox, NB-IoT (Narrowband IoT).

LoRaWAN is a network architecture that enables IoT devices to connect to the Internet or applications via LoRa infrastructure. The main purpose of this protocol is to allow the long-term operation of battery-powered devices in applications such as smart cities, asset tracking, environmental sensors, and agriculture (Adelantado et al., 2017). LoRaWAN uses a star-topology network in which devices (called nodes or end devices) communicate with gateways (base stations), and these base stations are connected to a central network server. Each LoRaWAN device communicates directly with one or more base stations, depending on the coverage, without the need to interconnect the devices (Loukil et al., 2022).

The components of the system are (Adelantado et al., 2017; LoRa Alliance, 2024):

1. End-devices: These are IoT sensors or devices that communicate via LoRa technology. These devices use LoRa modulation to transmit data to the nearest base station. Their main goal is to periodically send small amounts of data (e.g., information about temperature, location, and water level) to the network. Devices can be static (such as sensors in agriculture) or mobile (such as vehicle tracking systems).
2. Gateways: A LoRaWAN gateway or base station is a device that receives a signal from end devices via a LoRa module and forwards that data via the Internet to a network server. Gateways do not process data, they redirect the incoming signal. One base station can cover many devices and a significant area (up to several kilometers in urban areas and tens of kilometers in rural areas).
3. Network server: After the gateway receives the signal from the end devices, it forwards it to the network server. A network server processes incoming data, manages the network, forwards messages to user applications, and controls device access. It also filters multiple copies of messages from different base stations and performs data decryption.
4. Application server: After processing the data on the network server, it is sent to the application server, which provides an interface to the users for analysis and further use. The application server can be connected to software applications that control devices, perform data analysis, or automate various tasks.

LoRaWAN supports two-way communication, which means that devices can send data to the network (uplink) and receive messages from the network (downlink). This enables functions such as remote software updates, sending commands to devices, or monitoring status.

Key features of LoRaWAN (LoRa Alliance, 2024):

1. Long range: The range depends on the density of obstacles and the environment, but can be up to 5-15 km in rural areas and 2-5 km in urban areas.
2. Low power consumption: It is designed for devices with low power consumption. The devices are mostly in sleep mode and are only activated when they need to send data, allowing the batteries to last for years (often up to 10 years).
3. Use of unlicensed frequency bands: ISM bands are unlicensed and free to use, reducing operational costs. Bands vary by region, so Europe uses the 868 MHz band, while the US uses 915 MHz, and 2.4 GHz is available worldwide.
4. Adaptive Data Rate (ADR): This supports a mechanism known as ADR (Adaptive Data Rate) that automatically adjusts the data rate depending on the quality of the connection between the device and the base station. In this way, an optimal balance between range, connection stability, and energy consumption is achieved.
5. Security: LoRaWAN includes end-to-end data encryption and device authentication. There are two levels of security: network encryption, which protects the integrity and authenticity of messages between the device and the network, and Application encryption, which protects data from unauthorized access to applications.

LoRaWAN defines three classes of devices that have different operating modes to enable a balance between energy efficiency and speed of reaction to downlink messages. Class A devices have the lowest energy consumption. They support two-way communication, but can receive messages only a short time after sending an uplink message. This is the most energy-efficient class. Class B includes devices that periodically open time windows for receiving messages according to a predefined schedule, which enables more frequent downlinks. Class C devices constantly listen for incoming messages, except when sending uplink messages. Class C consumes the most energy, but provides the fastest response.
Examples of LoRaWAN applications are:

- Smart cities: Air quality monitoring, waste management, smart lighting.
- Smart farming: Monitoring soil conditions and automatic irrigation.
- Smart meters: Remote reading of water meters (**Error! Reference source not found.**), electricity meters, gas meters.
- Asset Tracking: Track vehicles, shipments, and other movable assets.

LoRaWAN operates in unlicensed ISM frequency bands (Industrial, scientific, and Medical bands) for which a license is necessary. These are different frequency bands used for wireless communication, and each has specific characteristics and uses in telecommunications (Rappaport, 2001).

ISM bands are frequency bands globally reserved for industrial, scientific, and medical purposes but are widely accepted for wireless communications in other applications as they do not require licensing. This means that any technology or

device can use those frequencies without permission or without paying spectrum usage fees (Rappaport, 2001; Tarjan, Tejić, Tegeltija. ISM bands are designed to withstand interference and different applications because they are used for different purposes.

The most commonly used ISM bands include:

- 433 MHz (in some regions)
- 868 MHz (Europe)
- 915 MHz (North America)
- 2.4 GHz (global) – used for Wi-Fi, Bluetooth, and many other wireless standards
- 5.8 GHz (used for certain industrial applications and Wi-Fi).

The advantages of ISM bands are that anyone can use them because they are free and do not require licensing, which reduces development and implementation costs. These bands, such as 2.4 GHz and 868/915 MHz, are available worldwide and are suitable for IoT, home devices, wireless sensors, industrial applications, and more.

The disadvantages of the ISM band are interference and limited range. Because these bands are license-free and open to wide use, interference often occurs, especially in densely populated areas and places with a large number of devices operating in the same bands (e.g., residential Wi-Fi networks). Compared to licensed bands, these bands, especially those at higher frequencies like 2.4 GHz, may have a shorter range and less penetration through obstacles (walls, buildings).

## Implemented solution

Communication modules from LilyGO were selected to improve the modular control device. These modules integrate the ESP32 platform and Lora communication transceivers on the same module. Depending on the LoRa frequency band they support, these communication modules come in multiple versions. To implement this solution, we used two versions of LilyGO T3 S3 modules (LilyGO, 2024). One version uses a Semtech SX1276 transceiver for operation on an 868 MHz frequency band. Other version use a Semtech SX1280 transceiver for operation on a 2.4 GHz frequency band. Figure 1 shows a modular control device with an attached LilyGO T3 S3 module with a LoRa communication module operating at 2.4 GHz. LilyGO T3 S3 modules were chosen because they have a very similar footprint to the DOIT ESP32 DevKit V1 used as a control module in the original version of the modular control device. With minor modifications (due to the different arrangement of power supply pins, digital IO pins, and pins for communication via the I2C interface), it is possible to directly install these modules as the central module of a modular control device. The basis of the control software of the central module is identical because the same development environment (Arduino IDE) is used, the only thing that needs to be added is the commands for communication via the LoRa communication interface. All this makes it possible to easily and quickly implement

the software in the central module to add the possibility of LoRa communication through the LoRa network. An additional advantage of LilyGO modules is the relatively low price.

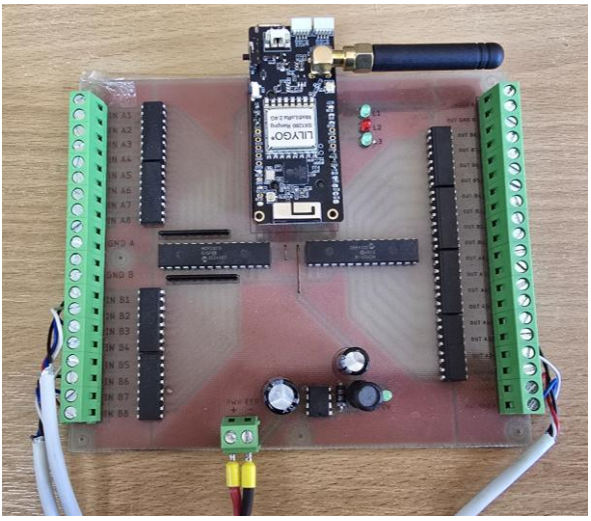

*Figure 1: Modular control device with LilyGO T3 S3 SX1280 module*

It is planned to use LilyGO T3 S3 LR1121 modules for future work because they have integrated bands of 868/915 MHz and 2.4 GHz on the same module. This would further improve the modular control device because the same communication module is used for the 868/915 MHz and 2.4 GHz bands, which increases flexibility and enables quick and easy adaptation to different LoRa networks in different regions.

## 4. Conclusion

This paper describes the proposed solution for improving the modular control device based on Internet of Things technology. The improvement has brought the possibility of communication via LoRa networks to the modular control device. Communication modules were selected to enable the improved version of the modular control device to maintain simplicity, speed of implementation, modularity, and relatively low price.

The improved version of the modular control device maintains the basic functionality that the original version had, but communication via the Lora network was added. Initial tests of communication through the Lora network gave very good results. Still, it is necessary to carry out additional research to determine the optimal communication parameters within the LoRa networks in various scenarios. Such scenarios may depend on the user's needs, such as the required range and speed of

data transmission and the different environments in which the control devices are placed (urban and rural environments, plain or mountain areas, forests, fields, etc.).

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DATA ANALYTICS CASE STUDY IN OPTIMIZING WELL WORKOVER PROCESS

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***Abstract***

*This study focuses on optimizing well workover processes in the oil and gas industry using advanced data analytics and digital tools. Data collected from the OIS Well Workover IT solution is analyzed with Python to enhance efficiency, reduce costs, and improve decision-making during workover operations. By examining planning, execution, and monitoring phases, the research identifies inefficiencies and proposes automation strategies to streamline processes. Actionable recommendations are provided to address operational challenges and enhance data quality, contributing to cost savings and optimized production. This work establishes a foundation for future research on leveraging digital solutions to promote innovation and efficiency in the oil and gas industry.*

***Key words:*** *Data analytics, Workover operations, Operational efficiency, Predictive Analytics, Oil & Gas industry*

## 1. Introduction

The oil and gas industry relies on artificial lift methods to maintain production across numerous onshore oil wells, which require regular maintenance by workover rigs (McKinney, 2022). Limited rig availability and high service demand challenge the minimization of production losses. Decisions on allocating workover rigs depend on factors such as well production, rig location, and the type of service needed.

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Efficient scheduling and management of workover operations are crucial for optimizing production and reducing downtime, but traditionally these decisions were made with incomplete information.

This study explores the optimization of workover processes through data analytics from the OIS Well Workover IT solution and Python, focusing on operational and financial data. By analyzing data from the planning, execution, and monitoring phases, the study identifies key areas for improvement and provides actionable recommendations for automation and data-driven decision-making.

The article is divided into four chapters: the introduction outlines the study's purpose; the theoretical background reviews relevant literature on workover wells, digital tools, data analytics, and data science; the third section presents the tested hypothesis and analysis results; and the conclusion summarizes findings and offers recommendations for further research.

## 2. Theoretical Background

### 2.1 Understanding Workover Operations

Workover is a term used in the oil and gas industry to describe the maintenance and repair of existing wells (Drilling manual, 2022). This process is used to restore production from a well that has decreased or stopped flowing, and it is an important part of the lifecycle of an oil or gas well. These tasks are performed using specialized equipment, such as workover rigs, and a team of skilled workers (Mendes et al., 2013). A series of activities should be followed to ensure that the company performs workover operations safely and efficiently during the planning, execution, and monitoring phases (Landgren et al., 2013).

The planning phase is crucial for the success of workover operations. It involves detailed assessment and preparation to ensure that the workover is necessary, feasible and can be conducted safely and efficiently. The realization phase involves the actual implementation of the workover plan, requiring careful coordination and management to adhere to the planned objectives, budget, and timeline. The control phase focuses on evaluating the workover operation's success, analysing outcomes, and implementing learnings for future operations (Mendes et al., 2013).

### 2.2 Digital tools, Data analytics and Data Science

The data in the oil and gas sector is one of the key components. Daily, vast amounts of data are collected every day (Tsay, 2013). Digital tools are software, applications, platforms, or systems that facilitate the execution of various tasks in a digital environment, including communication, collaboration, and problem solving (Alexander et al., 2017). Digital tools, in the way it is usually used, is a practice of analyzing large quantities of data where a comprehensive review of all transactions can be visualized including identification of anomalies (Ciric et al., 2022; Basulo-Ribeiro et al., 2023).

Data analytics can be defined as the process of analyzing raw data to identify trends and answers to questions. Advanced analytics deals with the 'What if?' question. This part of data science uses advanced tools for data extraction, making predictions and identifying trends. These tools include classical statistics, as well as machine learning (Mohammadpoor, 2021). Data Analytics competencies refer to the combination of skills, knowledge, abilities, and expertise required to effectively analyze data (Ciric et al., 2021; Bartlette, 2022; Crabtree, 2023).

Currently, the existing workflows to select workover candidates require a large amount of manual work. The workover potential is evaluated in terms of both additional production and economic profitability, for every well individually. This process is very time consuming so for determination and ranking of workover candidates, software solutions are used (Tavalli, 2018). In this case study, historical data from IT solution OIS Well Workover was used.

## 3. Case Study Insights on Workover Efficiency

This case study can be considered descriptive and explanatory. It follows quantitative approach, being implemented through observational methods. For any upstream operation, it is of vital importance to be able to run oil production at maximum safety while achieving the best financial and economic results possible. In 2018, IT solution OIS Well Workover was implemented focusing on automation of well workover process (OIS Well Workover, 2005).

For the research purposes, workover services performed in NIS j.s.c. during 2022 were selected as a sample period that included 230 workover rig activities, 221 documents with technical limits, 5.510 daily drilling report, 5.135 routing and allocation plans. The observation period covers the use of IT solution OIS Well Workover from which the data were uploaded to Python for the purpose of identifying potentials for increasing the efficiency of business processes and reducing inherent risks during workover services of oil and gas wells.

As part of case study, the following approach was applied: (1) Data were collected from of daily reports, workover rig routing and allocation plans, and workover rigs technical limits, (2) data were sorted in Python, following unique format, including data validation and verification of completeness, (3) standardized business process flow is defined as per internal procedures, key steps uploaded in Python, (4) Actual data of business process was imported into Python, forming actual business model adding further text mining and clustering of historic data and further structured, (5) Analysis was performed in Python identified potentials for optimization such as identification of gaps between standardized and actual process flow, identification of patterns and rout-cause analysis, defining potentials for process improvements (Ciric et al., 2021).

Key areas of analysis were formulated to guide case study. Key areas that were analysed based on which each potential for improvement was concluded was: (1) *Data quality* was tested through identification of mandatory field entries and real-time data validation in daily workover reports, (2) *Planning phase* of workover

operations was tested from the perspective of introduced automatic controls and restrictions comparing to technical limits of each workover rig, (3) *Routing and scheduling decisions* were tested from the perspective of logistical planning and nearest-well prioritization, (4) *Monitoring of routing and scheduling* was analysed using real-time tracking and identification of inefficient logistical movements of workover rigs comparing to wells locations, (5) *Execution* of workover operations were compared to technical limits where deviations were identified increasing risk of excessive usage or failure, (6) *Process transparency* of workover operation was analysed assessing gap between workover operations against planned objectives.

### 3.1 Case Study Key Results and Opportunities

One year of data collected and structured from IT solution OIS Well Workover were used to identify alternative and more effective scenarios of business process workflow and further areas for automation. Results are structured in 6 segments where the potential for optimization is identified including development of dashboard for the purpose of easy configuration, alerting functionality with the capability of defining meaningful and complex real-time alarms, and automated processes combined with easy-to-analyze visualizations proved valuable and resulted in enhanced decision-making (Meinlschmidt, 2018).

### 3.2 Data Quality Improvement

Data quality deficiencies in daily reports were identified such as blank daily reports, incorrect data formatting, recorded time without a date of execution, daily reports without a workover plan (0.3% of all daily reports), no objectives or type of workover operations defined.

Potentials for future improvement are focused on implementing automatic controls for key data entries, or by incorporating double- check procedures in order to enhance the accuracy, completeness, timeliness, and consistency of data ensuring its suitability for further use.

### 3.3 Optimizing Planning Phase Efficiency Relative to Technical Constraints

In the framework of the developed analysis, a total of 5.135 scheduling plans were analyzed, 65.036 operations were recorded in the works plans, out of which 21.407 were unique operation types. During the analysis, it was identified 2 .456 operations (3.8%), which exceed the maximum of technical limits for planned workovers, 24.661 operations (37.9%) that cannot accurately be compared to technical limits and 37.919 operations (58.3%) that correspond to technical limits for planned workover operations.

Potentials for improvement are identified in enabling software functionalities to enable automated controls and prevent the planning of workover operations that exceed technical limits, ensuring activities are kept within acceptable levels.

### 3.4 Streamlining Routing and Scheduling of Workover Rig Units

Analyzing the planning of routing of workover rig units for the period 2022 following statistics have been identified: 2 cases when the same workover rig crew should move to 2 different wells on the same day, 9 duplicated activities in planning the daily workover report and 9 cases of incorrect date entries, where relocation start date was later then workover completion date.

Potentials for improvement are identified in implementation and enabling automated controls in planning schedule to prevent assigning a single rig to two different locations within the same time period, enable system functionality for determining the nearest well where maintenance is needed, including defining moving dates and enable system functionality to guide and plan logistics when moving equipment and crew members.

### 3.5 Dashboard Reporting for Workover Rig Routing and Scheduling

As part of a case study where low efficiency was tested related to routing and scheduling of workover equipment, few standard dashboards are created in Python in order to identify and control the occurrence of such situations. In total, as part of the logistical planning of the workover rig allocations, the most common overlapping has been identified in 2 oil fields, where intersections/overlap movements were identified for following rigs – B-5, T-4, T-2, T-1.

Potentials for improvement are identified in implementation of dashboards that can be used to identify inefficient routing and scheduling of workover rigs.

### 3.6 Efficiency Gains During the Execution Phase of Workover Operations

As part of the execution phase, a total of 5.150 daily reports were analyzed, 65,391 operations were recorded in the daily reports, out of which 36.984 were unique executed operations. Applying detailed analysis in Python, it was identified: 827 operations (1.3%), exceeding the maximum of technical limits for workover execution, 25.378 operations (38.8%), could not be correlated to technical limits and 39.186 operations (59.9%), corresponding to the technical limits for workover execution.

Potentials for improvement are identified in enabling software functionalities by enabling additional fields for comparison with the plan, enabling automatic control of operations length.

### 3.7 Enhancing the Reporting Process

The analysis of daily reports and workover schedules identified 21,407 unique planned and 36,984 execution types of workover operations. High variability of used terms is creating difficulties in assessing deviations from the plan both in terms of schedule and efficiency and makes it nontransparent.

Future improvement can be achieved by implementing standardized types of workover operation categories, including introducing additional fields for different

intervention types to increase the quality of monitoring over the planning and execution of operations. Taking into consideration all potentials for increase in process efficiency, overall internal assessment was performed considering usage percentage of each OIS well workover module, were the following percentage of use of available functionalities were identified: Candidate well selection module (17%), Maintenance candidate distribution module (67%), Workover candidate distribution modeling (67%), Work document module (43%), Workover control module (38%), Workover reporting module (13%), Monitoring of activities module (not implemented), Routing and scheduling module (57%), Report on interventions module (50%), Evaluation module (not implemented).

Future improvement can be achieved by implementing all the functionalities of the IT solution OIS Well Workover for all phases of the workover process focusing on further automation including standardization of operation categories, monitoring deviations of key indicators including development of appropriate dashboards, and standardization through electronic documentation workflow.

## 4. Conclusion

The integration of advanced analytics and digital technologies in workover operations marks a transformative shift in the oil and gas industry, significantly enhancing operational efficiency and optimizing production. By analyzing well candidates across the portfolio and proposing economically viable interventions, companies can optimize oil production with maximum safety and financial returns. Automating manual tasks allows engineers to focus on higher-value activities, fostering innovation during planning and execution stages (Dakovic et al., 2020).

The comprehensive functionalities of the OIS Well Workover solution promise substantial improvements in operational efficiency and a reduction in human errors, leading to smarter intervention strategies through automation and advanced data analytics. Enabling software functionalities and standardizing reporting will support economic production gains while considering operational constraints. Through standardized, automated software that captures best practices from past interventions, companies can maximize asset potential (Popara et al., 2023).

This research focuses on the OIS Well Workover digital solution in the oil and gas industry. The findings can inform future research by addressing limitations in planning and execution, such as minimizing rig movement costs, accounting for technical constraints, and fostering innovative business practices to achieve strategic goals.

Future research opportunities include consolidating data from field development and well operations to account for uncertainty, integrating rig scheduling with operational decisions, and extending analysis to include detailed performance indicators and benchmarks.

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# SMART GRID AND CHALLENGES OF GRID SUPPORT BY E-MOBILITY

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***Abstract***

*This paper explores the role of electric vehicles (EVs) as new grid elements, focusing on the technological and legislative prerequisites necessary for their optimal integration. The widespread adoption of renewable energy sources (RESs) introduces significant unpredictability in energy generation and uncertainty regarding grid capacity to accommodate RES electricity. This necessitates a paradigm shift in network planning to effectively manage these uncertainties. A smart grid (SG) integrates the actions of generators, consumers, and prosumers, relying on advanced metering infrastructures (AMI), two-way communication (such as PLC), advanced energy storage (ES) solutions, data management, big data analytics, and cyber-physical security. These technologies, particularly ES systems, are essential for the effective operation of EVs as new network entities. SG planners face numerous challenges, including establishing criteria for the design and construction of charging stations (CSs) and addressing various legal aspects. This paper also examines modern trends in this field and the impact of traffic electrification on ageing distribution networks (DNs). Are e-vehicles exclusively compatible with smart grids?*

***Key words:*** *Smart Grid, e-vehicle, e-storage systems, AMI*

## 1. Introduction

Recent years have seen a power system paradigm shift. In order to cut carbon dioxide emissions, more and more RESs have been integrated into the grid. This significantly changes the system topology from top to bottom, moving it from the concept of several large production units connected to the towards a decentralized structure with numerous distributed RE generators (DG). This new system structure poses challenges to network stability, not only due to the two-way flow of electricity

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but also due to the volatile nature of weather-dependent RES. To address these challenges, smart information and communication technology (ICT) devices are being introduced to automatically monitor and control the power system, which, in conceptual terms, constitutes a SG (Malla&others, 2022). Both power and ICT systems are part of the national critical infrastructure and therefore require to be designed as resilient systems. The term "resilience" can be defined as the ability of a system to "anticipate, absorb and quickly recover from an external high-impact low-probability shock" (Parol&others, 2022).

The integration of data block chain technology into electricity networks makes electricity networks smart and enables their decentralisation. The role of EV as a e-storage network element in SG will be discussed here. Several categories of importance will be defined in the continuation of the paper, highlighting the challenges of implementation in ageing distribution grids.

### 1.1 Smart Grid concept

A SG is an electricity grid that integrates the behaviours and actions of all users connected to it entities (Fig. 1), namely three types of users: generators that produce electricity, consumers who consume electricity, and those who do both, i.e., prosumers. Together, these entities create a peer-to-peer network to ensure efficient electricity distribution, low losses and a high quality and security of electricity supply (European Technology Platform, 2010)1.

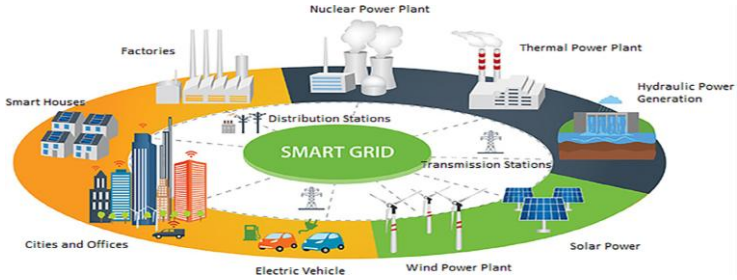


*Figure 3: Smart grid concept2*

The peer-to-peer network eliminates intermediaries in trade between trusted entities, giving buyers and sellers the freedom of preference, choice and price. A smart network is expected to be able to solve more complex problems more effectively and securely, through intelligent monitoring, control, communication and self-healing technology3. One of the challenges in the SG deployment is how to support a communication infrastructure consisting of millions of entities (EVs are one of them) operating and trading in a single market. Energy traceability is also becoming a serious issue. Blockchain data was also used to optimise energy

1 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0202:FIN:EN:PDF
2 https://www.eolasmagazine.ie/smart-grid-evolution
3 https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group3_first_year_report.pdf

transactions in μGs. In this case, a green certificate is used, which attests that the energy was produced from RES.

### 1.2 Microgrid arhitecture

Microgrids (μGs) consist of various DERs, reactive loads, and critical loads (Fig. 2). They connect to the utility power system through a point of common coupling (PCC). Whether operating in grid-connected or islanding mode, each DG unit is linked to the grid via power interface electronics enabling effective control, measurement, protection, and reconnection of the unit after shutdowns. In grid-connected mode, a μG can exchange surplus energy with the power system. If a power failure occurs, the μG seamlessly transitions to islanding mode to maintain stability for the area it serves. This ensures a continuous supply to critical loads through efficient integration of DGs and load management, which may include load shedding based on predefined protocols. Central μG controllers and local controllers manage this operation.

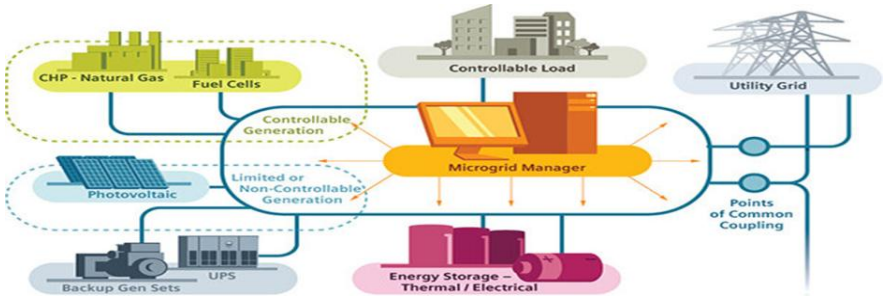


*Figure 4: Microgrid architecture1*

Effective control and coordination of DG within μGs significantly enhance system performance and support sustainable development. As awareness of climate change and socio-economic development grows, μGs are increasingly integrating sustainable energy plants, RES, and energy-efficient technologies that convert waste into energy. Numerous papers emphasize the importance of sustainable energy systems for effective energy management in μGs (Zahraoui&others, 2021, Thirunavukkarasu&others, 2022, Ahmad&others, 2023). Microgrids can be classified based on several criteria: (1) Type of Current, (2) Level of Centralization, (3) Mode of Operation, (4) Number of Phases, (5) Purpose of Utilization, etc.

### 1.3 Electric Vehicle and μG

When grid-connected, EVs can offer a cost-effective solution for electricity storage. Their batteries can be utilized in several ways:

[1] http://content.icicidirect.com/mailimages/Microgrids.htm

- Vehicle-to-Grid (V2G): This technology allows energy from an EV battery to be returned to the grid, enabling charging or discharging based on predefined signals.
- Vehicle-to-Everything (V2X): This encompasses various applications, including "vehicle-to-home" (V2H), "vehicle-to-building" (V2B), and V2G, depending on where the electricity from EV batteries is utilized.

Smart charging technology (CT) facilitates controlled management of EV charging, allowing stored energy to be fed back into the grid to balance production and consumption mismatches.

By 2040, the number of passenger EVs on the road is projected to reach 730 million, with annual lithium-ion battery demand rapidly increasing to approximately 5.7 TWh by 2035 and a cumulative total of 244 TWh by 2050. V2G technology could play a significant role in peak load management. In Germany, if 100% of EVs were V2G-enabled, they could provide 300% more power than the current estimated peak level. Even with just 25% of EVs participating in V2G and 50% availability, they could contribute 40% of the estimated peak load1. With battery storage capacities ranging from 30 to 200 kWh (depending on vehicle size and range of 200 to 700 km), managing tens of TWh of storage capacity becomes essential. Additionally, with charging capacities between 3 to 20 kW, a 0.5 MW PV power plant in an average-sized parking lot could store energy in several EVs, which is typical for such facilities.

When integrated into a μG, excess electricity generated from a RES can be stored in EV batteries, providing an efficient alternative to external ESSs. As the use of RES increases, the power system may become more unstable, necessitating new solutions for energy balancing and storage. Utilizing EV batteries can address this challenge. Traditionally, network balancing relies on rapid adjustments in generator output. However, power regulation can also be achieved through network load management. This approach is particularly effective when inverters are integrated into every photovoltaic (PV) system, allowing for quick responses to maintain system stability. However, the high charger power and the grid challenges that arise during the charging process should be taken into account. The massive presence of EVs will have a dramatic impact on DN's performance if the plan-based sustainable implementation of CSs is absent (particularly relevant for ageing DNs).

## 2. Impact of EV batteries on network operation for different network loads

EVs and their CSs are becoming integral components of DNs. Most EV batteries are charged during daily off-peak periods when electricity demand is lower. However, some EVs may need to be charged during peak electricity price periods.

[1] Electric Vehicle Outlook 2023, BloombergNEF https://about.bnef.com/electric-vehicle-outlook/

To facilitate rapid charging, high-power chargers exceeding several hundred kWs are often required. This level of power cannot typically be supplied solely from the grid, making it essential to source energy from RES as well. Additionally, utilizing power from EV batteries themselves can be a viable solution. A third option is prompt power supply, though network capacity limitations may arise due to potential congestion. EVs play a crucial role in grid stability, especially during power deficits, as they can provide electricity at the point of consumption. When connected to the grid, an EV's battery can serve as a power source. As more EVs are charged at home or through company-provided or public chargers, they could become significant power sources during short emergency periods when grid power is scarce.

V2G technology allows EV batteries to draw energy from the grid when prices are low and supply it back when prices are high. This capability transforms each EV owner into an energy service provider during battery-to-grid interactions. Furthermore, EV owners can use their EV's battery to power their homes during peak pricing periods, avoiding costly grid energy. Depending on the battery type, the stored energy may be sufficient to power a household for several hours.

As the EV fleet continues to grow, the implications of off-peak battery charging become increasingly significant, potentially leading to rising energy prices during traditional off-peak times. The increasing number of EVs may also drive down costs for "smart" chargers and battery systems, including reductions in system management and grid integration expenses.

### 2.1 Charging stations for electric vehicles

EV CSs can be designed as energy facilities connected to the existing DN, integrated into a μG within a larger SG, or operate autonomously using RES like solar power. Each configuration has its own advantages and disadvantages for both the CS and the network operator. The growing demand for faster charging and increased energy supply to EV's batteries presents significant challenges. This demand accelerates the expansion of charging infrastructure while placing additional strain on the connected network. Achieving this with minimal energy loss and maximum efficiency is crucial for profitability. RES-based CSs, when part of a SG and integrated into a μG, can lower operating and charging costs, reduce GHG emissions, and enhance network performance while enabling new services. μGs that utilize PV energy connect to EV CSs through power converters, allowing the use of renewable energy without storage. However, PV energy is intermittent and requires regulation through the network resources of the connected μG.

There are two types of EV chargers:

- On-board chargers: Built into the EV, these chargers connect directly to an AC outlet, converting AC power to DC for the battery. They have limited power and longer charging times.

- Off-board chargers: These chargers convert AC to DC at the CS, providing high DC power directly to the vehicle's battery. They are more robust, enabling rapid charging and supporting V2G technology.

Despite the advantages of off-board chargers, a significant portion of energy consumed by EV CSs still comes from fossil fuels or conventional hydropower. Therefore, developing EV charging systems in conjunction with RES is environmentally beneficial. However, integrating CSs with PV systems requires substantial space for PV panel installation, often in combination with wind power plants (WPPs, especially vertical WPPs) within a μG.

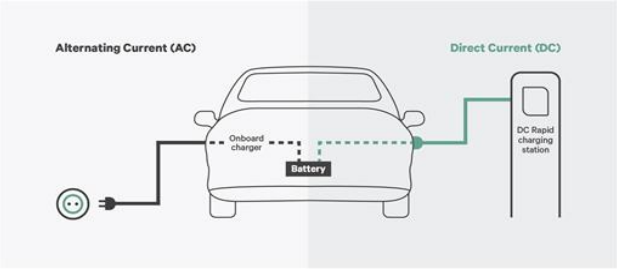


*Figure 5 On-board and off-board chargers – symbolic presentation1*

## 3. Establishment of EV charging infrastructure

To ensure the sustainability of the EV CS system, it is crucial to meet two key criteria: establishing legal regulations and defining spatial positioning and design standards. The architecture of the CS, along with the choice of power source and operational mode (isolated or grid-connected), significantly impacts battery sizing, project costs, and overall performance. When planning the construction of a CS, the following factors must be considered:

1. CT and Connection: Evaluate the CT, EV connection method, operational mode.
2. Rated Power and Supply Method: Determine the rated power of the CS and how it will be supplied with energy.
3. Standards Compliance: Adhere to standards for connecting charging cords, cables, and connectors to maximize performance.
4. Charger Cost and Performance: Understand that the cost and performance of a charger depend on the semiconductor devices used and its topology, which influence the choice and size of the charging system.
5. RES: RES-based CSs can significantly reduce environmental impact and highlight the benefits of RES generation. When connected to a μG, these stations enhance stability and, when paired with batteries, can serve as ES solutions.

Following these factors, the EV CSs design and functionality can be optimized.

[1] https://wallbox.com/en_catalog/faqs-difference-ac-dc

### 3.1 The establishment of entities and regulation of the EV charging market

The legislation in this area should encompass the following key roles:

- Charge Point Operator (CPO): CPOs are responsible for building and maintaining EV CSs. They install hardware from various EV power equipment suppliers and ensure the ongoing efficiency of charging operations. CPOs provide the essential charging network infrastructure and facilitate the connection between the charger and the EV.

- E-mobility Service Provider (EMSP): EMSPs utilize the services of CPOs to manage relationships with EV owners. Their operations heavily rely on CPOs, particularly for real-time system monitoring, control, and customer support.

- Marketplace Operator (MO): MOs play a crucial role in the e-mobility market, facilitating transactions and interactions between CPOs, EMSPs, and EV users.

Together, CPOs and EMSPs are vital participants in the evolving e-mobility landscape, ensuring a seamless charging experience for EV users.

### 3.2 EV charger station location and power optimisation

To determine the best location for a CS certain research must be conducted. Choosing the ideal location is crucial to maximizing the performance of the CS for an expected number of EVs. Several factors influence the placement of CSs, including customer satisfaction. Other important factors concern EV charging demand, characteristics of charging devices, charging fee policy and electricity costs, costs of CS installation, operation, maintenance and land purchase, controlling the duration of the charging process and determining the type of charger or battery replacement options, and some other factors (Abraham&others, 2021).

For CSs location optimization, sophisticated multi-criteria decision-making methods such as MCDM, VIKOR, PROMETHEE, or a combination of these are often necessary (Morocho-Chicaiza&others, 2024).

### 3.3 EV charging infrastructure in an ageing distribution network (DN)

An ageing DN is characterised by several decades of under-investment, a capacity deficit and high levels of energy inefficiency and carbon intensity. Its low-voltage (LV) substations are designed to supply 150 to 300 consumers, with an average connection power of about 15-20 kW three-phase and about 5 to 7 kW single-phase. In the Western Balkans region, the development of these networks has been going on since the end of World War II, throughout the period of greater or lesser investment. The typical transformer (TR) power in urban area is 400kVA (much less in rural). Assuming a typical EV battery power of 10 kV and a household connection load of 10 kV, can be analyzed two scenarios: one without grid-connected EVs and one with them. In the scenario where one in four consumers purchases an EV and charges it at home, with a load simultaneity factor of 0.3, the results are presented (Tab. 1). The increase in EV connections is akin to a rise in consumer demand, leading to evident TR overloads in the EV context. The use of a home peak controller is a palliative solution, as they continuously keep the peak load

close to the maximum. This directly can affects the dramatic increase in the simultaneity factor. In the EVs scenario, the load increases by approximately 12%. This is a highly optimistic outcome. In this simplified example, the optimistic outcome is based on favorable assumptions. However, reality is far more complex and nuanced.

*Table 7. Transformer load in two scenarios*

| scenario | TR power (kWA) | number of customers | average customer load (kW) | load simultaneity factor | TR simultaneity power (kW) |
|---|---|---|---|---|---|
| without EVs | 400 | 120 | 10 | 0.3 | 360 |
| | 630 | 200 | 10 | 0.3 | 600 |
| with EVs | 400 | 150 | 10 | 0.3 | 450 |
| | 630 | 250 | 10 | 0.3 | 750 |

However, it's important to note that the power of EV batteries is significantly greater, and ultra-fast chargers operate at power levels comparable to MV/LV TRs. The impact will remain the same, whether the CS charges the EV batteries directly or the empty ones are swapped for full ones when the EV arrives. In the second case, the waiting time is only shortened. Previous analysis of network models including high EV charging demands is essential. Specialized software like SINCAL, DIgSILENT, MATLAB, etc., can be used for network modeling.

Additionally, not having an AMI is the serious obstacle to the implementation of V2G and all other services related to RES and ES. That's why a massive rollout of AMI is the first and mandatory step for any ageing network.

## 4. Conclusions

Insufficient EV charging infrastructure poses a significant barrier to the growth of e-mobility. To overcome this challenge, it's essential to break the existing vicious cycle[1].

To address the urgent need for shorter charging times and the installation of ultra-fast chargers with high power output, it's essential to go beyond relying solely on the existing network. Only RES-based CS can support EV charging effectively. Upgrading the current network to accommodate the growing power demands of chargers is a lengthy process. Additionally, EV's batteries represent a significant potential for ES. Comprehensive legislation is needed to regulate this sector, alongside the development of sustainable design principles, site selection, and operational strategies for these systems. Grid support can be essential to address the potential operational limitations of RES.

Effective planning is essential for transitioning from a traditional DN to one that includes a high presence of EVs. This requires a multi-sectoral approach to identify key corridors for future CSs, involving transportation, tourism, energy,

[1] https://eur-lex.europa.eu/eli/dir/2014/94/oj, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52023SC0088

agriculture, and spatial planning. Additionally, regulations should be prepared and adopted to recognize new entities in the electricity market related to e-mobility. These regulations include technical guidelines and methodologies regarding several sectors, and the spatial planning sector is no less important than the energy sector. MCDM can help overcome challenges and reconcile many existing and sometimes conflicting interests. Finally, promoting the use of EVs and implementing sustainable measures will further encourage the shift toward e-mobility.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DIGITAL TRANSFORMATION STRATEGY DYNAMIC FOR UTILITY SMART GRIDS: SYSTEM DYNAMICS MODELLING IN UNTANGLING COMPLEXITY

*Minja Bolesnikov*[1] *[0000-0003-3735-602X]*, *Himadri Banerji*[2] *[0000-0002-2896-7219]*

***Abstract***

*This paper explores System Dynamics Modeling (SDM) as a tool for addressing the complexities of large-scale systems, focusing on the digital transformation (DT) of the electricity utility industry and the rise of smart grids. While DT is widely recognized for its strategic significance, current research lacks methodologies to help business strategists manage its complexity over time. This paper fills that gap by demonstrating how SDM offers a structured approach to strategy design and long-term planning. Smart grids, driven by technological innovation and shifting consumer needs, pose significant challenges for policymakers and utility managers. Their interconnected nature, characterized by feedback loops, creates a socio-technical system that requires careful management. However, SDM provides a beacon of hope, helping stakeholders navigate this complexity by allowing them to simulate system behaviors, test interventions, and design strategies to address key issues such as grid stability, energy management, and consumer engagement. This research introduces a system dynamics model for utility smart grids, breaking the system into twelve submodels. This decomposition method not only makes large-scale systems more manageable but also fosters a collaborative modeling approach. By simulating policy interventions, stakeholders gain critical insights to support informed decision-making in innovative grid development. This approach emphasizes the shared responsibility in managing large-scale systems, promoting a collaborative and inclusive process. The study highlights that SDM and decomposition techniques are both academic and practical tools for improving complex systems' strategic planning and policy design. The paper concludes by identifying future research opportunities in strategic modeling using SDM, particularly in longitudinal studies in utilities.*

***Key words****: digital transformation, longitudinal research, dynamic modeling, feedback loops, system dynamics, smart grids, grid stability,*

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*energy management, customer engagement, large-scale systems, decomposition techniques, policy design.*

## 1. Introduction

Digital transformation (DT) is essential for modern businesses, driven by technological progress and evolving consumer behaviors. However, many organizations face difficulties executing effective DT strategies due to the complexity and absence of practical methodologies. Despite the significance of DT governance, there is a notable lack of longitudinal studies that model the long-term dynamics of DT, which complicates future planning. System Dynamics Modeling (SDM) is proposed as a valuable tool for addressing these challenges, particularly in large-scale systems like the transition to smart grids in the electricity sector. Smart grids pose unique challenges—such as grid stability and energy optimization—and SDM aids in simulating policy interventions, understanding feedback loops, and supporting strategic planning.

We propose a decomposition approach to building a system dynamics model tailored to utility smart grids, improving understanding by breaking down the system systematically. This method, as introduced by Chiriac et al. (2011), divides complex systems into major components and then into smaller parts, enabling comprehensive strategy development (Ledet and Himmelblau, 1970). Our approach identifies twelve submodels to capture the smart grid's complexity. The paper further details the construction of a Causal Loop Diagram (CLD), a key element in developing a robust system dynamics model (Binder et al., 2004).

## 2. Literature Review

Research indicates that nearly 30 percent of digital transformation efforts fail, even among Fortune 500 firms (Siebel, 2017). This failure is often due to managers not recognizing that DT requires a holistic strategy involving the organization's internal and external environments, including employees, resources, customers, suppliers, regulators, and the government. Digital transformation (DT) signifies organizational change influenced by widespread digital technology diffusion, encompassing broader organizational change. Insights from scholars suggest organizational designs must adjust dynamically to their environments, introducing the idea of a "malleable firm" (Hanelt et al., 2021). However, DT processes result from converging organizational, technological, and environmental forces within digital business ecosystems ((Bharadwaj et al., 2013)). Systems theory emphasizes that DT involves organizational design and interactions with customers, regulators, and platforms. Systems theory and system dynamics highlight that changes in one area can impact the entire system ((Fowler, 2003)). Key feedback loops in DT include the interaction between technology organizations and society, addressing significant social and ethical issues that can drive the creation of responsible technologies (Kutzschenbach, 2017). DT involves complex

technological, organizational, and cultural changes, understood through system theory and system dynamics. Scholars can use these frameworks to study DT's dynamic changes within organizations and industries. Smart meters symbolize DT by providing real-time energy consumption insights, empowering consumers, and enhancing grid management through data analytics and AI. (Alotaibi et al., 2020). Regulatory frameworks have supported digital transformation initiatives in the electricity sector, promoting renewable energy adoption and emissions reduction. The sector's transformation showcases its adaptability and innovation. Future trends will focus on energy storage, electric vehicles, and microgrid technologies. (Matallana et al., 2019). The transition towards smart grids involves fundamental changes in the electricity industry's operating model, integrating technologies for more efficient energy allocation. (Pereira et al., 2018) and aiming for sustainability and energy efficiency (Światowiec-Szczepańska and Stępień, 2022), adapting to market dynamics, technological innovations, and regulatory requirements to enhance operational efficiency and meet evolving consumer needs (Gebauer et al., 2014).

## 3. Decomposition of Large-Scale System

As stated earlier, our Smart Grid model will consist of twelve subsystems, as shown in Table 1.

*Table 1: Twelve sub-systems of the Smart Grid System in a Utility*

| | |
|---|---|
| 1. Energy Efficiency (EE) and Peak Demand Management Model:<br>2. Stability vs Sustainability sub-model (Described in this paper as Microgrid DER Model<br>3. Market Dynamics Sub-Model: Examines supply, demand, and competition. (Comprises of Stocks: Energy Demand, Energy Supply, Market Prices Flows: Energy Production, Consumption, Price Adjustments<br>Rates: Demand Growth Rate, Supply Growth Rate, Price Change Rate<br>Feedback Loops: Positive between Demand and Price; Negative between Price and Consumption) | 4. Regulatory and Policy Sub-Model: Considers regulatory environment and policies<br>5. Cybersecurity Sub-Model:<br>6. Renewable Energy Integration and Sustainability Sub-Model:<br>7. Digital Resources Sub-Model:<br>8. Utility, Customer, and Societal Benefit Model:<br>9. Energy Conservation<br>10. Modelling Customer Response to Smart Grids (Described in this paper as customer response to HEQ submodel)<br>11. Modeling Cost Benefits Analysis and Investment Returns:<br>12. Infrastructure Development Sub-Model: Focuses on developing transmission lines and substations. |

### 3.1 Modeling A Microgrid using System Dynamics Modelling

Considering limitations in space and time, in this paper, we have showcased the development of a causal loop diagram (CLD) for a specific subsystem, the Micro Grid, in conjunction with Customer Engagement in a Utility employing Vensim. We have illustrated the process of visually defining stocks, flows, feedback loops, and delays, showcasing their interconnectedness to depict the system's dynamics. In the following sections, we describe the remaining sub-models and list the variables, stocks, flows, feedback loops, delays, etc. This will aid utility executives in relating to their work. A microgrid is a network of interconnected loads and distributed energy resources (DER) that function as a single controllable entity relative to the primary grid. It can operate in grid-connected and island modes, thus enhancing customer reliability and resilience to grid disturbances. Due to their intermittent generation patterns, the increasing integration of distributed renewable energy and storage represents a challenge. Microgrids face stability, power electronics, safety, communication, and energy management challenges, underscoring the need for robust control and Energy Management System (EMS) strategies to handle fluctuations. A system dynamics model can help understand the complex interactions within a microgrid affected by DER integration. This model encompasses various stocks, flows, and rates that govern these interactions, including delays that represent the system's response time to changes in DER penetration and generation/consumption dynamics. To effectively model DER penetration impacts using system dynamics, it is necessary to identify stocks and flows, pinpoint feedback loops, as detailed below in Table 2. and build causal loop diagrams (CLD) to incorporate these elements. This will offer insights into the microgrid's operation under varying conditions.

*Table 2. Stocks, Flows, Rates, Delays, Feedback Loops or Dynamic Modelling*

| 1. Stocks and Variables | 2. Micro Grid DER Model: Flows and Rates |
|---|---|
| *Stability Index* | *Power Generated by Distributed Resources* |
| *System Inertia* | *Power Consumed by End Users* |
| *System Stability* | *Power Flow to/from the Grid* |
| *Intermittency factor* | *Energy Storage* |
| *Renewable Generation Capacity* | *Coal Generation Capacity Addition rates* |
| *Hydrogen capacity* | *Nuclear Power Addition Rates* |
| *Nuclear Capacity* | *Hydro Addition rates* |
| *Coal Capacity* | *RES Addition rates* |
| *Sustainability Index* | *Smart Meter Addition rate* |
| *Battery Storage Capacity* | *Economic Activity Rate (GDP)* |
| *Gas Generation Capacity* | *Demand Growth Rate* |
| *CO2 Emission* | *High-efficiency equipment purchasing rate* |
| *High-Efficiency Equipment* | *Customer Engagement Rate* |
| *Population* | *Rate of Change of Stability Index* |
| *High Efficiency Equipment* | *Rate of Change of Population* |
| *Availability* | 5. Micro Grid DER Model: Stochastic Process |
| *High Efficiency Equipment Price* | *Intermittencies:* |

| | |
|---|---|
| *Smart Meter Population*<br>*Customer Intervention*<br>*Customer Utility Co-Creation Index*<br>*Demand Side Management Index*<br>*Proportion of Dynamic Tariff Population*<br>*Economic Activity*<br>*Customer Demand*<br><br>3. Microgrid DER Model Units for Stocks and Variables:<br><br>*Energy Storage Capacity: Megawatt-hours (MWh)*<br>*Stability Index of the Microgrid: Unitless*<br>*Safety and Protection Index: Unitless*<br>*Energy Management System Performance: Unitless*<br><br>4. Microgrid DER Model Units (Rates and Delays)<br><br>*DER Penetration Rate: Percentage per period (%/year)*<br>*Power Fluctuations Rate: Kilowatts per period (kW/year)*<br>*Power Generation: Kilowatts per period (kW/year)*<br>*Consumption Rate: Kilowatts per period (kW/year)*<br>*Stability Index Factor Unitless*<br>*Delays: Response Time to Power Fluctuations:*<br>*Time (minutes, hours)* | *Intermittencies associated with DERs can be represented as a stochastic process that affects the power generation flow. For example, you can model the probability distribution of power generation levels from DERs over time based on historical data or predictive algorithms. Incorporate this intermittency factor using stochastic methods into the power generated by distributed resource flow. This will affect the overall power balance in the*<br>6. Micro Grid DER Model: Feed Back Loops<br>*Positive Feedback Loop: Increased penetration of DERs leads to lower system Inertia, which degrades the stability index. This prompts more investments in stability measures like storage batteries and grid enhancement, further increasing the stability index.*<br><br>*Negative Feedback Loop: Fluctuations in power generation from DERs during weather-induced intermittencies trigger actions from the energy management system to balance supply and demand for stabilizing the microgrid and increasing reliance on external grid support from fossil fuels, reducing sustainability index.*<br><br>7. Micro Grid DER Model: Mitigation Strategies:<br>We are implementing advanced energy storage systems to buffer fluctuations in power generation.<br>We are enhancing power electronic interfaces to improve efficiency and accommodate variable generation from DERs.<br><br>We are strengthening safety and protection systems to ensure grid stability and prevent equipment damage.<br>We are improving communication systems for real-time monitoring and control of distributed resources. We optimize energy management algorithms to effectively balance supply and demand in response to intermittencies. We are Enhancing the grid infrastructure.<br>Moreover, it added more nuclear capacity. |

## 5. Results

The decomposition of large-scale systems in conjunction with system dynamics modeling is a valuable tool for strategic design in digital transformation.

Decomposition techniques play a vital role in addressing the intricacies of large-scale systems. Decomposition simplifies the overall synthesis and design process by breaking it down into smaller, more manageable sub-problems and eases the challenge of integrating subsystems. One of the core issues in complex systems integration arises from the involvement of multidisciplinary teams, each operating with different expertise and often using incompatible tools. Decomposition techniques facilitate cross-disciplinary collaboration, enabling the seamless integration of various subsystems while allowing teams to focus on their specific areas without losing sight of the larger system goals. Organizing the system into smaller, focused parts makes it easier to manage complexities and achieve a cohesive design for innovative smart grid solutions.

Next, we illustrate how a causal loop diagram (CLD) for the microgrid is developed using Vensim to study the impact of distributed energy resource growth on the stability of the grid supply.

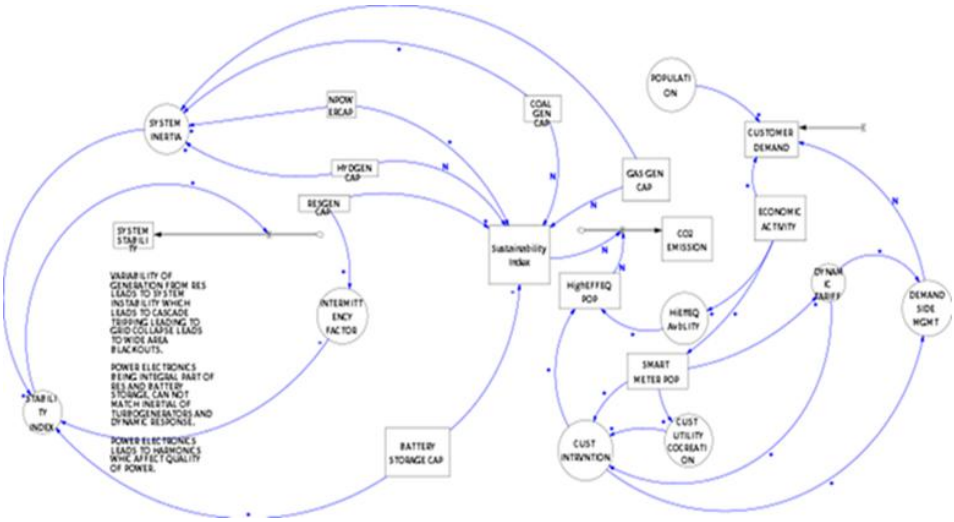


*Figure 1: Causal Loop Diagram, the first step in developing a system dynamic model*

The Goal of the Smart Grid Strategy is accentuated in a pilot-scale Micro-Grid Model, whose CLD is shown in Figure 1.

**The model's goal is to meet a targeted 'Sustainability Index' defined by Climate Change Goals, keeping in view a desired 'Stability Index' for the power supply determined by the Regulator to assure customers of a reliable Power Supply.**

From the preliminary analysis and study of the CLD, the positive and negative loops in a power grid and any growth of renewable energy sources comprising mainly static equipment reduce system inertia. In contrast, fossil-powered power generation, mainly comprised of sizeable rotating equipment, positively contributes to system inertia, providing a reserve in case of any disturbances when a generating system goes out of action. Hence, to maintain balance, we will need a stabilizing loop. Thus, while renewable energy sources like wind and solar are considered "unlimited" in the long term, there is a technical limit to how much renewable energy can be integrated into a grid before impacting stability due to their intermittent nature. This requires additional grid infrastructure and energy storage solutions to manage fluctuations in supply and maintain a balanced grid. Besides, since the smart grid is bidirectional, a safety and protection loop must be juxtaposed with the stability loop.

The customer behavior loop shows that the availability of HEQ (High-Efficiency Equipment) has positive feedback on customers' Purchases of HEQs, thus increasing the population of HEQs, which has positive feedback on the sustainability index. Customer Demand is influenced by both the population and the economic activity index. However, the utilities lack customer-friendly applications that help them reduce their bills or improve their safety applications with intelligent meters, resulting in a decaying loop and a loss of customer motivation.

## 6. Proposed Future Course of Research

This study is a broad exploratory study that shows the use of decomposition techniques in analyzing large complex systems using system dynamics modeling and feedback loops. The author is working on the development of the complete system dynamics model as a part of future research, and the steps that must follow are as follows,

- Develop the Stock and Flow Diagram
- Parameter Estimation
- Develop the validation against real-world data.
- Use simulation to assess policy effectiveness.

This sequence of steps must be followed for the 12 subsystems defined by earlier decomposition analysis and a unified system dynamics model developed.

Future research must focus on developing indices like the stability or sustainability indices, which involve defining objectives, selecting indicators, fixing metrics, weighing them, collecting data, normalizing data, aggregating scores, benchmarking, validating, communicating, and improving the index.

## 7. Conclusions

By following this outline defined in the paper using the decomposition technique for large-scale systems and system dynamics modeling, future researchers can develop a robust System Dynamics model that enhances understanding of digital transformation strategies in utilities and captures the intricate feedback loops and time-dependent behaviors inherent in these systems. System Dynamics modeling allows for the simulation of various strategic interventions over extended periods, providing invaluable insights into the long-term impacts and potential unintended consequences of different policies. This dynamic approach enables utilities to test and refine their strategies iteratively, ensuring more resilient and adaptive decision-making frameworks grounded in comprehensive, data-driven analysis.

Dynamic modeling is particularly significant for longitudinal studies of smart meter and smart grid strategies, as it enables a deeper understanding of the time-based processes that shape adoption and development across regions. Our research applies system dynamics modeling to explore why countries like Italy and Finland have outperformed others like Germany in embracing smart meters and grids. Italy, for example, achieved a 94% smart meter penetration rate by 2018, while Finland reached full deployment by 2014. In contrast, Germany has lagged, with only about 15% penetration by 2021, illustrating the complexity of strategic decision-making and its outcomes. The significance of our work lies in uncovering the dynamic factors behind these performance differences. My research leverages system dynamics to develop behavioral theories that explain the evolution of smart grid strategies by focusing on the managerial decisions that influence technology adoption over time. System dynamics is uniquely positioned to address gaps where traditional strategic approaches have struggled, particularly in understanding feedback loops, delays, and tipping points that drive long-term change. Our contribution adds a dynamic dimension to strategy research, helping to provide more effective tools for utilities and policymakers to navigate the complexities of smart grid transformation." Ultimately, System Dynamics becomes a powerful tool for shaping sustainable, efficient, and customer-centric utility transformations.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CURRENT LANDSCAPE AND CHALLENGES: PRODUCT DEVELOPMENT OF ELECTRIC SCOOTERS IN INDIA

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***Abstract***

*Electric Vehicles have been on the roads in India for more than a decade. The issue of urban traffic congestion, pollution, and energy imports has made it imperative to take strong measures to adopt green technologies. India has very large homegrown automotive OEMs and also Multinational companies from developed countries. The ecosystem for automotive manufacturing is one of the largest in the globe. This paper provides an in-depth analysis of the current landscape and challenges surrounding the product development of electric bikes in India. The Electric Vehicle in India has come a long way encouraged by policies, local design and manufacturing capabilities, and adoption by consumers. The analysis covers the strength of Indian product development capabilities, Manufacturing ecosystem, Services industries, and policy implementations. The presence of charging infrastructure and the importance of the same is studied. Insights from industry stakeholders, government policies, and consumers, this study identifies critical gaps in the product development process. A comprehensive assessment of the current status and challenges in electric scooter product development is developed with an aim to inform policymakers, industry stakeholders, and researchers about the opportunities and roadblocks in advancing green transportation solutions in India. The goal of this research would be to identify the gaps which exist to make India a product development capability centre.*

***Key words:*** *Electric Vehicles (EV), Urban Traffic Congestion Pollution consequences. Charging Infrastructure, Industry Stakeholders*

## 1. Introduction

Electric vehicles (EVs) represent a burgeoning market globally, driven by sustainability initiatives and technological advancements. Despite India's efforts to increase the adoption of EVs, particularly electric scooters, the country continues to

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rely heavily on imports, particularly from neighbouring China. This reliance underscores the need for a deeper understanding of the challenges and barriers hindering India's ability to indigenously design, develop, and manufacture electric scooters.

Through this research, India's transition from a service-oriented economy to an indigenous product innovation powerhouse is envisioned with a focus on electric scooters. By synthesizing insights from academia and industry, this study offers practical recommendations for policymakers, industry stakeholders, and researchers alike, paving the way for India's emergence as a global leader in product development.

## 2. Challenges and Opportunities

There are lot of factors that are contributing to the adoption of Electric Vehicles and especially Electric Scooter as depicted in Figure 1.0.

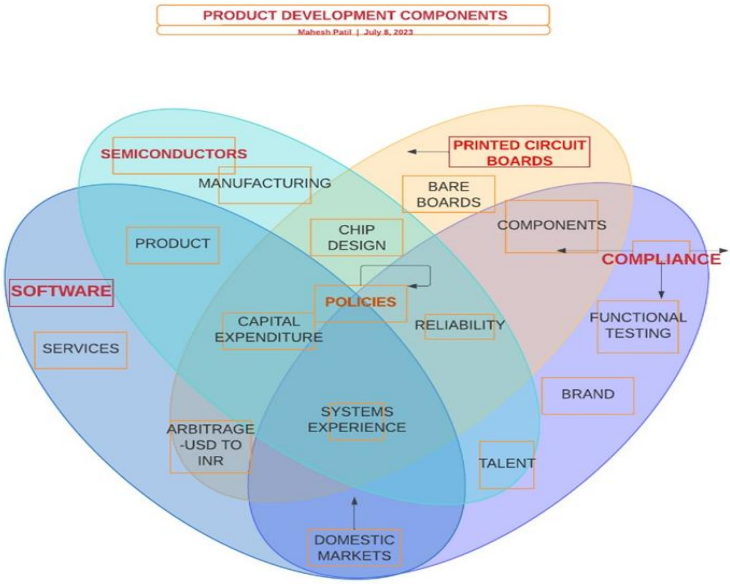


*Figure 1: Factors affecting adoption of Electric Scooters*

*(Source: Author)*

They comprise of Push factors like Regulations and incentives, Technology advancements, Infrastructure and Pull factor like reducing Battery prices. The Electric Scooter is an ecosystem comprising of Printed Circuit boards, Electric motors and Drives, Software, Semiconductors and other components.

At the same time the adoption and feasibility of electric scooters is based on the Supply Chain economics, Manufacturing and economies of scale, Regulations and other external influences.

**2.1 Electric Scooter:**

The Electric Scooter is explained below in the block diagram Figure 2.0 . The key components of Battery, electronics associated with the Battery and motor form the system.

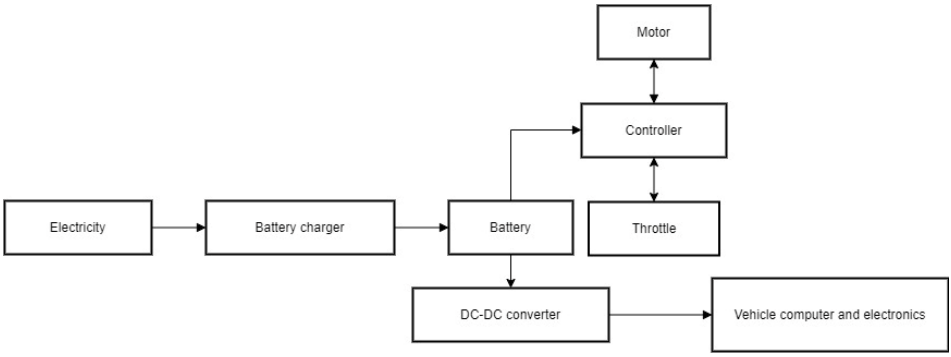


*Figure 2: The key components of Electric Vehicle (Powertrain)*
*(Source:-Prof. Mahesh S. Khande et al May 2020)*

The EV scooter with the integration of electronics, software, motor and other typical automotive parts is a challenge to be built in India even when there lies huge expertise over the decades in parts manufacturing.

The recent going back and forth on the Faster adoption and manufacturing of EV's FAME policy after more than 5 years of implementation and now linking EV growth framework to the Production linked innovation scheme points out to the inconsistency in policy frameworks in India for product building.

The rare earth material like Neodymium is available in large deposits in China and a few other countries. With China needs to take care of its domestic needs, it is imperative for other countries to ensure a reliable supply chain.

The battery cost is approximately 42-46% of the vehicle cost and this is primarily due to the import cost as Lithium is a natural resource with limited availability globally.

Also, Electric Vehicles require a good charging infrastructure and that also means 24X7 availability of Electric Power.

The ecosystem of the Electric Scooter is depicted below in Figure 3.0.

Overall, the literature underscores the importance of addressing range anxiety, expanding charging infrastructure, advancing battery technology, and implementing viable business models to support the widespread adoption of EVs and the alleviation of dependency on Chinese imports.

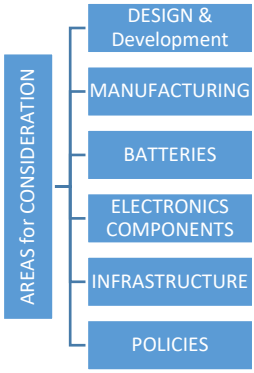


*Figure 3: Electric Scooter Ecosystem Lifecycle Elements (Source: Author)*

## 3. Methodology

The research attempts to understand India's electric scooter industry, aiming to understand the ecosystem, capabilities, barriers that define its present state and create a roadmap to achieve leadership status. With a clear focus on establishing a baseline understanding of competency levels vis-à-vis China, the research sets out to meticulously examine various dimensions of electric scooter development. A mixed methodology of qualitative and quantitative research was carried out.

The qualitative analysis was a major part of the research and the quantitative will focus on the cost factors of EV bikes in India compared to China, Trend in battery costs, and charging infrastructure availability expressed in terms of Vehicle to charger ratios. The qualitative analysis was a semi-structured discussion to elicit the responses to the questions for the study. The participants were EV users and industry experts. There were interviews with industry experts in this domain. The interviewees were entrepreneurs. Senior executives in the marketing and technology functions, design development engineers, suppliers of components, and policymakers.

Quantitative research on the EV ecosystem in India and China involved collecting secondary data from government reports, industry publications, and academic studies. This data was used to calculate the vehicle-to-charger ratio, revealing insights into the availability of charging infrastructure relative to EV populations in each country. Additionally, advancements in battery technology, such as energy density and cost per kWh, were analyzed to compare adoption and innovation trends. The total cost of ownership (TCO) for EVs, encompassing purchase price, charging, maintenance, and government incentives, was also assessed to evaluate affordability and economic feasibility in both markets.

### 3.1 Research Questions

The research addressed the following questions which helped achieve the objectives of understanding the barriers, baseline and understanding the status of the Electric Scooter lifecycle and develop a comprehensive Framework. A mixed methodology of qualitative and quantitative research was carried out.

1. What are the existing strengths and weaknesses in India's product development ecosystem, particularly concerning electric scooters?
2. What specific challenges and barriers exist in developing electric scooters in India, and how do they compare to successful models like those in China?
3. What policies, infrastructure improvements, and industry initiatives are needed to overcome these challenges and position India as a leader in electric scooter manufacturing?
4. How can India leverage its talent pool, manufacturing capabilities, and technological expertise to compete globally in the electric scooter market?

## 4. Results and Analysis

The primary instrument utilized for collecting data from EV users was a carefully crafted survey, designed and administered through SurveyMonkey, a widely used online survey platform known for its user-friendly interface and robust data management capabilities.

### 4.1 Qualitative Findings

The survey findings offer valuable insights into the preferences, behaviors, and perceptions of EV users, highlighting patterns and trends in EV usage across different demographic groups and geographic locations.

The survey instrument was thoughtfully developed to cover a range of pertinent topics related to EV usage, including driving habits, charging preferences, satisfaction levels, and perceptions of EV technology. Through SurveyMonkey's intuitive survey creation tools, a structured questionnaire comprising both closed ended and open ended questions was administered.

Additionally, interviews were conducted with senior personnel within the EV industry to gain expert insights and nuanced perspectives on key issues. The interview protocol, also developed, served as the guiding instrument for these discussions. It outlined a series of questions aimed at eliciting in depth responses regarding present competencies, barriers, challenges, and future outlooks.

SurveyMonkey as the digital platform for survey administration and data collection, a wide audience of EV users across diverse geographic locations were leveraged efficiently and effectively. In this study conducted early 2024 , a total of 110 participants took part in the survey, representing a diverse range of cities and users of electric vehicles (EVs). This broad sampling approach allows for insights

from a wide demographic and geographic spectrum, enhancing the richness and depth of the data collected.

| Category | Concern/Statistic | Percentage (%) |
|---|---|---|
| Costs of Ownership | Initial cost affordable | 58.18 |
| | Overall satisfaction (including maintenance, charging, etc.) | 59.6 |
| | High initial cost | 62.73 |
| | Concerns about battery life | 60 |
| | Desire for longer battery life | 50.91 |
| | Interest in lower cost of ownership | 48.18 |
| Charging Issues | Limited range per charge | 47 |
| | Need for increased charging infrastructure | 46.36 |
| | Importance of range | 39.81 |
| | Concerns about charging time | 36.11 |

Based on the interviews, below is the summary of the research objective questions.

**Baseline Competency Levels:**

Largely India has a design competency in power train design and also mechanicals. The experience in product development needs to be developed as the electric scooter is a nascent industry compared to China. Also manufacturing competency and scale is the concern.

**Barriers to Indigenous Development:**

The barriers are largely the availability of lithium-ion, and rare earth magnets as raw materials and Semiconductors for product development. Also, the charging infrastructure is a concern along with the policy ambiguity. The funding is largely available for large production houses but does not encourage Research and development.

**Comprehensive Framework Development**

The framework for indigenous leadership has to be based on supply chain risk alleviation through innovation, alternate materials, product development intellectual property. Focus on costs and hence make the EV available cheaper, build charging infrastructure, and collaborate between startups and large corporations. Also educating the population and building reliable safe vehicles are important. Policies favoring the retail segment, startups, and R&D funding will help.

### 4.2 Quantitative Findings

The quantitative research process provided valuable insights into the vehicle-to-charger ratio, battery technology advancements, and TCO of EVs in India and China, shedding light on the respective developments and challenges in the EV ecosystems of both countries.

*Table 1: Specific Metrics for Quantitative analysis*

| Category | Metrics | Indicators |
|---|---|---|
| **Product Development Capability** | Annual EV numbers in India vs. China | Comparative EV growth in both countries |
| **Charging Infrastructure** | Charging stations and vehicle numbers | Vehicle-to-charger ratio |
| **Lithium Material Availability & Battery Technology** | YOY lithium battery cost and density | Cost per kWh, YOY density increase |
| **Total Cost of Ownership** | Cost of 2W, 3W, and 4W in India vs. ICE | Ownership cost (capital + operational), |

China's EV market is substantially larger than India's. By 2023, China had over 20 million EVs on the road, whereas India had around 3 million EVs.

In India, the vehicle-to-charger ratio has shown fluctuations over the years, with improvements observed from 2018 to 2022 before a slight increase in 2023. The ratio ranged from 149 to 248 EVs per public charger by 2023.In contrast, China has maintained a relatively stable vehicle-to-charger ratio, ranging from 6 to 9 over the years.

The cost of battery storage (USD/KWH) has shown a significant decline over the years, from 780 in 2013 to 139 in 2023. There's an indication of a continuous decrease in cost, with fluctuations in the percentage decrease. Energy density (Watt hr/litre) has generally increased from 140 in 2013 to 693 in 2023, with fluctuations along the way.

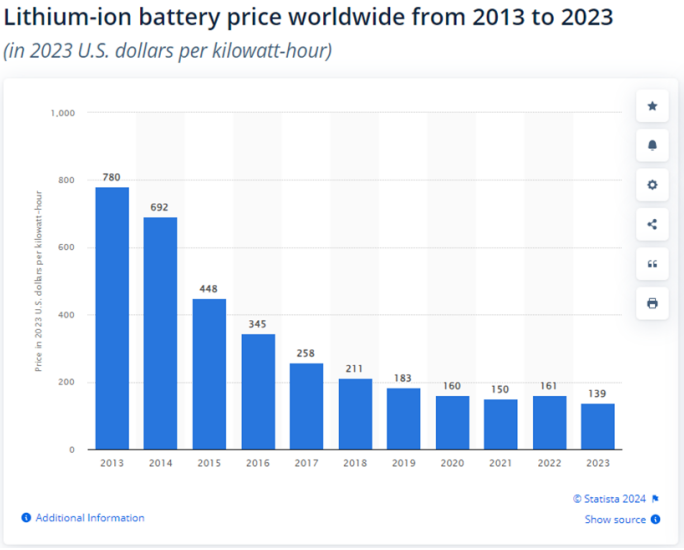


*Figure 4 Lithium-ion battery price worldwide from 2013 to 2023 (Source: https://www.statista.com/statistics/883118/global-lithium-ion-battery-pack-costs)*

For 2-wheelers and 3-wheelers, TCO parity already exists. A large part of the Indian population looks for low upfront costs and ease of maintenance which includes charging infrastructure and fast charging times, while for 4-wheelers, it's expected to be achieved beyond 2025. The increase in demand in all segments will cater to economies of scale.

## 5. Conclusion and Recommendations

The research is focused on the electric scooter industry in India, aiming to evaluate its current state, identify barriers for indigenous development, and develop a comprehensive framework for advancement

The implications of the research findings and proposed framework for the electric scooter industry in India are multifaceted and far-reaching:

1. Policy Reforms: The development of supportive regulations that incentivize domestic manufacturing, investment in infrastructure, and technological innovation must be prioritized.

2. Investment and Financing: Policymakers and financial institutions must get together to provide financial incentives, subsidies, and loans to electric scooter manufacturers, startups and also the consumers through banking institutions. Cost of Capital should be lowered for EV users of 4 wheelers.

3. Infrastructure Development: Governments, along with private sector partners, should prioritize investment in charging infrastructure and the establishment of integrated EV clusters at all major hubs like petrol stations, hotels, Malls, and other clusters.
4. Research and Development: Universities, research organizations, and corporations must collaborate to develop specialized skills in power train, battery technology, and software development. Collaboration and Partnerships: Companies should explore opportunities for mergers and acquisitions (M&A), joint ventures, and technology partnerships to access resources, expertise, and technologies.

By focusing on the identified challenges and leveraging the opportunities presented, India can achieve leadership status in electric mobility, driving innovation, Technology Leadership, economic development, and environmental sustainability.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-084 Review paper

# IMPACT OF GLOBALIZATION ON THE PERFORMANCE OF MEDIA SYSTEMS AND MEDIA

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***Abstract***

*Globalisation is the characteristic of the 21st century, and it is a notion used to describe changes in society, culture and global economy which lead to a dramatic increase of the international exchange in trade, culture, people, and ideas. Globalization affects all aspects of society, from the economy, through culture, to the media.This paper is concerned with the impact of the globalisation on the performaces of media systems and media. However, most media today are digitalised, and digitalisation is a process of transformation of one object, picture, sound, document or a signal (usually an analogue one) into digital. It is emphasised that media are intermediaries in the transmission of information between those who disseminate it (e.g., governments, corporations, multinational corporations...) and the end users, or, the population as the recipients of the information. However, media, apart from being intermediaries of information, can also create different media content, and that way significantly impact the countries' population views. This paper will present a part of a research related to the performances of media systems through the example of one media company in Serbia, and it is expected that the answers will be provided on how and in what way media content are susceptible to global influence. Therefore, this analysis is expected to lead to findings on how globalisation influences the following performances of media systems: financial, operative, employees' performances, and development performances.*

***Key words****: globalisation, media, digitalisation, performances.*

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# 1. Introduction

With the advent of the Internet, media around the world have become connected, and today information can be transmitted all over the planet in just a few minutes. Therefore, scientists increasingly use the term globalization, which implies something global, world-wide, something that does not know the borders of countries and regions. Although there is no single definition of globalization, most theoreticians emphasize that it is a process of political, social, economic and cultural action, which transcends the borders of countries and strives to unify the entire planet. "Globalization refers to the fact that we increasingly live in one world, in which our actions have consequences for others, and world problems have consequences for ourselves. Globalization today affects the lives of people in all countries, rich and poor, bringing changes not only to global systems, but also to everyday life." (Giddans, 1998).

If we look historically, television made a significant step forward when it comes to electronic media, and until today it holds a high ranking place as a means of informing citizens. The famous American journalist, writer, critic and essayist, Dwight McDonald said: "Television is a product of the mass needs of our time." Television is a discovery of the 20th century, but the first attempts to transmit static images (phototelegraphy) and then live images (telecoscopy) are much older. After numerous attempts by many scientists and constructors, the history of civilization assumes that the Scottish engineer John Logie Bear was the first to succeed in this. On April 25, 1925, he managed to transfer a picture of a doll with the help of his assistant William Tayton from the attic of the house where he lived to the store on the ground floor. The technique was based on a signal recorded on an Edison record, and the machine used to record was called the phonoscope. In 1927, the American Philo Fansfort succeeded in perfecting the cathode ray tube (kinescope), which forms the basis of the TV receiver, and thanks to him, on April 7, image transmission was realized at a much greater distance from Washington to New York. The first regular television program began broadcasting on November 2, 1936 in England (this is an unprecedented standard when it comes to BBC television). The first professional demonstration of television in Serbia was organized in September 1938 at the Belgrade Fair, with the engagement of local actors and singers to perform the program. The development of television in our country was slowed down by the Second World War, and only after reconstruction and economic recovery could one think of introducing television. The first step is symbolically linked to the centenary of the birth of Nikola Tesla, one of the founders of radio broadcasting in the world. On this occasion, in July 1956, a television program was broadcast at the Technical High School in Belgrade as part of the exhibition of radio amateurs of Yugoslavia. In February 1958, Radio Belgrade grew into Radio-television Belgrade. (https://edukacija.rs/poslovne- vestine/marketing/vrste-i-karakteristike-medija, 10.08.2024.)

Television, although a relatively young medium, has undergone a significant transformation since its inception until today. From the moment when we had

black-and-white images and static frames, where sound and image were recorded separately, and then combined by editing, to today when high-performance mobile phones can be used to re1cord reports and make live broadcasts from various parts of the world, all thanks to the Internet and digitization. However, that is not the end, because television develops every day with the development of digital solutions, which means that today it is closely related to information technologies.

## 2. Media Performances

All media have a need to analyze performance indicators, so in this paper we will use the famous Balance Scorecard approach (BSC) on the example of the Public Media Institution, Radio Television of Vojvodina (JMU RTV). Norton and Kaplan (the creators of the balance sheet) divided the organization's goals into four parts:

- Finances – financial goal of the organization,
- User – goals concerning users who use the organization's products or services,
- Processes – goals that concern the processes themselves within the organization and
- Knowledge and development - goals that concern people within the organization, ie. learning and raising the quality, competence and abilities of employees. (https://project-management-srbija.com/strategijski-menadzment-balansna-karta, 01.08.2024.)

Based on all of the above, we can point out that the performance of media systems can be divided into four groups, which are as follows:

1. Financial performance (includes indicators such as income, profit, etc.)
2. Operational performance (includes the satisfaction of service users, i.e. viewers or readers)
3. Employee performance (describe employee satisfaction and morale, employee productivity, motivation, earnings, etc.)
4. Development performance (includes investments in research and development, increase in viewership, etc.)

Radio-television of Vojvodina is a provincial public media service formed by the Law on Media Services with a clearly defined role and position, which are essentially determined by programs in Serbian and the languages of the national communities living in the territory of Vojvodina. In 2023, Radio-television of Vojvodina performed its role through seven registered media service providers: two television, three radio programs, internet radio and the website of the multimedia portal at www.rtv.rs, adhering to the highest professional standards. Among its most important tasks in 2023, RTV had the production of its own program of all genres, both in Serbian and in the languages of the national communities, for the most broadly defined audience on all grounds: age, gender, religion, nationality, education, professional, social or whatever which other, satisfying the interests of the public at all levels. Vojvodina Radio and Television paid special attention to the

position and activities of registered religious communities in order to spread intercultural and interreligious tolerance. By doing so, she contributed to the development and preservation of Serbian cultural and national identity, as well as multi-ethics, that is, to the development and preservation of the cultural and national identity of the national communities living on the territory of Vojvodina. In 2023, RTV's operations were financed from the following sources:

- RTV fees,
- the budget of the Republic of Serbia,
- commercial income,
- donation from republican and provincial administrative bodies,
- other revenues determined by the Statute of the Public Media Service (funds of international organizations).

Based on the above, the financial performance of JMU Radio Television of Vojvodina includes the indicators of the financial report, regarding income, expenses and actual profit/loss. We will focus on the following table:

*Table 1: Presentation of income and expenses of JMU RTV for 2023 and 2022 (in thousands of dinars)*

| | **2023. year** | **2022. year** |
|---|---|---|
| **Total income** | 3.642.035 | 3.537.373 |
| **Total expenditure** | 3.614.881 | 3.419.610 |
| **Net gain** | 25.665 | 106.955 |

From the official report of JMU RTV, we see that the result of operations for the year 2023 was expressed in the form of a profit in the amount of 25,665 thousand dinars, compared to a profit of 106,955 thousand dinars, which was reported in the operation in 2022, which as a conclusion states that the financial performance of RTV should be significantly improved, that is, it should be enabled to generate higher revenues in the coming period, so that its operations would be more successful. When it comes to operational performance, it can be concluded from the report that the viewership of RTV slightly increased compared to the previous year, but that it is necessary to produce more attractive media content in order to survive in the battle for viewership. When we look at the performance of employees, we see from the report that JMU RTV on 12/31/2023. has a total of 1,231 employees, of which 1,072 (87.08%) are permanent employees and 159 (12.92%) are permanent employees. A big disadvantage is precisely the work of people for an indefinite period of time, so it is recommended to managers to employ these people as soon as possible in a permanent employment relationship, in order to improve their status and increase their motivation to work. Also, one of the main shortcomings is the low wages of employees, which on average in 2023 amounted to 81,875 dinars. Therefore, the recommendation to the management would be to increase earnings, at the expense of reducing costs in business. RTV has an organizational unit, the Department of Program and Audience Public Opinion Research, which deals with research into TV viewership and Radio listening. Special

importance is given to development in terms of technical and technological progress (construction and equipping of a modern RTV home). The report states the continuation of the investment - equipping the new office building of RTV, investing in tangible and intangible assets of RTV and its development, efficient investment in technical and production equipment for the production of programs with the function of use in current and future conditions. Which means that the development performance of the observed television JMU RTV Vojvodina has a good perspective, that is, additional work is needed on the realization of these planned activities. After the performance analysis of the media systems of the Public Media Institution Radio Television of Vojvodina, we can conclude that it is a provincial public service that has an excessive number of employees, whose finances are not at the best level and that requires organizational, financial and technological transformation. If we consider that more than 2,500 media outlets operate in Serbia alone, then it is quite clear what a difficult market game JMU RTV is playing. However, what is not stated in the business report is precisely the way news is created. From the conducted anonymous survey of the editors at JMU RTV, we obtained the information that more than 57% of the news in the centrally informative broadcasts is obtained from foreign agencies (mostly Reuters, over 80%), which means that world media agencies, by marketing the news, significantly influence the performance of media systems around the world. Therefore, the influence of globalization on the formation of media content is enormous, and modern technology contributes to the rapid spread of news and information on the planet. If it is taken into account that JMU RTV is subject to the influence of global news and content, it can be inferred that other media houses are under the same, and perhaps stronger, influence of globalization and digitization.

## 3. Digitalization and its Impact on the Media

With the fourth industrial revolution, digitization is becoming the main catalyst for innovation, modernization, economic growth, competitiveness and comprehensive socio-economic progress and development. (https://www.ite.gov.rs/tekst/sr/4287/srbija-digitalizuje.php, 29.07.2024.) Digitization is the process of converting an object, image, sound, document or signal (usually analog) into digital form. The result of this process is a digital object, ie. a digital image for an object, or a digital form for a signal. Literally speaking, digitization is the recording of an analog signal in digital form. Which would mean for the document that the image of the object follows the visual identity, frames and structure of the object itself. (https://sr.wikipedia.org/wiki/Digitalizacija#cite_ref-2, 02.07.2024.) The best representation of the digitization of our country will be given in the following table:

*Table 2. How many households in Serbia have high-speed internet?*

| Internet | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|
| City | 66,8% | 67,5% | 77,9% | 85,6% | 87,0% | 85,6% | 87,6% | 88,9% |
| Village | 44,0% | 52,3% | 63,5% | 69,5% | 70,1% | 74,5% | 75,8% | 79,8% |

From this table, we can see that the percentage of households that use high-speed Internet both in the village and in the city is constantly increasing, and if this trend continues, in just a few years we will have literally the entire population using the Internet, and therefore, they will be informed through it. The Office of the Government of Serbia for Information Technologies and e-Administration recently announced at a press conference that the number of Serbian citizens who have an account on the e-Administration portal has increased to 2.2 million, which speaks in favor of the fact that information literacy is increasingly developed and that everyone has it. a larger number of people.

*Table 3. How many households in Serbia have digital devices?*

| Device | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|
| Personal computer | 65,8% | 68,1% | 72,1% | 73,1% | 74,3% | 76,7% | 77,0% | 75,9% |
| Mobile phone | 90,2% | 90,5% | 93,0% | 93,7% | 94,1% | 94,6% | 95,0% | 94,4% |
| Laptop | 39,2% | 43,7% | 47,6% | 49,0% | 52,3% | 53,9% | 56,1% | 55,0% |

From the second table, we see that the number of households in our country that use a computer, mobile phone or laptop is increasing, but that the number of those who have a phone is almost 95 percent, which means that digitization has achieved its mission, and that there is almost no human which is not used by some of the digital devices. According to data for 2023, 56 percent of European Union residents aged 16 to 74 have at least basic digital skills, it was concluded based on information on the use of information and communication technologies. The Netherlands has the highest percentage of people with basic digital skills (83%), followed by Finland (82%) and Denmark (70%). In Romania, that percentage is the lowest - 28 percent, followed by Bulgaria (36%) and Poland (44%). In Montenegro, 52% of citizens have basic digital skills, while data for other countries in the region are not available. The goal of the European Union is that by 2030, 80 percent of EU citizens aged 16 to 74 have at least basic digital skills. In Serbia, almost 90 percent of citizens use the Internet for private purposes, which is almost 2.5 times more than in 2010 (38%). 85 percent of households in Serbia have access to the Internet. Almost all residents of Luxembourg, the Netherlands and Denmark use the Internet, while this percentage is the lowest in Bulgaria (80%), Croatia (83%) and Greece (86%). At the EU level, 92% of citizens use the Internet, compared to 67% in 2010. Luxembourg and the Netherlands are also in first place for the percentage of households with internet access (99%), while Greece (87%), Bulgaria and Lithuania (89%) are at the bottom of the list. Nine out of 10 users in the European Union accessed the Internet via a mobile phone, 63 percent used laptops or tablets, and 31 percent used desktop computers. In Serbia, mobile phones are also the most used

for Internet access (81%), followed by laptops and tablets (41%) and desktop computers (39%). Users in Serbia as well as in the EU use the Internet mostly for phone calls, video calls and instant messages (84 percent in Serbia, 82 percent in the EU), then for online learning (27 percent in Serbia, 31 percent in the EU), and the least for civic and political participation (three percent in Serbia, 18 percent in the EU). ( https://www.nin.rs/drustvo/vesti/42385/trecina-gradana-srbije-ima-osnovne-digitalne-vestine-skoro-90-odsto-koristi-internet, 09.08.2024.)

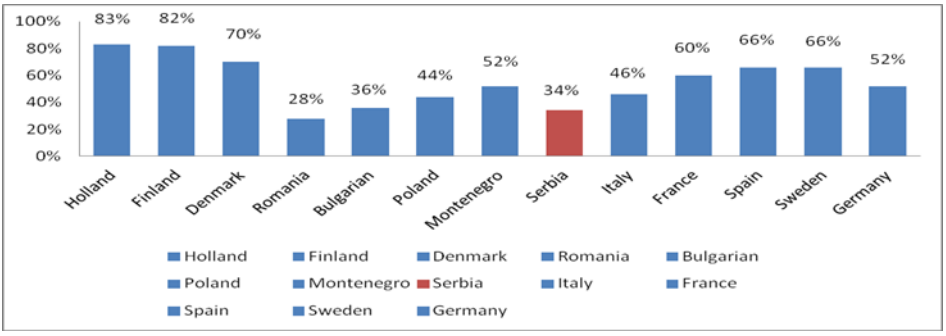


*Figure 1. Percentage of citizens with digital skills in Europe*

From the above, we see that numerous European countries have significantly improved the digital skills of their population, which implicitly affects their way of informing and accessing information. By way of comparison, Serbia, with around 34% of citizens with digital skills, and the Netherlands, with as many as 83% of digitally literate citizens, differ greatly. First of all, the Netherlands has a stronger and more developed economy, and one of the reasons for that is certainly the application of digitization and the realization of savings. Therefore, we must emulate the developed European countries. With the increase in the number of people who have digital skills, the world is becoming a global village, where everyone has the ability to connect via the Internet, and the media is enabled to exchange content and information. Therefore, information about global events "sweeps" us every day.

## 4. Conclusion

Based on this work, we can conclude that media performances and media are strongly influenced by globalization, through digital devices, i.e. digitization. Also, information technologies make a strong contribution to the development and dissemination of global news, and the world's major media agencies greatly influence the creation of news in the media around the world. Also, the data we obtained in this paper show that the percentage of the population that uses digital tools and is computer literate is growing rapidly, and digital media are the future. However, large and complex media systems, such as the Public Media Institution Radio Television of Vojvodina, are gradually losing the race on the market, and it is necessary to reorganize it, reduce the number of employees and, of course, focus on

the production of more attractive media content. This work also showed us how quickly the number of digitally literate people in our country is increasing, and we can conclude that the Internet is one of the strongest tools in advertising. Print media is the source of information for a decreasing number of people, television maintains a dominant influence among the older population, while young people and middle-aged people are focused on information via the Internet. All this indicates that with the advent of digitalization, editors working in the media are greatly influenced by global news and events, which we see in an increasing number of reports. It is necessary to continue research in the direction of the impact of globalization on media performance, focusing on the Internet.

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# BRIDGING KNOWLEDGE, PROTECTION AND DEVELOPMENT GAPS THROUGH AN INTERDISCIPLINARY MULTI-STAKEHOLDER APPROACH TO NATURAL HAZARDS RISK MANAGEMENT

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***Abstract***

*The escalation of climate-induced disasters underscores how climatic variability has become a main question in designing risk-sensitive policies in advanced and developing countries. The macroeconomic implications of Natural Hazards (NHs) are extremely significant as they can compromise financial stability and long-term prosperity. To mitigate risks and close the knowledge, protection and development gaps can free resources speeding up reconstruction of infrastructures, recovering from disruption of supply chains, returning to pre-disaster levels of activities. This is not a simple task involving different steps of a "ladder approach" sharing the burden of cost and responsibilities across the relevant stakeholders and reducing moral hazard. This approach rests on Public-Private-Partnerships (PPP) and technological R&D public investments able to crowd private ones in and establish useful Public-Private-Insurance-Schemes enhancing the disaster risk managing role of the State. The paper proposes leveraging innovation technology both to enhance risk assessment and reduce uncertainty for climate-related NHs such as landslides. It is an important interdisciplinary question, in fact, despite the unequivocal acknowledgment of the warming global climate system, the precise ramifications of global warming and associated climatic shifts on NHs like landslides remain still elusive. The advanced modelling technique implemented by our interdisciplinary PPP contributes to geographically circumscribe the areas eventually subjected to landslides and constantly monitor the vulnerability of their structures, infrastructures, economic activities and hence population. The reliable data that we can produce through remote sensing acquisition systems are necessary inputs to contain risk exposure both physically and financially.*

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*Key words: Climate Change; Natural Hazards; Resilience; Risk Management; Economic Development; Innovation Technology.*

## 1. Introduction

Engagement in Public-Private-Partnerships (PPPs) addresses the largest and most complex risks modern societies are facing. As evidenced by the Geneva Association (2023), this approach can tackle even the Changing Risk Landscape due to tangible risks as climate-induced Natural Hazards (NHs). Technological advancements such as richer datasets and sophisticated modeling may improve the insurability of risk.

Our interdisciplinary multi-stakeholder approach precisely fits this evidence focusing its attention on climate-induced NHs, specifically landslides and floods, leveraging new advanced physical modeling and reliable data that will be obtained through new generation of remote sensing monitoring systems.

Among climate-induced NHs, Lin et al. (2020), showed that despite the unequivocal acknowledgment by the Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) of the warming global climate system, the precise ramifications of global warming and associated climatic shifts on landslides are still elusive.

Defining risk management in the case of hydrogeological hazards linked to climate change such as floods and landslides requires a dynamic susceptibility assessment to circumscribe, from time to time, subjected areas, structures and infrastructures and hence populations and their environmental and economic exposure. Moreover, if these hydrogeological hazards occur in seismic and volcanic areas the continuous happening of events produces a progressive negative impact on structures and infrastructures increasing the vulnerability and catastrophic impact of each following event. This problem is very complex in the Eurozone because of its crumbling structures and infrastructures result of decades of austerity and underinvestment, in an era of extremely severe emergencies as the climate change and aggressive global competition. This is even far more engaging in Italy as it involves cultural and historical sites very difficult to protect from NHs while maintaining their priceless values.

In the case of the Eurozone the opportunity of a new financial strategy to increase resilience of society from NHs is suggested by the coexistence of the private savings glut of the rich and the strict fiscal rules.

In the following the paper refers to the role of financial institution and technological innovation in Natural Hazard Risk Management. (§ 2). The discussion highlights the role of interdisciplinary research and the need for cooperation between public and private sectors through Public-Private Partnerships (PPPs) (§ 2.1). In section 3 it is presented the Italian smart climate risk protection policy evidencing European comparisons and concluding about how it is possible to improve insurance affordability and the behavior towards risk. Section 4

summarizes the risk assessment methodology. Section 5 explains how to refine risk assessment to increase resilience. The advantages of refining risk assessment and future perspectives are evidenced in section 6.

## 2. The Role of Financial Institution and Technological Innovation in Natural Hazard Risk Management.

In Macroeconomics and Finance literature the de-risking approach is everything but new. The de-risking role of financial institutions as the Central Bank is well described in making efficient financial markets and safe assets to satisfy "Liquidity Preference as Behavior Towards Risk" (Tobin, 1958), and the need for money capital in the firm (Vickers, 1987). Different components of risk can then be managed, not only financial risk but even operative and technical ones (Ross, 2013).

In a speech at Lloyd's of London given by Carney (2015), the former Chairman of the Financial Stability Board and Governor of the Bank of England, on September 29, 2015, the UK insurance industry was invited to reflect on how urgent was to take into much more serious account the threat of climate change posed to the financial stability and hence long-term prosperity. Since the 1980s the number of registered weather-related loss events had tripled and NatCatSERVICE of Munich Re evidenced the extraordinary increase of inflation-adjusted insurance losses from these events.

More recently "the soft budget constraint syndrome has penetrated capitalism" (Kornai, 2012) and "de-risking" regimes involving PPPs have become hegemonic (Gabor & Braun, 2023) with respect to State-led planning that, as well evidenced by Kornai, may suffer from inconsistency and be less reliable especially in a context of the very high uncertainty of the NHs.

### 2.1 A Path to Sustainable Financial Protection

In de-risking regimes, multiple stakeholders must be effectively involved through Public-Private Partnerships (PPPs) and Public-Private Insurance Programs (PPIPs). As evidenced in "High-Level Framework for Public-Private Insurance Programs" presented in May, at G7 Italia (2024), global financial markets and particularly insurance markets can accomplish the extremely important role to absorb damages and losses from NHs.

According to OECD (2023a) "Recommendation on Building Financial Resilience to Disaster Risks", for a sustainable development to be guaranteed it is necessary to prevent new disaster risks, reduce the existing and manage the residual ones. All this must be done even "Leveraging technology in insurance to enhance risk assessment and policyholders risk reduction" and "Enhancing Financial Protection Against Catastrophe Risks" through "the Role of Catastrophe Risk Insurance Programs" (OECD, 2023b). The International Association of Insurance Supervisors, then, underlies in its Report "A call to action", "the role of insurance supervisors in addressing natural catastrophe protection gaps" (IAIS, 2023). It's evident in this context the extremely effective role of technology and innovation to

measure the effects and reduce uncertainty for whatever NH and degree of climate change. This is to some extent what it is done by Aladdin (BlackRock), to cite the biggest example in the new era of investment management tech. Our PPP, a networking cooperation between universities and enterprises, fits precisely into this area to create spill-over effects as catalyst for economic and social development at local level, strengthen universities' entrepreneurial capacity supporting innovation and even research commercialization.

# 3 The Italian Smart Climate Risk Protection Policy and European Comparisons

Draghi et al. (2024a, b) evidenced the opportunity to issue guidelines for EU Pension Plans and fix capital adequacy rules for insurance companies established in the Eurozone as the existing fragmented regulatory framework can compromise European economic growth. In fact, EIOPA (2021) reports, for example, that in France the coverage of NHs was already compulsory in 1982; policies are mandatory and due to a principle of solidarity among citizens insurers charge an extra premium for the NHs coverage which is set by the law as a fixed percentage on the Property and Causality insurance premiums of the underlying contracts.

As far as the Italian approach to the regulation of insurance industry, on 31 December 2024 it is going to start a new Smart Climate Risk Protection policy specifically implemented for catastrophic damages characterized by a compulsory scheme, circumscribed, by now, to a limited target of policyholders made of enterprises and households. We will refer to the last Italian Budget Law 2024 (https://www.gazzettaufficiale.it)) to describe its perimeter and the role of each stakeholder involved in it; namely the Italian government, insurance industry and its Supervisory Authority (IVASS), the Italian insurance-financial group directly controlled by the Ministry of Economy and Finance (SACE), and the national reference price comparison site for the insurance sector (Facile.it). In the paper the Italian approach will be briefly compared to a Lloyd's catastrophe insurance policy in the Netherlands (§ 3.2.4) as referred into the EIOPA's Report (2021).

## 3.1 Bridging protection gaps

Climate change and NHs can rapidly and severely hit the financial stability of economies. Due to scarce information and awareness on their impact on the economies and lack of financial literacy, the effective demand for insurance may be scarce and public and private finance may end up being extremely exposed. Thus financial "protection gaps", happening whenever those who may be directly or indirectly injured by the NHs cannot rapidly recover from a disaster due to the absence of insurance coverage and other financial protection, can be very far to be closed. This can justify the choice of the Italian de-risking government to adopt a compulsory coverage as that introduced by the last Italian Budget Law 2024 (https://www.gazzettaufficiale.it).

## 3.2 Regulation and Re-insurance.

### 3.2.1 Businesses

With reference to the hazards to be covered, pending the detailed indications that the Ministers of Economy and Finance and of Enterprise and Made in Italy, in agreement with the Institute for Insurance Supervision, IVASS, the current list (i.e. earthquakes, floods, landslides, inundations and overflows) is merely exemplary.

Similarly to civil liability arising from the circulation of vehicles and vessels, insurance companies will not be able to avoid the obligation to contract, under penalty of applying an administrative pecuniary sanction ranging between €100,000 and €500,000.

Acting as a public reinsurer, then, SACE, an Italian insurance-financial group directly controlled by the Ministry of Economy and Finance, will ensure that the obligations undertaken by the insurance companies are fulfilled, indemnifying the private insurance and reinsurance companies up to 50% of the compensation paid by the latter, for an amount not exceeding 5000 million Euro for the year 2024 and, for each of the years 2025 and 2026, not exceeding the greater amount between 5000 million Euro and the free resources at December 31 of the immediately preceding year, not used for the payment of compensation in the reference year.

To further ensure the overall solvency of the system, it is expected that the obligations assumed by SACE will be guaranteed on first demand and without the possibility of recourse by the State as insurer of last resort. The State guarantee is explicit, unconditional and irrevocable (parag. 109 of art. 1 of the Budget Law 2024; https://www.gazzettaufficiale.it).

### 3.2.2 Real Estate Sector

With specific reference to the real estate sector, the legislator also intended to extend the range of subjected to the mandatory insurance to those who have benefited from the tax benefits under the so-called "superbonus" (see art. 119, paragraph 8-ter, Italian Leg. Decree 34/2020; https://www.gazzettaufficiale.it), in relation to expenses for interventions started after 30 December 2023. The beneficiaries of the "superbonus", therefore, could find themselves in a delicate position: while, on the one hand, they are entitled to the enjoyment of specific tax breaks, on the other they will now be required to take out additional insurance policies, representing a further financial burden for them.

### 3.2.3 Online platforms

On the 4th of July 2024 SACE (SACE, 2024), in partnership with Facile.it, launched the Smart Climate Risk Protection a catastrophic damage policy for micro-enterprises. The partnership between SACE and Facile.it marks an important point in the world of insurance and, for the first time, two leading companies join to allow micro-enterprises to obtain maximum benefits with the best technology available

on the market. The aim of the agreement is to make Climate Risk Protection smart, accessible in a simple and fast way, with a direct link to MySACE.it, the Facile.it platform.

With this initiative, SACE extends its commitment to serve micro-enterprises, providing them with tailor-made products and digital promotion channels, while Facile.it confirms its desire to become a point of reference in savings not only for end consumers, but also for the B2B sector.

### 3.2.4 Improving insurance affordability and the behavior towards risk

It was the European Insurance and Occupational Pensions Authority (EIOPA), a European Union financial regulatory institution, that introduced the concept of "Impact Underwriting" that is "the development of new insurance products and the engagement with public authorities, without disregard for actuarial risk-based principles of risk selection and pricing" (EIOPA, 2019, 2021).

The compulsory regime chosen by de-risking Italian government can be mitigated by big data and technologies, useful to better adapt the insurance products or services to customers' needs, but even to prevent NHs and their consequences. Reflecting actual risk a policyholder is exposed, risk-based pricing as premiums and deductibles can produce safer behavior helping climate change adaptation and mitigation of the risks. This then reflects on a reduction in risk, less money to afford losses and decreasing premiums.

For example, a Lloyd's catastrophe insurance policy in the Netherlands, allowed purchasing coverage for flood damage, earthquake and terrorism risks. As far as flood risk, policyholders received premium discounts if they take measure to "floodproof" their home. They found flood risk information on the insurer's website on which they could enter their zip code to extract information about flood probabilities, potential water levels, quality of flood protections and the risk-based insurance premium. Four different measures allow each a 5% premium discount: 1) installing electrical equipment, 2) the central heating installation above the ground floor level, 3) having flood shields available, 4) having a water-proof floor on the ground floor level, such as tiles.

Similar approaches have already been adopted even in Italy through the DERRIS (Disaster Risk Reduction InSurance) Pilot Project (Climate, 2020) by UNIPOLSAI (a multi-line insurance company belonging to the Unipol group, which is a leader in the Italian non-life sector). DERRIS is a project (2015-2018) co-funded by the European LIFE program. The project aims to test and implement an innovative form of PPP between insurance companies, municipalities, and businesses to enhance the resilience of Italian SMEs to climate change. It provides them with a simple and free tool linked to their zip code (the CRAM tool; https://cram.derris.eu/) for the assessment, prevention, and management of risks related to NHs considering five hazards: Flood, Lightning, Rain, Hail, Landslide, Wind, and Temperature. The approach is essentially empirical, using reference scenarios found in the IPCC (Intergovernmental Panel on Climate Change) climate reports (IPCC AR5, 2014) and ISPRA (ISPRA 58, 2015). It starts with a simplified

assessment of the effects of NHs without analyzing the causes and physical mechanisms of natural phenomena, but directly evaluating qualitatively the consequences on the territory. For example, regarding the risk of landslides, a simplified methodology has been referenced, based on the National Geological Map (ISPRA) (www.isprambiente.gov.it/Media/carg/index.html) and the Italian Landslide Inventory (IFFI) (www.progettoiffi.isprambiente.it/). The assessment of the hazard considers simply that the increase in precipitation associated with climate change may trigger only shallow landslides among the documented landslides. The assessment of vulnerability is based on the CRAM tool for self-assessment by companies, with the construction of a risk class matrix.

The definition and pricing the policy will be linked to the eventually adoption of a series of intervention strategies.

The examples cited above of the Lloyd's catastrophe insurance policy in the Netherlands and the Italian Derris pilot project offer us the occasion to stress the importance of our contribution. Firstly, the climate change effect may produce dynamic extreme tail events that very simplified and static systems of evaluation are not able to detect. Secondly, the risk assessment based on a zip-code identification rests on an extremely simplified territorial schematization (§ 4). Finally, a contest of changing climate, expectedly growing climate-related losses and increasing premiums, justify the intervention of public re-insurances and PPIPs to contain the "protection gap". The unaffordability for the policyholders on one hand and a crowding of the private insurances and re-insurances out of the market due to their incapability to remain profitable were, in fact, other sources of long-term financial instability to economies.

## 4. Risk assessment methodology

Our working methodology is based on a critical analysis of the weaknesses dis-cussed earlier for Derris Pilot Project in Turin (Italy). Indeed, as highlighted in Gariano & Guzzetti (2016), there is no universally accepted methodology to define the landslide risk assessment in a changing climate.

The data sources of the Italian pilot project to define the landslide risk assessment are the Geological Maps of ISPRA and the Inventory of Landslides in Italy.

The methodology they use to calculate risk, and its evolution induced by climate change is based on the estimation of hazard (IFFI landslide inventory) and vulnerability (CRAMTool and zip code).

It is a very reliable starting point of analysis but assuming the estimation of vulnerability valid, even if based on a self-assessment, the technical weak point, where our PPP can in-tervene to improve the methodology is the assessment of hazard at more detailed scale.

In fact, the IFFI inventory on Landslides suffers from a series of problems inherent in the methodology used for mapping landslides:

- The national territory is described by collecting heterogeneous data obtained with different mapping and interpretation techniques.
- the scale adopted for mapping of landslides (1:10,000 or 1:25,000) is too broad to allow for a correct assessment.
- although the inventory contains 635.003 landslides (based on 1.009 landslide events), the coverage of the national territory is still partial.
- The periodic updating of the maps is carried out in a heterogeneous manner across the national territory.

Considering all that has been discussed, and intending to apply the same working methodology, the next paragraphs outline actions to be taken to enhance the risk assessment.

## 5 Refining risk assessment to increase resilience.

The probability of a catastrophic event is related to the system's ability to counteract it, depending on the mechanical and geometric characteristics of the natural and built system in question. Therefore, the calculation of the probability of occurrence is more accurate the more precise is the definition of the models capable of following the underlying physical phenomenon and the related physical parameters. Hence, the probability of occurrence is closely tied to the uncertainties inherent the definition of behavioral models and the related physical parameters. The techniques available in the engineering field for handling uncertainties have been discussed in Ferrero et al. (2004), Baecher & Cristian (2003) and Hudson (2013). Each source of uncertainty must be adequately considered and addressed. Epistemic uncertainty can be overcome as it is linked to a lack of knowledge that can be refined through in-depth investigations. As discussed earlier one of the main sources of epistemic and aleatory uncertainty in risk assessment for landslides lies in the quality of the data and the scale to which they refer. For example, in modeling landslide phenomena, a scale of analysis with insufficient level of detail induces not only epistemic errors with serious repercussions on the geological and geotechnical models used, but also errors with high aleatory uncertainties due to greater data dispersion resulting from an excessively broad scale of analysis. Thus, having a detailed analysis of the geotechnical model through a combination of conventional monitoring systems and innovative instruments, along with continuous data acquisition, results in a significant reduction of both epistemic uncertainty (allowing previously unavailable information to be obtained) and aleatory uncertainty (availability of a large quantity of high-quality data) (Dubois & Guynnet, 2011)

Our PPP therefore works in the direction of producing information for accurate calculation of the probability of occurrence of catastrophic events and managing the related uncertainties to reduce risk and improve resilience. Moreover, as previously discussed, the huge quantity and quality of data that will be disposable can be useful to train AI algorithms to refine the precision of the forecasts with further significant implications even for the insurance and reinsurance industries

by providing more accurate risk calculations. Clearly, the distribution of the population, strategic and non-strategic civil and military structures and infrastructures, as well as productive activities across the territory, can provide guidance on the priority scale to adopt and the level of detail to reduce uncertainty.

In the following, the attention is devoted exclusively on NHs related to climate-induced landslides. In fact, the landslide risk assessment can be effectively supported by our PPP as it includes even the expertise to develop advanced models to simulate the effects of climate change and, on the other hand, the creation of innovative investigation and monitoring systems.

## 6. Advantages of refining risk assessment and future perspectives.

The application of the refining assessment just described is presented for three cases where the Derris approach would have been un-reliable due to the extreme complexity of hydrological, geological and geotechnical characteristics of the sites as generally found throughout the Italian territory. Different approaches have been developed depending on the characteristics of soil deposits and the type of landslide.

In the case of rainfall-induced landslides in shallow pyroclastic deposits of the Campania Region (Figure 1), Netti et al. (2012) proposed a multidisciplinary approach that involves the expertise of hydrologists, meteorologists, computational mechanics experts, economists, and geotechnical engineers for landslide risk management, which significantly impacts the epistemic component of uncertainty. In the territories under consideration, a supplementary investigation program was developed, which included the redaction of thematic maps at detailed scales (1:1000 and 1:2000) and the execution of in-situ and laboratory tests for the mechanical characterization of soils. Furthermore, complex monitoring systems with continuous data acquisition and remote management were installed in the study areas. A framework (Figure 2) was proposed for the assessment of landslide evolution under a simplified hypothesis, which can be used to create a Decision Support System (Damiano et al., 2012) for stakeholders involved in land management and the protection of areas at risk.

This also led to the creation of a soil database for hydro-geotechnical models for volcanic soil deposits (Damiano et al. 2023). The database contains all the data needed to define advanced constitutive relationships to be implemented in a physically based model to capture landslide failure under weather rainfall forecasts (such as those caused by climate change). The data contained in the soil database represent an essential input for initializing AI algorithms, while the monitoring data serve to train the AI.

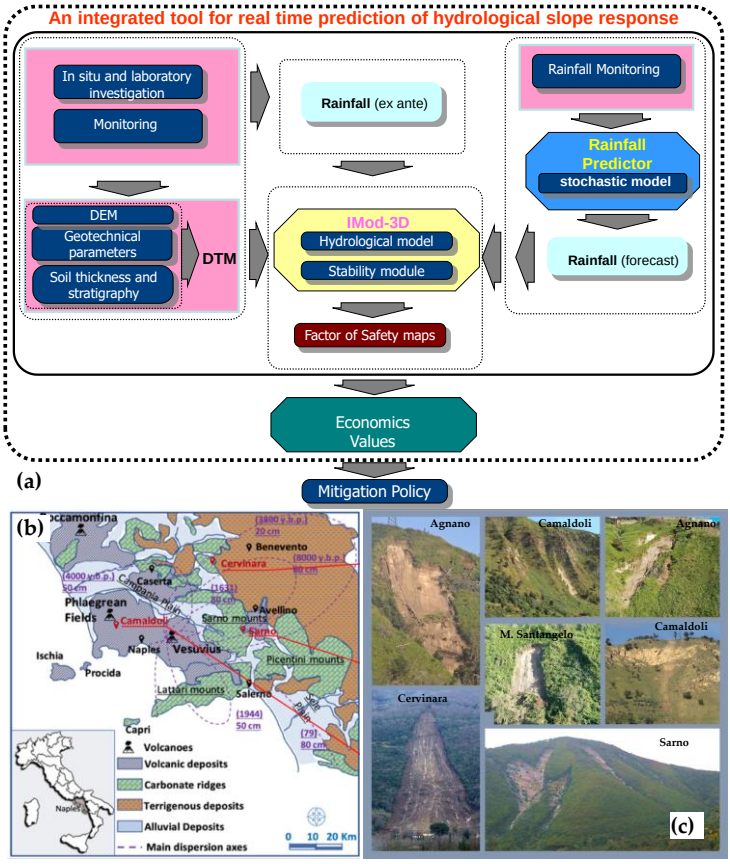


*Figure 1. a) Flow chart of the Decision Support System (DSS); b) Geomorphological contexts of the pyroclastic deposits in Campania, Italy c) Landslides case history.*

Moreover, since 2019, the research has been implementing technological innovation and advanced expertise in defining advance monitoring systems both for the study of the effects of landslides and earthquakes and for Structural Health Monitoring and Reinforcement (SHMR) (Di Gennaro et al 2022). This research activity led to the realization of the New Smart Hybrid Transducer (NSHT) (Figure3) and the registration of industrial property patents (EP-3948167-A1, 2022). In the Figure 3a there is a schematic representation of an application of NSHT as a landslide Early Warning System (EWS) and as SHMR system by a single acquisition system (Figure 3c). The proposed monitoring system is constituted by distributed strain and temperature NSHT transducers based on optical fiber sensing technology. NSHT transducer (Figure. 3 b) is constituted by a mono-mode optical fiber for communication embedded in a composite support material connected to an interrogation system (Figure 3c).

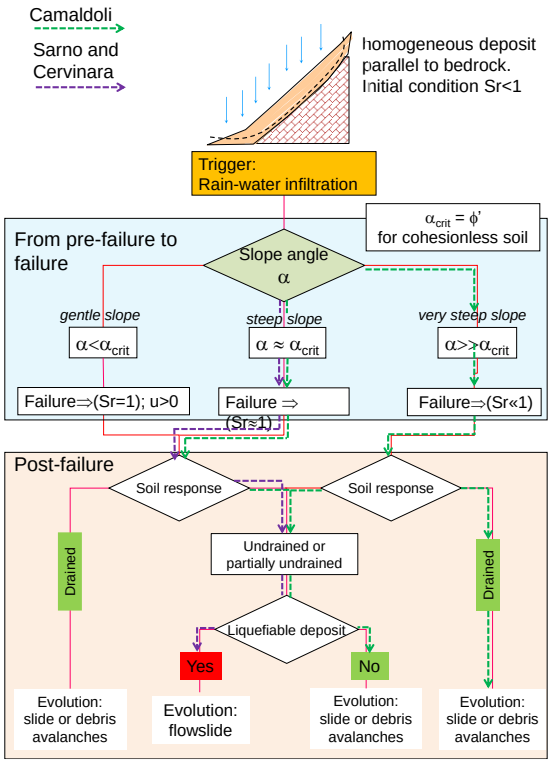


*Figure 2. Flow chart for simplified assessment of the post failure evolution of landslide.*

This NSHT transducer can be remotely interrogated with different techniques (Brillouin scattering and Rayleigh backscattering) and each part of fiber act as sensor. In static acquisition, a monitoring system including the NSHT, is capable of continuously monitoring strains and temperatures along the transducer covering 1 km up to 50 km with a spatial resolution of up to 20 cm and spatial sampling of 5 cm. In dynamic acquisition, it can monitor sections from 20 m to 100 m with a sampling frequency of 20 to 50 Hz and subcentimeter spatial resolution and sampling. Applying NSHT transducers (described by yellow line in figure 3a) in adherence to the structures of buildings, tunnels, viaducts, and in landslides (as a Smart Estenso Inclinometer), it is possible to continuously remotely monitor the strains induced and highlight in real time the occurrence of a failure (the strain peaks detected by the red curve in Figure 3a).

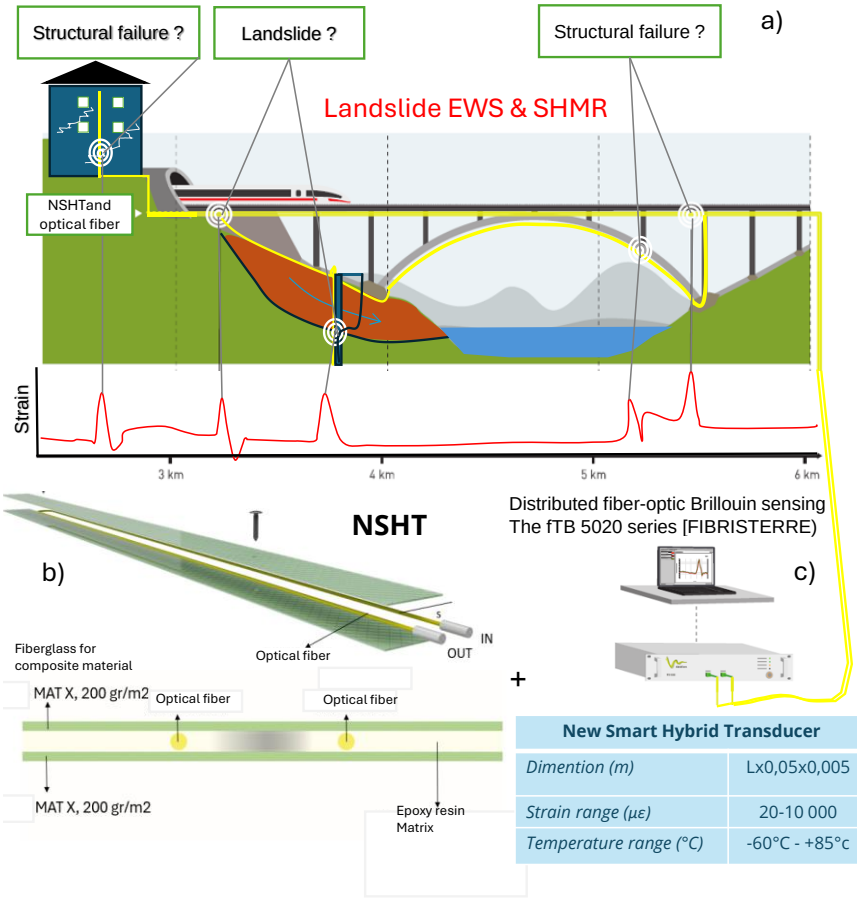


*Figure 3. a) Schematic representation of Landslide EWS and SHMR; b) implementing the NSHT as strain and temperature distributed transducer; and c) the interrogation system of FIBRISTERRE for optical fiber sensor.*

As a final example, NSHT has been implemented by CUGRI (inter-University Consortium, named the Research Center for prevision prediction and prevention of the Great RIsks) and Centola Municipality in the case of deep clay shales landslides as a smart estenso-inclinometer, with the complex monitoring system installed in Cilento Geopark (Southern Italy) (Damiano et al., 2024). This complex monitoring system has been providing practically continuous information on weather and subsoil variable, since 2021. This enables to identify the link between rainfall, pore water pressure, the underground strain profiles of deposits and the reactivation of landslides (Figure 4).

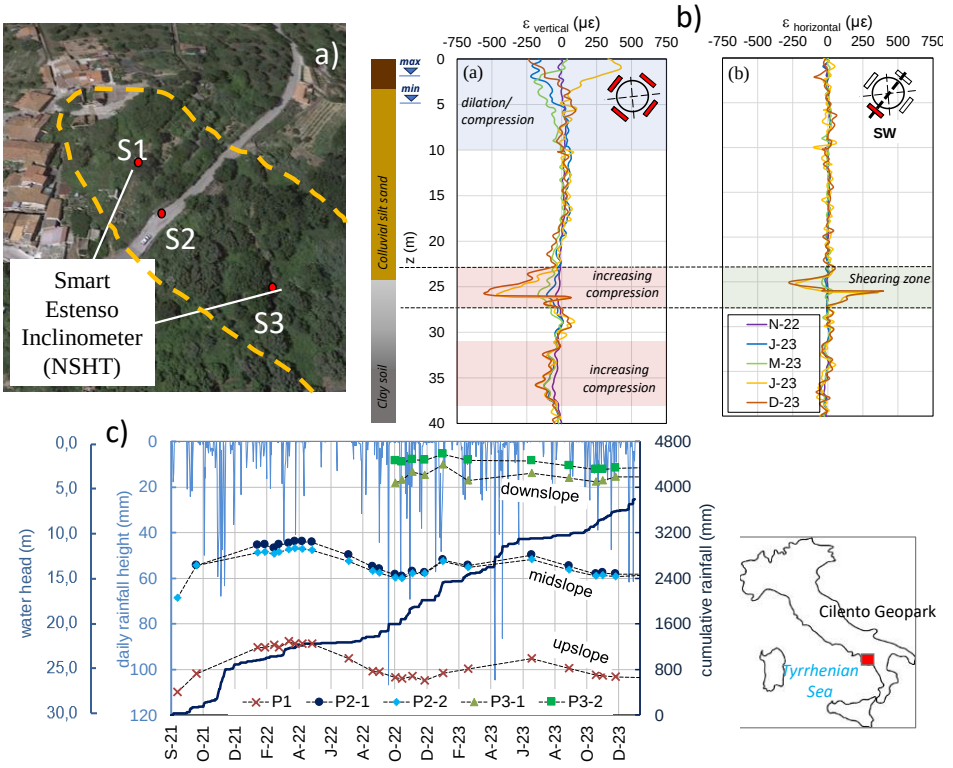


*Figure 4. a) San Nicola experimental field: location of the three monitored sites (S1, S2, S3); b) daily and cumulative rainfall and groundwater fluctuations at the three sites ; c) identification of land-slide activation by smart estenso inclinometer strain profiles..*

Applications on pile foundations and bridge piers are ongoing. For further research we suggest that NSHT might be used even to constantly monitor the strain of underground along very long distances (up to 50km) (e.g. the monitoring of the effects of bradyseism such as that recently seen in Campi Flegrei, in the Southern Italy).

## 7. Conclusions

In the paper it has been presented an interdisciplinary multi-stakeholder approach to NH risk management that exploits the expertise of meteorologists, geologists, engineers, economists of public institutions such as Universities, Knowledge Transfer Management, Interuniversity Centers for the Prediction and Prevention, Municipalities, Academic Spinoffs, Enterprises.

The approach has proposed to leverage innovation technology both to enhance risk assessment and reduce uncertainty for landslides. The advanced modelling technique presented contributes to geographically circumscribe the

areas eventually subjected to landslides and constantly monitor the vulnerability of their structures, infrastructures, economic activities and hence population.

This helps bridging protection gaps, encouraging behaviour towards risk, increasing the affordability of the policies and the capability of businesses to stay on the market hence boosting the socioeconomic resilience, financial stability and long-term prosperity.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# DIGITALIZATION POSITIVELY ASSOCIATES WITH THE ADOPTION OF SUSTAINABILITY PERFORMANCE METRICS IN MAINTENANCE PRACTICE: PRELIMINARY STUDY FINDINGS

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***Abstract***

*The study investigates the relationship between digitalization and sustainability in maintenance decision-making. The analysis relies on raw and coded data from a questionnaire-based survey targeting manufacturing companies in the Republic of Serbia. Our findings suggest a strong positive association between digitalization and sustainability (Kendall's $\tau_b$ = 0.324, Z = 2.681, p = 0.007), demonstrating that digitalization plays a vital role in adopting sustainable maintenance performance metrics. In addition, factor analysis leveraging Multiple Correspondence Analysis suggests an association between technology, digitalization and maintenance of sustainable responsibility levels, providing additional evidence about digitalisation's role in adopting a sustainable maintenance approach.*

***Keywords****: sustainable maintenance, digitalization, multiple correspondence analysis, maintenance sustainable responsibility*

## 1. Introduction

The development of digital technologies and imposed sustainability initiatives (e.g., Green Deal) forced manufacturers to alter their business models. This forced many to turn their attention to maintenance in the hope of coping with these challenges, ultimately providing novel maintenance policies under the paradigm of SM (Sustainable Maintenance) (Campos & Simon, 2019; Franciosi et al., 2020).

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With the advent of Industry 4.0 (I4.0) solutions (e.g., Internet of Things), many consider that enabling technologies play a vital role in organisational performance (Todorovic et al., 2022), especially in switching to SM practices (Vasić et al., 2024). For instance, Karki & Porras (2021) argue that digitalization plays a crucial role in adopting SM by considering the optimization of both economic and sustainable factors. Similarly, Orošnjak et al. (2021) propose an EBM (Energy-Based Maintenance) concept covering both diagnosis/prognosis aspects, which can serve as an optimization solution as well. Other SM concepts emerged, such as Green Maintenance (Ajukumar & Gandhi, 2013), Energy-Oriented Maintenance (Xia et al., 2018), Sustainable Predictive Maintenance (Karuppiah et al., 2021), etc. However, although most on a theoretical basis, many had difficulties altering their maintenance practices, presumably due to low digitalization and technology capacities (Ahmed et al., 2023; Johansson et al., 2019).

As others started questioning the barriers and challenges in the adoption of SM, many agree that digitalization may play an essential role in the easier adoption of SM (Saihi et al., 2022; Sari et al., 2015). Therefore, this study attempts to test whether there is an association between digitalization and factors of sustainability in maintenance decision-making practices using a questionnaire-based approach. To do so, we perform dual analysis by testing independence and the relationship between these factors on one side and factor analysis to understand the association between these factors on the other.

The rest of the manuscript is structured as follows: The second section provides an in-depth description of the questionnaire-based survey items used for the study, including the description of the proposed statistical tests and factor analysis. The third section provides results and discusses preliminary findings. The last section provides concluding remarks, limitations, and implications of the work.

## 2. Methodology

### 2.1 Survey items used for the analysis

The survey items used comprise demographic information—company size (e.g., Small, Medium, large), industry sector, classification of primary activity, available standards, etc. Specifically, the survey data comprise the following items: *maintenance technology level? maintenance digitalization level? To what extent does your company care about environmental protection and sustainable responsibility? Does your company dispose of waste and recycle it? What existing sustainable maintenance performance metrics are being monitored?*

The first two items consider the ordinal (ranked) scale (1-low level; 7-high level) and digitalisation (1-does do not consider; 5-to a large extent). The multiple choice question explains the sustainable performance metric, but it is not fully provided due to paper length constraints. Please note that the raw data used for this study includes items related only to the proposed research questions. The survey instrument is constructed with many more items for measuring the level of

sustainable maintenance readiness level and is available upon request. The targeted area is the Serbian manufacturing sector.

### 2.2 Coding of MSR levels

Delphi meetings are performed in person and online to code the variables. All three authors participated, and an interrater agreement was reached, relying on Cohen's kappa and Krippendorff's alpha. In the first round of coding, similar results are obtained for both Cohen's $\kappa = 0.916 \pm 0.055$ and Krippendorff's $\alpha = 0.916 \pm 0.048$ (Table 8). To ensure the replicability of coding, round 2 was performed with a 100% agreement score. The levels are coded as follows: MSR-L1 – Basic Sustainable Responsibility; MSR-L2 – Basic Sustainable Responsibility; MSR-L3 – Moderate Sustainable Responsibility; MSR-L4 – High Sustainable Responsibility; and MSR-L5, defined as Comprehensive Sustainable Responsibility.

*Table 8: Interrater agreement of coders*

| Delphi | Coding | Kappa/Alpha | SE | 95%CI$_{Lower}$ | 95%CI$_{Upper}$ |
|---|---|---|---|---|---|
| R1 | OM-KR* | 0.916 | 0.068 | 0.740 | 1.000 |
| R1 | OM-NB* | 0.874 | 0.042 | 0.876 | 1.000 |
| R1 | KR-NB* | 0.916 | 0.057 | 0.804 | 1.000 |
| R1 | AVG_Cohen | 0.916 | 0.055 | 0.806 | 1.000 |
| R1 | AVG_Krippendorff | 0.916 | 0.048 | 0.817 | 1.000 |
| R2 | AVG_Cohen | 1.000 | 0.000 | 1.000 | 1.000 |
| R2 | AVG_Krippendorff | 1.000 | 0.000 | 1.000 | 1.000 |

*NOTE: *authors initials; AVG = Average of Cohen and Krippendorff scores. SE = Standard Error*

Specifically, the MSR-L1 considers one or more maintenance performance measures but only in one of the TBL dimensions, ignoring all others (e.g., ENV = energy consumption and $CO_2$ emissions). The MSR-L2 explains where a company considers a minimum of one item in two out of three TBL dimensions. For instance, an entity measures environmental (e.g., energy consumption) and social (e.g., health and safety) but ignores the economic dimension. The MSR-L3 explains the state where a company measures at least one item in all three dimensions but considers more than one item in only one dimension. The MSR-L4 suggests high sustainable responsibility with a minimum of two or more items in two dimensions. The MSR-L5 explains a fully sustainable, responsible maintenance function that measures at least two or more items in all three sustainability dimensions (e.g., social, environmental, and economic). The coded categories are then used to test the association with proposed items and for factor analysis.

Since our interest includes understanding the association between multiple variables, we perform coding of digitalization and technology items. Both items are coded as binary variables "low" if ranking (level) is ≤ 3, and "high" otherwise. All items are then used for factor analysis and visualisation leveraging MCA (Multiple Correspondence Analysis). The Chi-square distance metric is used. The explanation of individual variable contribution is given by variable inertia (variance). For

hypothesis testing, we use Kendall's tau-b as a non-parametric correlation measure due to the items' ordinal (ranked) scale. The Chi-square statistic tests the association between other categorical (nominal) variables. Lastly, the diagnosticity of *p* values is performed using VS-MPR (Vovk-Sellke maximum *p*-Ratio) (Sellke et al., 2001), while corresponding test statistics report the relationship's strength.

# 3. Results & Discussion

## 3.1 Descriptive and inferential statistics

Firstly, we provide descriptive results of raw data (Figure 6). Most companies are within the process industry (82%) sector, where primary activity includes – manufacturing parts of vehicles (12%) and production of plastic packaging (10%), followed by others. Company sizes include large companies (43%), followed by medium (31%) and small (10%). The personnel filling out the survey are mostly Directors (19.6%), followed by Quality Managers (15.7%), Head of Maintenance (9.8%) and Head of Production (9.8%). Interestingly, 75% of companies have implemented the ISO 9001 standard, while 18% of companies do not carry out waste disposal tasks as part of their maintenance activities (e.g., oil treatment).

As for the survey items, 31% of companies claim that they take care of environmental protection and sustainability to a large extent, while 41% to a high extent. The technology level seems to follow a normal distribution, with most companies at the medium level (31%), suggesting a balanced approach, including some software solutions. Two companies reported that maintenance activities are performed manually without software solutions, and only two reported some technological and software solutions. Lastly, answering the question about digitalization's role, most companies report none to the minor (31%).

As for the MSR levels, most companies report MSR-L3 (27.4%), followed by MSR-L4 (21.6%) and MSR-L5 (19.6%). Only 7% of companies consider one TBL dimension (MSR-L1), while 17.6% consider at least two sustainable performance dimensions (e.g., environmental and economic aspects) in MDM (Maintenance Decision-Making). Given that digitalization and sustainability levels are reported as ordinal variables, we conduct Kendall's $\tau$ test statistic.

The results (Table 9) show a statistically significant positive association ($p < 0.05$) of reported variables. The correlation is highest between digitalization and technology level ($p < 0.001$, VS-MPR = 6122), followed by the technology and sustainability ($p < 0.001$, VS-MPR = 5308), and technology and MSR ($p < 0.001$, VS-MPR = 185). More importantly, there is a moderate correlation between digitalization and sustainability ($\tau = 0.398$, $p < 0.001$) and digitalization and MSR ($\tau = 0.324$, $p = 0.007$) with VS-MPR = 10.196, suggesting that there is 10 times more likely to find evidence under the alternative hypothesis that there is a positive association between digitalization and suggested MSR levels.

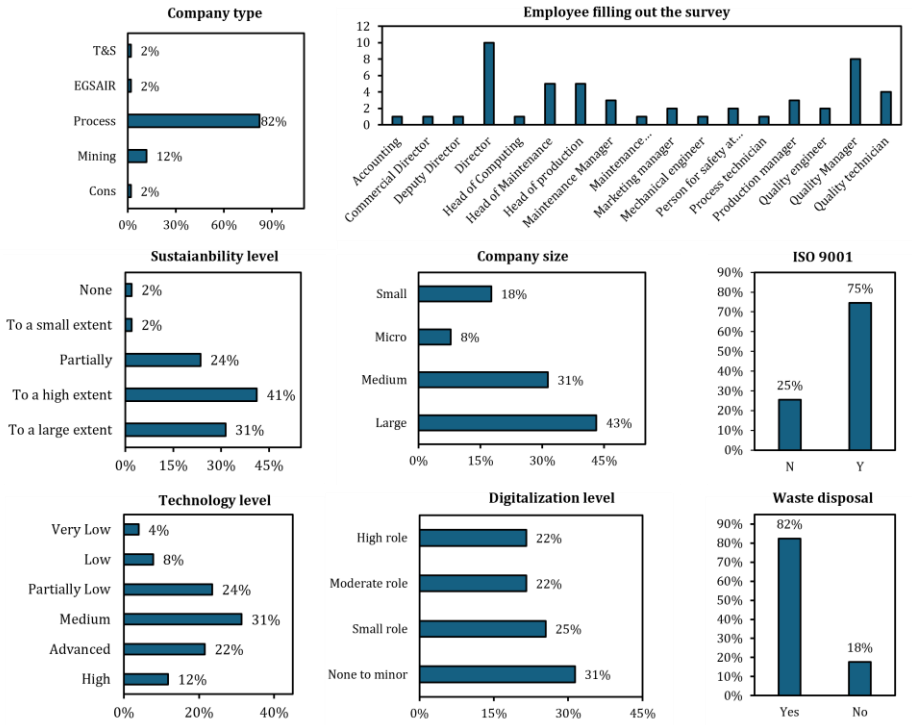


*Figure 6: Descriptive results of demographics and selected survey raw data items*

*Table 9: Performed test statistics reported per Kendall's tau-b*

| Test Pairs | Statistic | Value | *Z*-score | *p* | VS-MPR |
|---|---|---|---|---|---|
| DIG – SUSRES | Kendall's $\tau_b$ | 0.398 | 3.430 | < 0.001 | 82.270 |
| DIG – MSR-L | Kendall's $\tau_b$ | 0.324 | 2.681 | 0.007 | 10.196 |
| DIG – TECH | Kendall's $\tau_b$ | 0.532 | 4.568 | < 0.001 | 6122.012 |
| TECH – SUSRES | Kendall's $\tau_b$ | 0.540 | 4.536 | < 0.001 | 5308.469 |
| TECH – MSR-L | Kendall's $\tau_b$ | 0.420 | 3.675 | < 0.001 | 185.301 |

In addition, testing the association between variables using independence Chi-square statistic, all reported cases suggest the absence of independence and significant association between variables ($p < 0.05$). After comparing companies with ISO 9001 and the variables above, there is only a significant association between the items regarding waste disposal activities ($\chi^2 = 5.201$, $p = 0.023$). Thus, the reason for selecting Kendall's tau is that it provides both the strength and direction of the relationship, which is a Chi-square test limitation.

In sum, we confirm that there is strong evidence favouring the positive relationship between the level of digitalization and sustainability dimensions, specifically in sustainable responsibility and considering sustainable maintenance performance metrics in MDM. To gain deeper insight and understanding of the

association between levels of MSR and included variables, dimensionality reduction and data visualization using MCA are performed.

### 3.2 Multiple Correspondence Analysis Results

The total inertia is $\Phi^2$ = 1.750 (Table 10), whereas the PC1 and PC2 account for 43%, while the first three PCs account for 59% of the total inertia. Note that the common practice is to use 70% of total inertia (Orošnjak & Šević, 2023)Hence, we additionally performed the analysis, which included four components. Ultimately, data did not suggest changes in association per the biplot projection of PC1 and PC2, which had sufficient inertia to understand the association between items. Thus, we rely on the first two components for discussion. (Note: Data and full MCA analysis can be provided to the reader per request.)

*Table 10: The results of MCA representation of data and components*

| | | | | *PC1* | | | *PC2* | | | *PC3* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | ***Q*** | ***m*** | ***λ*** | ***Cd*** | ***Co*** | ***Ctr*** | ***Cd*** | ***Co*** | ***Ctr*** | ***Cd*** | ***Co*** | ***Ctr*** |
| MSR_L1 | 0.69 | 0.03 | 0.12 | 0.94 | 0.14 | 0.07 | -1.23 | 0.24 | 0.18 | 1.40 | 0.31 | 0.25 |
| MSR_L2 | 0.05 | 0.04 | 0.12 | 0.44 | 0.04 | 0.02 | 0.13 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 |
| MSR_L3 | 0.73 | 0.07 | 0.10 | 0.33 | 0.04 | 0.02 | -0.14 | 0.01 | 0.00 | -1.34 | 0.68 | 0.46 |
| MSR_L4 | 0.67 | 0.05 | 0.11 | -0.02 | 0.00 | 0.00 | 1.48 | 0.60 | 0.40 | 0.48 | 0.06 | 0.05 |
| MSR_L5 | 0.68 | 0.05 | 0.12 | -1.50 | 0.55 | 0.24 | -0.70 | 0.12 | 0.08 | 0.25 | 0.02 | 0.01 |
| Low_Dig | 0.69 | 0.20 | 0.03 | 0.37 | 0.49 | 0.06 | 0.24 | 0.20 | 0.04 | 0.00 | 0.00 | 0.00 |
| High_Dig | 0.69 | 0.05 | 0.11 | -1.34 | 0.49 | 0.21 | -0.86 | 0.20 | 0.14 | -0.01 | 0.00 | 0.00 |
| Waste_Dis | 0.54 | 0.21 | 0.03 | -0.24 | 0.26 | 0.03 | 0.16 | 0.13 | 0.02 | 0.19 | 0.16 | 0.03 |
| No_Waste_Dis | 0.54 | 0.04 | 0.12 | 1.10 | 0.26 | 0.12 | -0.76 | 0.13 | 0.09 | -0.87 | 0.16 | 0.12 |
| High_Tech | 0.62 | 0.16 | 0.05 | -0.50 | 0.46 | 0.09 | 0.19 | 0.07 | 0.02 | -0.23 | 0.09 | 0.03 |
| Low_Tech | 0.62 | 0.09 | 0.09 | 0.92 | 0.46 | 0.16 | -0.35 | 0.07 | 0.04 | 0.41 | 0.09 | 0.06 |

Note: *Q* = Quality; *m* = mass; *λ* = inertia; *Cd* = Coordinate; *Co* = Correlation; *Ctr* = Contribution.

The MCA biplot (Table 10) suggests two clusters. The blue cluster suggests the association of high levels of digitalization, technology MSR-L4 and MSR-L5 and waste disposal items. Thus, we infer that companies with high levels of digitalisation and technology tend to include more sustainable maintenance performance indicators (SMPIs) in their MDMs. In contrast, companies having lower levels of digitalization and technology do not have capacities to consider many SMPIs but instead focus solely on economic (e.g., downtimes, costs) or environmental (e.g., energy consumption) indicators in their MDM.

In sum, the findings suggest a positive association between digitalization and sustainability aspects within the maintenance function. This suggests that companies with higher technological and digitalization capacities adopt more sustainability performance metrics within MDM. In contrast, companies with lower technological and digitalization capacities do not suggest dependency on sustainability metrics, consequently focusing primarily on specific TBL dimensions (e.g., economic factors—time between failures, time to repair, etc.).

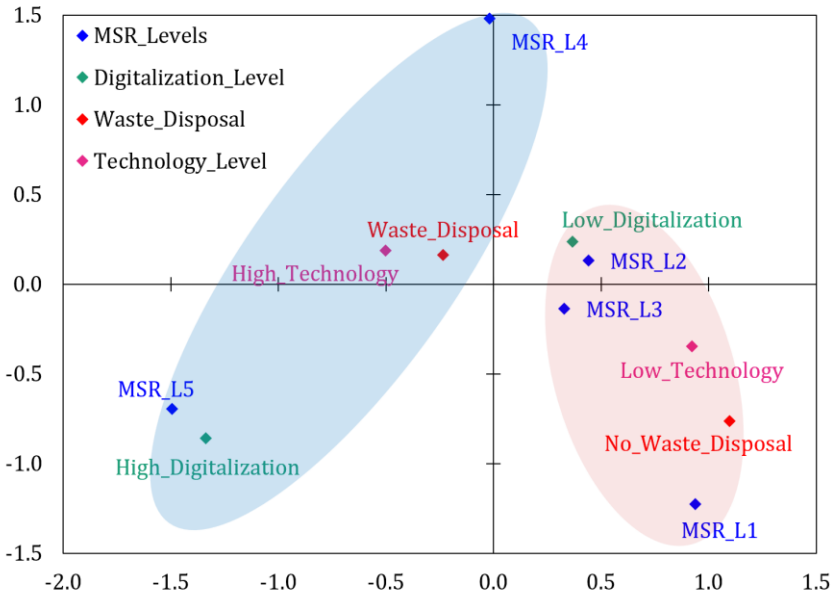


*Figure 7: MCA biplot PC1 (x-axis) and PC2 (y-axis). The association of digitalization, waste disposal, technology and MSR levels (blue cluster). The association between lower levels of digitalization, no waste disposal, technology and MSR levels (red cluster).*

## 4. Conclusion

The study performs dual analysis using the Chi-square test of independence and Kendall's Tau test to investigate the relationship between digitalization level and sustainable responsibility factors in decision-making. The findings suggest significant evidence in favour of the relationship between the factors above, suggesting that companies with higher levels of digitalization tend to be more environmentally and socially responsible. Additionally, the MCA analysis suggests that companies with lower levels of digitalization tend to monitor fewer sustainability factors and lack appropriate waste management and recycling practices, presumably due to limited technological capacities.

Several limitations were reported in the study. Namely, the study relies on a preliminary sample of 51 companies, which is still collecting data. Although the sample is not representative, we believe the data will undoubtedly add evidence supporting the hypothesis that digitalization plays a vital role in adopting SM practices. Next, the sample may suffer from the heterogeneity of company size and types of applications in which maintenance practices are performed. This, in turn, may cause bias across findings where micro and small businesses tend to include less digital technologies in their maintenance practices. Lastly, obtained findings regarding the association between different items leveraging MCA, the results are

discussed based on the 43% of shared inertia. However, we performed additional analysis using the first four components and found no additional insights about the dependency between items.

The study's implications will undoubtedly play a role for decision- and policy-makers in altering their existing maintenance practices by adopting and increasing their digital capabilities, especially since it becomes easier for engineers and managers to track their performance via sustainability metrics. This offers additional advantages since using energy resources effectively reduces unnecessary waste and improves resource efficiency, ultimately shifting traditional industrial maintenance practices to sustainable maintenance practices.

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# SUSTAINABILITY AS THE GOAL IN INNOVATIVE APPLICATIONS

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***Abstract***

*Innovation and sustainability are now pivotal in modern applications, aiming to solve current issues and prevent future challenges. Sustainability objectives in innovative applications cover five key areas: Environmental Preservation; Focusing on clean energy technologies, energy efficiency, waste management, and water conservation. Economic Viability; Promoting green economy models, digital transformation, and social entrepreneurship to drive sustainable economic growth. Social Sustainability; Advancing education, health technologies, and inclusive innovations to foster equitable societal development. Business Sustainability; Implementing sustainable business models, ethical governance, and employee engagement to align corporate objectives with long-term sustainability goals. Cultural Heritage Preservation; Safeguarding traditional practices and promoting cultural diversity to maintain cultural identity in sustainable development. The synergy between innovation and sustainability is evident across these domains. Innovative methodologies are essential in achieving sustainability objectives, addressing the needs of both present and future generations. Our research elucidates that by integrating and implementing both concepts, remarkable outcomes may be attained across all industries. This approach enables the most comprehensive development from the very beginning, supported by practical examples and detailed explanations.*

***Keywords****: innovation, sustainability, digital transformation.*

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# 1. Introduction

Artificial intelligence (AI) has become a significant factor in the business sector, providing unique opportunities to optimise operations, enhance customer experiences, and achieve a competitive advantage (Gil et al., 2019; Bughin et al., 2017). The growing adoption of AI by businesses necessitates the integration of AI-powered automation to streamline tasks, enabling employees to concentrate on more strategic activities. The literature emphasises the significance of AI in predictive analytics, allowing businesses to derive valuable insights from extensive datasets, thereby facilitating personalised customer experiences and informed decision-making (Chernov et al., 2020; Yau et al., 2021).

Successful implementation of AI necessitates more than mere technological adoption. Organisations should invest in essential infrastructure, cultivate AI competencies among employees, and implement effective data management practices (Wagner, 2020). Artificial intelligence should be strategically aligned with overarching business objectives to promote innovation and ensure sustainable success (Plastino & Purdy, 2018; Reim et al., 2020). Furthermore, collaborations with universities, AI startups, and research institutions can facilitate access to advanced technologies and specialised knowledge, thereby enhancing the pace of AI adoption (Bughin et al., 2017; Wagner, 2020).

By addressing these various aspects, businesses can harness the transformative potential of AI, positioning themselves at the forefront of the digital revolution.

# 2. Methodology

This study utilises a systematic review methodology, noted for its rigour and thoroughness in synthesising current literature. This methodology enables a systematic and reproducible approach for locating, assessing, and integrating pertinent studies, thus guaranteeing that the conclusions are grounded in a solid evidentiary foundation. The systematic review approach is especially beneficial in rapidly evolving domains like artificial intelligence (AI), where the literature is extensive and varies significantly in quality.

A comprehensive search strategy was created to discover pertinent material regarding the role of AI in enhancing work performance and employee behaviour for the systematic review. This entailed establishing precise inclusion and exclusion criteria to guarantee that only studies relevant to the research topics were included. The inclusion criteria generally comprised peer-reviewed articles, conference papers, and pertinent grey literature published within a specified timeframe, whereas the exclusion criteria discarded works that did not concentrate on AI applications in the workplace or lacked empirical substantiation.

The search was performed across many academic databases, including IEEE Xplore, Scopus, and Google Scholar. These databases were chosen for their comprehensive coverage of literature in computer science and associated

disciplines. Keywords and phrases including "artificial intelligence," "machine learning," "work performance," and "employee behaviour" were employed to optimise the retrieval of pertinent studies. Boolean operators were utilised to enhance the search outcomes, guaranteeing that the search was both thorough and focused.

Subsequent to the preliminary search, the obtained publications were evaluated for relevancy based on their titles and abstracts. The screening technique was essential in reducing the literature to a feasible quantity of research for comprehensive examination. The full-text articles were subsequently assessed according to the predetermined inclusion and exclusion criteria to ascertain their appropriateness for included into the final synthesis.

Data extraction was conducted on the chosen studies, emphasising critical aspects including study design, sample size, applied AI approaches, and outcomes pertaining to work performance and employee behaviour. The systematic extraction of data facilitated a comparative analysis of findings across research, emphasising similar themes, trends, and gaps in the literature.

The methodology followed recognised principles, including the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, to guarantee the reliability and validity of the systematic review. This involved preserving a clear record of the search procedure, encompassing the quantity of articles reviewed, accepted, and rejected at each phase, along with the rationale for exclusions. A quality assessment of the listed papers was performed utilising suitable tools to evaluate methodological rigour and potential biases in the research.

The findings were synthesised using a narrative technique, facilitating the integration of various study outcomes into a unified framework. This method enabled the recognition of significant patterns and insights concerning the influence of AI on work performance and employee behaviour, thereby enhancing comprehension of the topic.

This study utilised a systematic review methodology that offered a thorough and organised framework for synthesising the current literature on the impact of AI on enhancing work performance and employee behaviour. This methodology, by adhering to stringent criteria of evidence synthesis, boosts the credibility of the findings and provides significant insights for practitioners and researchers navigating the complexity of AI integration in the workplace.

## 3. Discussion

This study's discussion section synthesises findings from a systematic literature review on artificial intelligence (AI) and its effects on enhancing work performance and employee behaviour. The analysis identifies key themes that underscore the complex nature of AI integration in organisational settings, highlighting the opportunities and challenges businesses encounter in utilising this transformative technology.

AI Integration and Application Areas; The literature reveals a wide range of application areas for AI in organisational contexts. Yau et al. emphasise that AI can be effectively integrated into multiple business functions, such as automation in customer service and production, predictive analytics for forecasting, and the personalisation of customer experiences. Yau et al. (2021) conducted a study that provides significant insights into the topic at hand. These applications enhance operational efficiency and contribute to improved customer satisfaction, which is essential for maintaining a competitive edge in the current market. AI-driven quality assurance systems can effectively minimise errors and improve product quality, which in turn promotes customer loyalty and trust.

AI Investment in Technological Infrastructure; Organisations must invest in robust technological infrastructure to fully realise the potential of AI. This encompasses the adoption of cloud computing solutions, the utilisation of big data analytics, and the procurement of high-performance processors to facilitate AI applications. Enholm et al. emphasise that these investments are essential for organisations to fully leverage AI technologies and enhance business value (Enholm et al., 2021). Research indicates that organisations prioritising technological investments are more effectively positioned to implement AI solutions, resulting in improved performance outcomes.

AI Competencies and Training Programs; The effective integration of AI depends on the cultivation of AI competencies among the workforce. Organisations should establish comprehensive training programs to provide employees with the essential skills required to collaborate effectively with AI technologies. This involves the recruitment of AI specialists and the enhancement of current employees' skills to ensure effective utilisation of AI tools in their positions. Mikalef et al. emphasise that cultivating a culture of continuous learning and adaptation is essential for organisations aiming to utilise AI to enhance performance (Mikalef et al., 2023). Investing in human capital enables organisations to improve their AI capabilities and foster innovation.

Data Management; Effective data management constitutes a crucial element in the successful integration of AI. Organisations should prioritise the collection and analysis of extensive datasets, while also safeguarding data privacy and security. Effective data management enhances the accuracy of AI-driven insights and fosters customer trust in data handling practices. Khushk highlights that optimised data management practices can enhance human resource management operations, resulting in more accurate hiring and performance monitoring (Khushk, 2024). This highlights the necessity of implementing strong data governance frameworks to facilitate AI initiatives.

Artificial Intelligence Strategy and Vision; Formulating a coherent AI strategy that aligns with organisational objectives is crucial for directing AI implementation initiatives. Organisations should cultivate leadership support and encourage a cultural shift that integrates AI as an essential element of their business model. Reim et al. highlight the necessity of a structured roadmap for AI implementation, ensuring alignment with the organization’s strategic objectives (Reim et al., 2020).

Articulating a clear vision for AI integration enables organisations to mobilise resources effectively and fosters a shared understanding of AI's benefits at all organisational levels.

Partnerships and Interconnected Network; Engagement with external entities, including universities, research institutions, and innovative AI startups, can significantly augment an organization's AI competencies. Organisations can expedite their AI initiatives and remain informed about emerging trends and technologies by utilising external expertise and resources. Research indicates that these partnerships may result in innovative solutions that enhance competitive advantage and promote a culture of continuous improvement (Mishra & Pani, 2020). The interconnected network of collaboration is essential for organisations aiming to address the complexities associated with AI integration.

Evaluation and Enhancement of AI Performance; Continuous monitoring and assessment of AI applications are essential for ensuring their effectiveness and relevance. Organisations must establish processes for continuous improvement to adapt to evolving market conditions and technological advancements. Stone et al. (2020) emphasise the urgent requirement for research focused on assessing AI performance in strategic marketing decision-making. Establishing metrics for success and conducting regular reviews of AI initiatives enables organisations to pinpoint areas for improvement and confirm that their AI investments achieve the intended results.

The discussion emphasises the complex nature of AI integration within organisations, illustrating its capacity to improve performance alongside ethical and leadership challenges. Organisations can effectively navigate complexities and leverage the transformative potential of AI to enhance work performance and employee behaviour by implementing a strategic approach and cultivating a culture of innovation. This systematic review offers insights that augment the current body of knowledge and presents practical implications for organisations aiming to improve their AI capabilities.

## 4. Conclusions

This study offers a thorough analysis of the impact of artificial intelligence (AI) on enhancing work performance and employee behaviour, based on a systematic review of the current literature. The findings emphasise the significant potential of AI in diverse organisational areas, demonstrating its ability to improve operational efficiency, foster innovation, and enhance customer satisfaction. As artificial intelligence evolves, businesses must strategically improve their AI capabilities to sustain a competitive edge in a progressively digital environment.

The literature identifies several critical domains in which AI integration can markedly enhance organisational performance. The implementation of AI in automation, predictive analytics, and personalised customer experiences has proven effective in optimising operations and improving service delivery. Enholm et al. (2021). Utilising AI-driven quality assurance systems enables organisations to

reduce errors and enhance product quality, consequently promoting customer loyalty. This is consistent with the research conducted by Han et al., which highlights the significance of AI in fostering marketing innovation and improving customer relationships (Han et al., 2021).

The importance of significant investment in technological infrastructure is paramount. Organisations should prioritise investments in cloud computing, big data analytics, and high-performance processing capabilities to effectively support AI applications. Reim et al. emphasise that comprehending and enhancing organisational capabilities in conjunction with AI integration is essential for successful digital transformation (Reim et al., 2020). This investment improves operational capabilities and enables organisations to respond effectively to market demands.

The development of AI competencies within the workforce is essential for successful AI implementation. Research indicates that organisations ought to establish training programs for employees and proactively recruit AI specialists to develop a proficient workforce capable of utilising AI technologies (Ramachandran et al., 2022). Mikalef et al. assert that cultivating a culture of continuous learning and adaptation is crucial for organisations aiming to enhance their performance via AI (Mikalef et al., 2023). Investing in human capital enables organisations to improve their AI capabilities and foster innovation.

Data management is essential for the effective integration of AI. Organisations should prioritise the collection and analysis of extensive datasets, while maintaining data privacy and security measures. Effective data management practices enhance the accuracy of AI-driven insights and foster customer trust in data handling (Mikalef et al., 2023). This is especially significant in a time when data privacy issues are critical, and organisations need to address the complexities associated with ethical AI implementation.

The establishment of a coherent AI strategy that aligns with organisational objectives is crucial for directing AI implementation initiatives. Organisations should cultivate leadership support and encourage a cultural shift that integrates AI as an essential element of their business model. Perifanis and Kitsios emphasise that the incorporation of AI into business strategies presents significant potential for establishing competitive advantages (Perifanis & Kitsios, 2023). Articulating a clear vision for AI integration enables organisations to effectively mobilise resources and foster a shared understanding of AI's benefits throughout all organisational levels.

Engagement with external entities, including universities, research institutions, and pioneering AI startups, can significantly augment an organization’s AI competencies. Organisations can enhance their AI initiatives and remain informed about emerging trends and technologies by utilising external expertise and resources (Benbya et al., 2020). The interconnected network of collaboration is essential for organisations aiming to address the complexities associated with AI integration.

Continuous monitoring and assessment of AI applications are essential for ensuring their effectiveness and relevance. Organisations must establish processes

for continuous improvement to adapt to evolving market conditions and technological advancements. Stone et al. highlight the urgent requirement for research focused on assessing AI performance within strategic decision-making environments (Stone et al., 2020). Establishing metrics for success and conducting regular reviews of AI initiatives enables organisations to pinpoint areas for improvement and verify that their AI investments achieve the intended results.

The incorporation of AI into organisational practices offers both advantages and obstacles. Organisations can effectively harness the transformative power of AI by adopting a strategic approach to implementation, investing in technological infrastructure, developing workforce competencies, and fostering collaborative partnerships. This systematic review offers insights that enhance the existing body of knowledge and provide practical implications for organisations aiming to improve AI capabilities and optimise work performance and employee behaviour.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# HOW TO INCREASE THE FUNCTIONS OF ARTIFICIAL INTELLIGENCE IN BUSINESSES

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***Abstract***

*Artificial intelligence (AI) is a revolutionary technology with far-reaching implications for humanity across all disciplines. Businesses must enhance their AI capabilities to ensure customer satisfaction and gain a competitive advantage. Key measures to improve AI utilization include: AI Integration and Application Areas; Automation is increasingly used in customer service and production processes, with AI also enhancing prediction and data analytics for forecasting and strategic planning. Additionally, AI helps personalize customer experiences and supports quality assurance systems. AI Investment in Technological Infrastructure; Organizations are investing in cloud computing, big data solutions, and high-performance processors, alongside procuring or developing AI software and related technologies that suit their specific needs. AI Competencies and Training Programs; Businesses are focusing on employee development by implementing training programs that enhance AI-related skills, while also recruiting AI experts and upskilling their existing workforce. Data Management; Effective data management includes the collection and analysis of large datasets, as well as ensuring robust data privacy and security measures. AI Strategy and Vision; Developing a comprehensive AI strategy aligned with organizational goals is crucial, with a focus on fostering leadership buy-in and promoting cultural transformation across the company. Partnerships and Interconnected Network; Collaboration with universities, research centers, and tech companies is essential, alongside forming partnerships with innovative AI startups to leverage new opportunities. Evaluation and Enhancement of AI Performance; Continuous monitoring and evaluation of AI applications ensures they perform optimally, while implementing ongoing improvement processes helps maintain and elevate performance. Enhancing AI capabilities requires not only technological investments but also strategic planning, competence development, and cultural transformation. By focusing on these areas, organizations can fully leverage AI benefits and achieve long-term competitive advantages. This approach provides a comprehensive overview of AI's impact on organizations and offers recommendations for current and future actions.*

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***Keywords**: artificial intelligence, business innovation, digital transformation.*

## 1. Introduction

The advent of Industry 4.0 has marked a significant turning point in the landscape of industrial innovation and sustainability. This new industrial paradigm, characterized by the integration of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics, offers unprecedented opportunities for enhancing sustainable practices across various sectors. Ghobakhloo et al. Ghobakhloo et al. (2021) emphasize that while the potential for sustainable process and product innovation is substantial, it is contingent upon the effective implementation of foundational Industry 4.0 functions, which are critical for achieving sustainable competitiveness in today's market. This assertion is supported by Awan (Awan, 2021), who highlights that the Sustainable Development Goals (SDGs) provide a conceptual framework that can guide manufacturing firms in leveraging Industry 4.0 technologies to foster innovation and sustainability.

Moreover, the role of multi-criteria decision analysis (MCDA) in identifying sustainable investments and projects is crucial for enhancing competitiveness and resilience in the face of evolving industrial challenges. Ali et al. Ali et al. (2023) note that stakeholder engagement is essential for aligning various SDGs, thereby facilitating a more integrated approach to sustainability. This integration is further reinforced by Bilderback (Bilderback, 2023), who discusses the importance of training and development programs that incorporate SDGs into organizational practices, thereby promoting long-term sustainability objectives.

The relationship between innovation and sustainability is multifaceted, as evidenced by Maier et al. (Maier et al., 2020), who conducted a bibliometric review that elucidates the intellectual structure and knowledge development directions in this field. This relationship is not only theoretical but also practical, as seen in the application of sustainable AI, which aims to align technological advancements with ecological integrity and social justice (Wynsberghe, 2021). The synthesis of these insights underscores the critical need for organizations to adopt innovative practices that are inherently sustainable, as they navigate the complexities of modern industrial ecosystems (Schilirò, 2019).

In conclusion, the intersection of Industry 4.0, innovation, and sustainability presents a dynamic landscape that necessitates a comprehensive understanding of the underlying principles and practices. As industries strive to meet the challenges posed by climate change and resource scarcity, the integration of sustainable practices into the core of industrial innovation will be paramount. This integration not only aligns with global sustainability goals but also enhances the overall resilience and competitiveness of industries in an increasingly complex world.

Innovation and sustainability are increasingly interconnected in contemporary applications, as organisations and industries strive to tackle present difficulties and avert future ones. Sustainability aims in creative applications encompass five principal domains: Environmental Preservation, Economic Viability, Social Sustainability, Business Sustainability, and Cultural Heritage Preservation. Seebode et al. (2012) Flores et al. (2018) Innovative techniques are crucial for attaining sustainability objectives, as they provide holistic development from the outset that meets the requirements of both current and future generations. The amalgamation of innovation and sustainability is apparent in these areas, since the adoption of new solutions is essential for achieving enduring sustainability objectives (Seebode et al., 2012).

## 2. Methodology

This study used a systematic review methodology to conduct a comprehensive search of relevant literature concerning the intersection of innovation, sustainability, and the Sustainable Development Goals (SDGs). The systematic review process involved several key stages, including the formulation of research questions, the establishment of inclusion and exclusion criteria, the execution of a literature search, the selection of pertinent studies, and the synthesis of findings.

Initially, the research questions were designed to explore how organizations can effectively integrate sustainability objectives with innovative practices, particularly in the context of the SDGs. The inclusion criteria encompassed peer-reviewed articles, books, and case studies published within the last decade that addressed themes of sustainability, innovation, and the SDGs. Exclusion criteria were applied to filter out studies that lacked empirical evidence or were not directly relevant to the research questions.

A comprehensive literature search was conducted across multiple academic databases, including Scopus, Web of Science, and Google Scholar. The search utilized a combination of keywords such as "sustainability," "innovation," "Sustainable Development Goals," and "systematic review." This approach ensured a broad capture of relevant literature, yielding a substantial number of articles for initial screening.

The selected studies were then analysed using qualitative synthesis methods, allowing for the identification of common themes and insights. For instance, Ghobakhloo et al. Ghobakhloo et al. (2021) provided a detailed examination of the functions of Industry 4.0 that support sustainable innovation, highlighting the importance of leveraging technological advancements to enhance sustainability outcomes. Similarly, Mhlanga Mhlanga (2021) explored the impact of artificial intelligence on poverty alleviation and infrastructure development within the framework of the SDGs, emphasizing the role of innovation in driving sustainable development in emerging economies.

Furthermore, the research incorporated findings from Bilderback (Bilderback, 2023), who reviewed the integration of training for organizational sustainability with the SDGs, identifying best practices and challenges faced by organizations in this endeavour. This literature review also included insights from Ali et al. (Ali et al., 2023), who discussed the implications of sustainability growth and its relevance to the SDGs, reinforcing the necessity for organizations to adopt innovative practices that align with sustainability goals.

The synthesis of these findings revealed a complex interplay between innovation, sustainability, and the SDGs, suggesting that organizations must adopt a holistic approach to effectively integrate these elements. This systematic review not only contributes to the existing body of knowledge but also provides practical implications for organizations seeking to enhance their sustainability practices through innovative strategies.

The synergy between innovation and sustainability has been extensively studied in the literature. Research has found that sustainable innovation, encompassing both environmental and social considerations, is positively related to firm performance. The integration of sustainability as an innovation objective has been shown to enhance innovation efficiency, with eco-innovation and green innovation emerging as key approaches. (Shin et al., 2018)

The relationship between innovation and sustainability has been further examined, with studies demonstrating a strong, positive correlation between the two. These studies highlight the importance of incorporating sustainability considerations into the innovation process, as it enables organizations to develop solutions that address both current and future challenges.

The literature also emphasizes the role of sustainable business models in driving innovation and long-term success. Firms that adopt sustainable practices and align their operations with sustainability goals are better positioned to innovate and stay competitive in the market.

The findings from this research paper underscore the critical role that the synergistic integration of innovation and sustainability plays in addressing the pressing challenges of our time and laying the foundation for a sustainable future.

Sustainability and innovation have become inextricably linked, as organizations strive to develop solutions that address current issues and prevent future challenges. By leveraging innovative methodologies and aligning them with sustainability objectives, remarkable outcomes can be achieved across various industries and domains.

## 3. Discussion

The findings of this study underscore the critical relationship between innovation and sustainability, particularly in the context of the Sustainable Development Goals (SDGs). As organizations increasingly recognize the importance of sustainable practices, the integration of innovative methodologies becomes essential for achieving these objectives. The systematic review revealed that

sustainability objectives can be effectively addressed through innovation across five key areas: environmental preservation, economic viability, social sustainability, business sustainability, and cultural heritage preservation.

Environmental preservation is a fundamental component of sustainable innovation, as emphasised by Ghobakhloo et al. (2021). Their research underscores the critical importance of Industry 4.0 technology in advancing environmental sustainability through increased energy efficiency, optimised waste management techniques, and the promotion of clean energy alternatives. The incorporation of these modern technology not only reduces environmental effect but also produces economic benefits, consistent with the tenets of the circular economy. The enormous potential for sustainable product and process innovation depends on the efficient application of fundamental Industry 4.0 technologies, which are often underutilised across many sectors (Ghobakhloo et al., 2021).

As organisations progressively adopt new technologies, the potential to diminish environmental footprints through innovative practices becomes more substantial. Ghobakhloo et al. (2021) contend that sustainable innovations in processes and products are essential for meeting environmental objectives. By utilising Industry 4.0 technologies like the Internet of Things (IoT) and big data analytics, businesses may optimise resource use, improve energy efficiency, and reduce waste. These technological breakthroughs contribute to environmental preservation and align with global sustainability objectives, emphasising the necessity for a strategic and integrated approach to technology-driven sustainability initiatives.

Economic viability is a crucial aspect in which innovation has a transformative impact. The advancement of green economy models and digital transformation is crucial for fostering sustainable economic growth. Mhlanga (2021) examines the role of artificial intelligence (AI) in promoting economic development in emerging economies through infrastructure enhancement and poverty reduction, thereby supporting various Sustainable Development Goals (SDGs). The convergence of artificial intelligence and sustainability highlights the imperative for organisations to leverage technological innovations that create economic benefits while simultaneously tackling social and environmental issues.

Economic viability is essential to the success of sustainability initiatives over the long term. Organisations ought to implement green economy models that foster sustainable growth and address environmental issues. Bibri and Krogstie (2020) emphasise the significance of smart cities in enhancing economic resilience via innovative technological solutions. With the acceleration of urbanisation, cities must adopt advanced technologies to enhance economic resilience and sustainability. The integration of digital transformation and social entrepreneurship can enhance sustainable economic growth, enabling organisations to maintain competitiveness while contributing to the achievement of the Sustainable Development Goals (SDGs).

Social sustainability is essential, involving progress in education, health technologies, and inclusive innovations. The incorporation of Sustainable Development Goals (SDGs) into organisational training programs, as detailed by

Bilderback (2023), establishes a solid framework for advancing equitable societal development. Aligning corporate training initiatives with sustainability objectives enhances employee engagement and fosters a culture focused on sustainability within organisations. This benefits the organisation and contributes to broader societal goals, illustrating the connection between social and environmental sustainability.

Social sustainability is crucial for promoting equitable development and enhancing the quality of life for individuals in various communities. The advancement of education, healthcare technologies, and the implementation of inclusive innovations are essential elements of this initiative. Bilderback (2023) highlights the necessity of integrating the SDGs into organisational training to enhance employee empowerment and promote social sustainability initiatives. Aligning corporate goals with social sustainability enables organisations to generate significant impacts in their communities, ensuring that innovations effectively tackle social challenges and foster inclusivity.

Business sustainability is fundamentally connected to the implementation of sustainable business models and ethical governance practices. The results indicate that organisations that prioritise sustainability in their core operations are more likely to attain long-term competitiveness. Ali et al. (2023) emphasise that multi-criteria decision analysis (MCDA) can aid organisations in identifying sustainable investments and projects. This analytical method enables organisations to assess the potential effects of their decisions on different stakeholders, ensuring the integration of sustainability considerations into the decision-making process.

Embedding sustainability into business models and governance frameworks enables organisations to cultivate a culture of sustainability. This strengthens commitment to long-term sustainability goals and enhances resilience in a rapidly evolving market. Ali et al. (2023) illustrates that utilising tools such as MCDA allows organisations to make informed and balanced decisions that align with stakeholder expectations and broader sustainability goals, thereby enhancing adaptability and competitiveness in the marketplace.

The preservation of cultural heritage is a critical component of sustainability that warrants increased focus. Preserving traditional practices and fostering cultural diversity are essential for sustaining cultural identity within sustainable development frameworks. This aspect of sustainability emphasises the necessity for a comprehensive approach that incorporates environmental, economic, social, and cultural factors.

Incorporating cultural heritage preservation into sustainability initiatives enables organisations to improve their contributions to sustainable development and promote a sense of community and belonging among diverse populations. Integrating traditional knowledge and practices with innovative solutions enables organisations to preserve cultural heritage and promote sustainable progress. This approach guarantees that sustainable innovation embodies the diverse cultural contexts that enhance societal resilience and vibrancy.

In conclusion, the synergy between innovation and sustainability is evident across these domains, demonstrating that innovative methodologies are crucial for achieving sustainability objectives. The integration of these concepts can lead to remarkable outcomes across industries, as organizations adopt comprehensive strategies that align with the SDGs. Future research should continue to explore the dynamic interplay between innovation and sustainability, particularly in the context of emerging technologies and their potential to drive sustainable development.

## 4. Conclusions

This study's findings emphasise the critical relationship between innovation and sustainability, especially in the context of the Sustainable Development Goals (SDGs). Organisations are increasingly acknowledging the significance of sustainable practices, making the integration of innovative methodologies essential for achieving these goals. This review identifies five key areas where sustainability objectives can be effectively addressed through innovation: environmental preservation, economic viability, social sustainability, business sustainability, and cultural heritage preservation.

Environmental preservation is a fundamental aspect of sustainable innovation. Advanced technologies, including the Internet of Things (IoT) and big data analytics, facilitate the optimisation of resource utilisation, enhancement of energy efficiency, and reduction of waste within organisations. Technological advancements support environmental preservation and align with global sustainability goals, highlighting the necessity for a strategic and integrated approach to technology-driven sustainability initiatives.

The economic viability of sustainability efforts is essential for their long-term success. The advancement of green economy models and digital transformation is crucial for fostering sustainable economic growth. Technologies like artificial intelligence (AI) are essential for promoting economic development through infrastructure enhancement and poverty alleviation, thus contributing to multiple Sustainable Development Goals (SDGs). The integration of AI and sustainability underscores the imperative for organisations to utilise technological advancements that yield economic advantages while simultaneously tackling social and environmental issues.

Social sustainability is crucial for fostering equitable development and improving the quality of life for individuals in diverse communities. Integrating the Sustainable Development Goals into organisational training programs provides a robust framework for promoting social sustainability. Aligning corporate training initiatives with sustainability goals enables organisations to foster a culture of sustainability that enhances both operational efficiency and broader societal outcomes.

Business sustainability is fundamentally linked to the implementation of sustainable business models and the adherence to ethical governance practices. Organisations that integrate sustainability into their core operations are more likely

to attain long-term competitiveness. The application of multi-criteria decision analysis (MCDA) enables organisations to identify sustainable investments and projects, thereby ensuring the integration of sustainability considerations into the decision-making process.

Cultural heritage preservation is an essential component of sustainability that warrants increased focus. Preserving traditional practices and enhancing cultural diversity enable organisations to more effectively contribute to sustainable development and cultivate a sense of community. Integrating cultural heritage preservation into sustainability initiatives allows organisations to ensure that innovations are reflective of diverse cultural contexts, thereby enhancing societal resilience.

In summary, integrating sustainability as a core objective in innovative applications is both a strategic necessity and a moral obligation for contemporary organisations. Organisations can establish a comprehensive framework for sustainable development by emphasising environmental preservation, economic viability, social sustainability, business sustainability, and the preservation of cultural heritage. Future research must further investigate the dynamic interactions among these domains, especially concerning emerging technologies and their capacity to promote sustainable innovation.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# A METHOD FOR CHOOSING THE LOCATION OF PRODUCTION SYSTEMS USING A MULTIDISCIPLINARY APPROACH

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***Abstract***

*Choosing a location for production companies is a complex task due to various factors that influence the choice of both wider (macro) and narrower (micro) locations. A macro location is defined as an area that is most suitable for establishing a company with minimal labor cots, whilst a micro location is a specific place that is part of a macro location where the company will be built. Location is one of the most crucial factors, which in the future will affect the perfomance of the company. This paper presents a method that results in a well-rounded decision-making process, enabling an informed choice of location that aligns with a company's operational needs, financial goals, and strategic vision, ultimately leading to the selection of the most suitable location for production companies. As for the wine production system, where the given method was applied, it was shown that it is of crucial importance to select a suitable location because it is a key factor in such a specific production system. The results underscore the method's effectiveness in identifying the most suitable site for a production facility.*

***Keywords****: location, production system, multi-criteria decision making (MCDM), AHP method.*

## 1. Introduction

Facility location selection is a multi-criteria decision problem and has a strategic importance for many companies (Ertuğrul & Karakaşoğlu, 2008). Companies often opt to set up their factories abroad rather than domestically due to factors such as frequent market changes, the evolution of market economies,

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improved international communication, easier capital flow between countries, and significant disparities in labor costs (Rikalović, 2014).

Geographical information systems (Xu et al., 2020) and other methods make it easier to make decisions about choosing locationsy (Abdel-Basset et al., 2021; Yong, 2006).

Choosing a site for a new winery necessitates clearly defining the criteria that the location must meet. Given that the primary consideration is the raw material over the finished product, it is crucial for the winery to be situated near the vineyard to minimize transportation costs. Therefore, the criteria for selecting the location should prioritize the ability to cultivate grapes of sufficient quality for wine production. The quality requirements for grapes vary by variety, with climatic adaptability being one of the most crucial factors. To determine the most suitable location, it is essential to identify all products that will be manufactured within the production system to ensure the integrity of the production process.

The term "representative product" refers to the primary focus of the company's operations. By defining this product, the necessary location criteria for the company can be established accordingly. In the context of wineries, the representative product should be wine made from grape varieties that are most adaptable to the conditions in Serbia.

### 1.1 Literature review

Identifying the optimal location for a specific purpose is a complex task that demands a multidisciplinary approach and the application of cutting-edge technology. Today, this scientific discipline relies heavily on computers and specialized software to analyze and solve location-related challenges

The choice of location significantly impacts a company's overall risk and profitability (Heizer J. and Render B., 2011).According to Zelenović (Zelenović D, 2003), the process of selecting a location involves:

- Identifying a set of influential factors pertinent to the location selection.
- Predicting and assessing the magnitude, direction, and impact of these factors under specific environmental conditions at a given time.
- Evaluating various potential solutions and selecting the optimal one.

Autschbach proposes a three-step approach to site selection: country selection, preliminary analysis, and detailed analysis of potential sites(Autschbach J, 1997).Goethe suggests a five-stage process: concept development, country evaluation, macro analysis, micro analysis, and decision-making(Goette T., 1994).Based on gathered data, a decision is made regarding the methodology to be employed for selecting both broad and specific locations for the production system. The foundation of all decision-making processes involves the following steps (Monks, 1982):

1. Clearly defining the problem and its parameters.
2. Establishing decision criteria or objectives to be achieved.

3. Formulating relationships between parameters and criteria (model creation).
4. Generating alternatives or actions.
5. Selecting the action that best aligns with the established criteria.

Zak and Weglinski (Zak & Węgliński, 2014) introduced a two-stage procedure for solving logistics center location selection problems.

The Multiple Criteria Decision Making (MCDM) approach is widely used across various fields and disciplines, particularly for resolving location selection challenges(Chien et al., 2020; Løken, 2007; Wang et al., 2018; Zhou et al., 2006).

## 1.2 Methods

When evaluating a broader location for a business, typically referring to the country or region where the business will be established, several crucial factors must be carefully considered:

- Market: Conduct thorough market analysis within the chosen region, including assessment of market size, growth prospects, demand trends, and target demographics. It's essential that the chosen location provides access to your target consumers or clients.
- Workforce: Research the availability of a skilled and qualified workforce with the necessary skills and education pertinent to your business needs. Additionally, examine labor costs and compliance with local labor laws in the prospective country.
- Infrastructure: Evaluate the adequacy of infrastructure crucial for your operations, such as transportation networks, energy supply reliability, communication infrastructure (including internet access), and logistics services.
- Tax Policy: Understand the tax regime in the selected country, as it can significantly impact business costs. Investigate potential tax incentives, subsidies, or other advantages offered to attract foreign investment.
- Regulatory Framework: Familiarize yourself with business regulations, labor laws, environmental protection standards, and other regulatory requirements that could affect operational costs and business conditions.
- Logistical Position: Consider the geographical location of the company in terms of transportation costs and ease of distribution to end-users and other markets.
- Economic Stability: Assess the stability of the economic and political environment in the country, as it can influence business security and long-term planning.
- Cultural Factors: Gain insights into local culture, language, and customs to facilitate effective communication among employees, partners, and customers.

- Competition: Conduct a competitive analysis to understand existing businesses in the target country or region. This assessment helps identify potential challenges and opportunities for your company.
- Risks: Understand hazards such as disasters, political instability, currency risk that may affect business.

Well-studied and analyzed factors will help in choosing a good location for the company.

The narrower location can be selected using various methods, one of which is the Analytical Hierarchy Process (AHP) method, developed by Thomas Satti in the early seventies. The AHP is a decision-analysis toolcreated with the aim of providing assistance to decision makers in solving complex problems (Ćosić I., 2016).

This method represents an adaptation of the linear assignment method and is based on the concept of balance used to determine the overall relative importance of a set of attributes, activities and criteria. This can be achieved by structuring any complex decision problem, involving multiple persons, multiple criteria, multiple hierarchical levels, assigning weights in the form of a series of pairwise comparison matrices.

The modeling process requires 4 stages:

1. Structuring the problem;
2. Data collection;
3. Evaluation of relative weights;
4. Determining the solution to the problem.

After the identified potential alternatives, the choice of the most favorable alternative can be made by considering several criteria imposed by the decision maker.

AHP is a multi-criteria decision-making method that enables consideration of objective and subjective factors in choosing the most optimal location. AHP is based on three principles: decomposition, comparative analysis and synthesis of priorities. The principle of decomposition requires that the decision-making problem should be decomposed into a hierarchy that takes into account the essential elements of this problem (Ćosić I., 2016)

### 1.3 Method for selecting the location of production systems

In order to choose the most suitable location for production systems, it is necessary to follow the given steps. The authors of this paper defined the steps described in the given method based on their experience.

Figure 1 shows the mentioned model for choosing a company location.

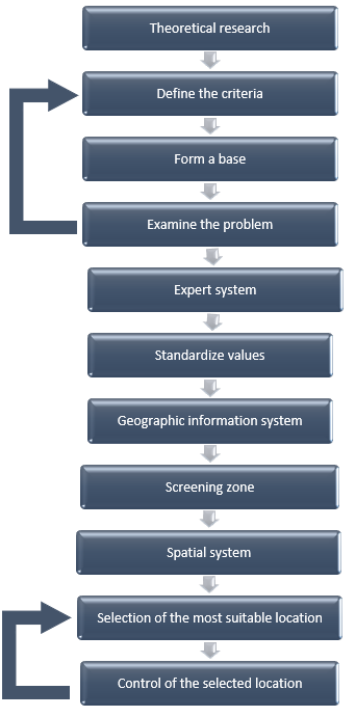


*Figure 1: A model for choosing a company location*

The results indicate that following the outlined steps for choosing a company location leads to the most suitable site for optimal business performance. Drawing from our analysis of real systems, we have developed a model that guarantees a high-quality selection of company locations:

- A theoretical research on the influence (factors) on the choice of location of the production system;
- Defining decision criteria;
- Forming a unique database of spatial data;
- Examining all possible problems and how they affect the production system and its location;
- Developing an expert system for decision support;
- Standardising the values of all relevant factors for choosing the location of the production system;
- Developing a functional geographic information system for the area of interest;
- Screening zones of interest in order to generate alternatives;
- Developing a spatial system for decision support;

- Performing a mutual evaluation of the criteria using the method of multi-criteria analysis and choosing the most suitable location for the production system;
- Minimizing changes to criteria and parameters to control the selected location.

## 2. Case study analysis of a wine production system

There are numerous factors that can influence the quality of grapes. Below, we will present the key conditions that a location in the Republic of Serbia must meet for opening a winery with a vineyard:
**Exposure and slope:** hilly area with south, southwest, southeast exposure; slope up to 10o;
**Altitude:** 100 - 300m;
**Temperature:** It should not drop below -20°C in winter or exceed 40°C in summer, as these are critical thresholds. Ideally, winter temperatures should range up to -10°C, and summer temperatures should be between 30°C and 35°C. For optimal yield, temperatures during the fruit ripening period should be between 20°C and 30°C.
**Precipitation:** An annual precipitation of 700 to 800 mm is optimal."
**Winds:** Winds in our country do not exceed the permitted limits, the average speed of the strongest wind that blows in these areas, košava, is 25-45 km/h, which the vineyards can handle;
**Light intensity:** The optimal area receives approximately 2,000 hours of sunlight per year;
**Land:** The land must not be swampy, and ideally, there should be no groundwater. It should not have been previously used by industry, and perennial woody plants (such as vineyards, orchards, forests, or bushes) should not have been planted before;
**Areas required:** A total of 7 hectares is needed—5 hectares for vineyards and 2 hectares for supporting buildings. It should be noted that the vineyard and facilities will be located on the same plot;
**Infrastructure: Road access, electricity connection, drinking water, and communal waste services are required.**

Before embarking on the research to identify potential locations for opening a winery, it is crucial to gather comprehensive information to ensure the selection of the most suitable site. The essential information required includes: technological procedures for wine production, land requirements and spatial layout.

A decision tree can also be used to select regions of interest. It is a decision support tool that uses a tree graph or model of decisions and their possible consequences, including chance of event outcomes, resource costs, and utility. Figure 2 shows the decision tree for selecting a region of interest based on the previously mentioned criteria for selecting a location for opening a new winery.

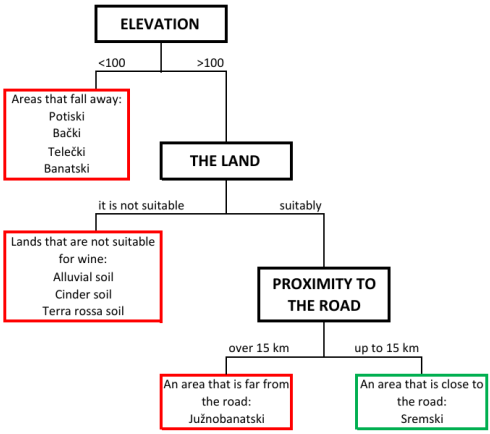


*Figure 2: Decision tree when selecting a region of interest*

## 2.1 Plot screening

To select a good area in various areas, screening is usually done in order to find the area that best matches the conditions that are important for location selection (Cazzaro et al., 2022).

In order to select the narrowest location of the winery, it is necessary to screen the plots of the selected wine-growing region.

In order to select plots that are suitable for opening a winery next to the surface, the important characteristics of the plots are:

- Land type (agricultural, construction site) and its purpose (what is currently grown on the plot and what the land class is);
- Infrastructure (is the plot located next to the main road or does it need to build an access to the winery, does it have access to electricity and water);
- Price (sale price of land);
- Labor availability according to data on the percentage of the working-age population by municipality.

Figure 3 shows the screening of the Srem region.

**There are no sources in the current document.**The screening of the Srem region was carried out along the entire southern side of Fruška Gora in a length of 56 km, the plots were selected based on their locations and crucially their sizes in order to avoid the need for consolidation of smaller plots. Due to the previously defined factors, parcels from three municipalities were finally considered: Inđija, Irig and Šid.

The problem being addressed was selecting the location for the new winery, with the initial focus on finding the best site for planting a vineyard. For the final product wine to be of top quality, the raw materials must also be of top quality.

Therefore, the search for a location was conducted with a primary emphasis on vineyard planting.

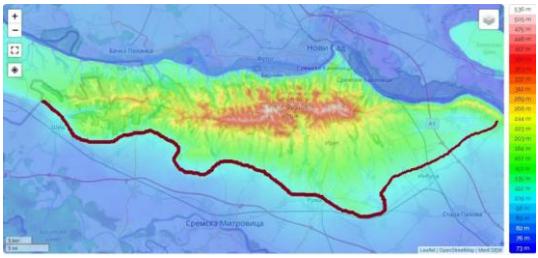

*Figure 3: The screening of the Srem region*

## 2.2 Results

The AHP method shown in Figure 4 was used to select the narrowest location, which is used to obtain a plot of land that is most suitable for planting vineyards and building a production system for wine production.

| Alternative | Ratings |
|---|---|
| A1 | 0.068 |
| A2 | 0.094 |
| A3 | 0.059 |
| A4 | 0.08 |
| A5 | 0.068 |
| A6 | 0.165 |
| A7 | 0.08 |
| A8 | 0.128 |
| A9 | 0.159 |
| A10 | 0.099 |

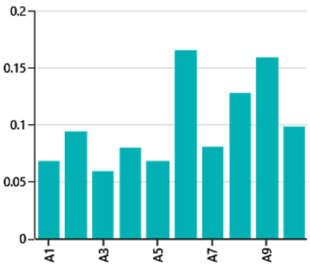


*Figure 4: Selecting a narrower location*

In the case study, it was necessary to choose the most suitable location for the cultivation of the most widespread white grape variety - Chardonnay.

It was decided that the location of the winery would be the same as the location of the vineyard in order to minimize transport costs.

The decision was made that the region of interest is AP Vojvodina, and by applying the decision tree, the region that is most suitable for finding a narrower location is the Srem region.

Within the Srem region, sub-regions with a potential closer location are: Šid (western sub-region) and Irig and Inđija (eastern sub-region).

The AHP method was used for the final determination of the narrower location. 5 criteria for selecting a narrow location are: plot area, land type and purpose, plot price, infrastructure and available workforce.

Using the criterion preference matrix, it was decided that the most important criterion for choosing a plot is the type of land and purpose. By comparing the

alternatives according to the criteria, the final selection of the narrower location is the alternative A6.

## 3. Conclusions

This paper presents a method that has proven effective for choosing a company location. One of the most important factors in building and advancing a company is its location, influenced by numerous factors. To ensure the final choice is well-informed, it is essential to implement the appropriate steps presented and explained in the method.

The method is specific in that it has the ability to "roll back" to check previous steps and ensure that the most suitable location for the production system has been selected.

It was tested on a case study that was very demanding and specific. Through the given case study (production system for wine production) it was shown that the method is effective and that it contributes to good results that are visible immediately, but which will only be examined and verified in the future. Attempts were made to skip a step in the method and the results were far worse than when the method was followed in the given order.

## 4. Acknowledgments

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# IMPLEMENTATION OF KAIZEN MANAGEMENT IN E-COMMERCE

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***Abstract***

*The rapid growth of e-commerce has become a significant part of the global economic paradigm, especially with the rise of digitalization and internet accessibility. Kaizen management plays a crucial role in Japanese companies across various industries, including e-commerce. In contrast, Serbia's e-commerce sector faces challenges that disrupt its ability to meet international standards of quality and speed. By implementing Kaizen principles alongside Lean methodologies, that focus on waste elimination and process optimization, the research proposes strategies for enhancing the efficiency of Serbian e-commerce platforms. The findings suggest that adopting Kaizen can lead to significant improvements in Serbia's online trade sector, driving continuous improvement and long-term growth. This interdisciplinary approach, inspired by Japanese excellence, holds the potential to revolutionize Serbian business practices, making them more sustainable and competitive.*

***Key words:*** *Kaizen, e-commerce, continuous improvement, Lean, process optimization*

## 1. Introduction

In recent years, e-commerce has become a key part of the global economy, with digitalization, internet accessibility, and growing digital literacy driving its expansion. As online platforms rise to prominence, effective management of these operations becomes crucial for maintaining a competitive edge. Kaizen, the Japanese philosophy of continuous improvement, is key to optimizing business processes.

Japanese companies, known for their efficiency and innovation through Kaizen, provide a valuable model for optimizing business operations across various industries, including e-commerce. While Serbia's online market is growing, it still faces challenges in meeting international standards of efficiency and quality.

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Serbia ranks mid-level in global e-commerce penetration, despite being more developed than other higher-ranked countries. This can be attributed to cultural factors such as a mistrust of online transactions, a preference for cash payments, and skepticism, especially among the elderly. (Ljubicic & Stokic, 2024).

This paper aims to analyse the Kaizen-driven Japanese model, identify inefficiencies in Serbian e-commerce, and propose improvements using Kaizen and Lean techniques. Serbia could harness these principles to transform its online platforms, fostering both competitiveness and continuous improvement.

## 2. Literature review

### 2.1 Kaizen management

Kaizen is a Japanese management approach centred on making continuous improvements through small, incremental steps and ideas. Its goal is to enhance labour productivity, business efficiency, product and service quality, as well as overall operational and financial performance (Janjic et al., 2019). Kaizen originates from two Japanese words: Kai (change) and Zen (good), which means "change for the better," or continuous and gradual improvement of every activity with the aim of creating more value and reducing waste (Project Management Srbija, n.d.). Kaizen can be defined as the principle of continuous productivity and constant quality improvement that never stops.

The Deming Cycle, also known as the Deming Wheel or the PDCA Cycle, is named after William Edwards Deming, who introduced this concept to Japan in the 1950s. This cycle represents a methodology for applying Kaizen and consists of four steps: Plan, Do, Check, Act (Lean Enterprise Institute, n.d.).

### 2.2 E-commerce in Japan

Japan represents the third-largest e-commerce market in the world, following China and the United States (Statista, 2023). The leading e-commerce platforms in Japan are: Rakuten Ichiba, Amazon Japan, DMM.com, Mercari and Yahoo! Shopping (Ulpa, 2024). Many Japanese consumers favor shopping from trustworthy local e-commerce companies, with only 10.2% opting to buy from international sellers (ClickPost, 2024). E-commerce markets in Japan are very popular, taking up to 60% market share and remaining top destinations for daily shopping (Rakuten, n.d.).

### 2.3 E-commerce in Serbia

Driven by the global digital economy, Serbia is experiencing a transformation in the way business is conducted, with a particular emphasis on the growing e-commerce sector. Companies that sell exclusively online are called "dotcom" companies. They don't have a physical presence but operate warehouses and distribution centers. For these companies, the sales channels are their websites.

Some of the leading online stores with a wide range of products on the Serbian market are: Ananas, Shoppster, Bazzar, eKupi, ePlaneta, Maxshop, and DotMarket.

### 2.3.1 Analysis of the current situation

**Growth of e-commerce** - Serbia has seen significant growth in online shopping over the past decade, with more consumers, frequent transactions, and higher spending. However, despite yearly increases, Serbia still trails behind EU countries in e-commerce development.

**Key players in the Serbian market** - It is difficult to find much information about their operations online and attempts to contact these platforms have not been met with responses. This limits the amount of information that can be gathered about these platforms, making detailed analysis impossible.

**Visual Presentation** - Visual identity is crucial for brand perception and customer trust. Elements like logos, design, and product images are key. Many Serbian platforms lack professional and intuitive designs, with some even missing an "About Us" section.

**Logistical Aspects** – The mentioned platforms offer external delivery services and allow product returns within a set period.

**Customer Support** - Each company offers its own form of customer support, which may include a contact form, communication channels, or both.

**Reviews** - In the Serbian market, companies receive a mix of positive and numerous negative reviews, often related to long response times, delayed deliveries, or poorly delivered products.

### 2.3.1 Challenges

The biggest challenge for online retailers is providing security to consumers, ensuring the privacy of the data that customers leave in online stores, and establishing a trusting relationship with buyers (Matovic et al., 2013). E-commerce platforms are prime targets for cybercriminals, who continually develop new hacking methods. Among consumers, there is a prevailing fear of losing personal data, fraud, and a lack of understanding of protection mechanisms. Illegal activities like data misuse, online fraud, and identity theft highlight the need for strict regulations to ensure robust legal security and protection (Randjelovic, 2015). Many prefer cash payments and in-person shopping, especially among the older population, who are not keen on using cards and the internet. This mentality slows the growth of e-commerce penetration in Serbia (Ljubicic & Stokic, 2024).

## 3. Case study: Rakuten Group Inc.

Rakuten is a Japanese e-commerce giant that gives retailers the opportunity to sell directly to consumers in various categories, including electronics, clothing, accessories, home equipment, cosmetics, and more. It was established in 1997 by

Hiroshi Mikitani, centered around the online retail marketplace Rakuten Ichiba (ClickPost, 2024).

### 3.1 Kaizen in Rakuten

Rakuten upholds high quality in its operations by ensuring high standards in its products and services. Rakuten's corporate philosophy represents a system of values, mission, and practices known as **Rakuten Shugi** – Rakuten basic principles.

Some of the Kaizen principles practiced by Rakuten include:

**Voice of the customer** - Rakuten uses feedback from social networks and call centers to address customer issues. Actions include adding chatbots for inquiries, expanding payment options, and establishing a UX Research Room in 2013 to gather direct customer feedback (Rakuten, n.d.). Loyalty programs are popular in Japan, and Rakuten incentivizes users with points through its SPU (Super Point Up) program, offering more points based on the number of services used. Offline, Rakuten points can be earned and spent at around five million locations across Japan (Rakuten Card, n.d.).

**Involving employees** - One of the three, but also the first on the list of focuses that Rakuten highlights, is the focus on employees: "Growing with our employees". Rakuten empowers people and society through innovation (Rakuten, n.d.).

**Asakai** - Rakuten's weekly Monday meeting, fosters unity by sharing business progress, best practices, and trends. It helps employees understand broader strategies and encourages cross-department collaboration through Yokoten (horizontal deployment) (Rakuten, n.d.).

**Training and development of employees -** Rakuten supports employee growth through training, skill development, and retraining, aiming to be a "learning organization." Key development steps are goal setting, 1-on-1 meetings, training programs, the Internal Open Position System, the Expert Certification Program (Rakuten, n.d.).

**Teamwork** - Rakuten values diversity and believes collaboration is key to turning it into a strength, with all employees working as one team.

**Continuous improvement** - Rakuten uses NPS® (Net Promoter Score) surveys to measure and improve customer loyalty. Since 2018, Rakuten has outperformed competitors, holding a 7.9-point lead by the end of 2022 (Rakuten, n.d.).

## 4. Implementation of Kaizen in e-commerce in Serbia

The rapid development of e-commerce in Serbia demands innovative approaches to address the complex market requirements and ensure competitiveness. While Kaizen was initially linked to the automotive industry, its principles can now be applied to all areas of business, including the digital economy.

Lean methodologies can help e-commerce in Serbia to optimize resources and enhance user experience. The combination of these two approaches, Kaizen and

Lean, has the potential to improve business efficiency and contribute to sustainable market growth in Serbia.

### 4.1 Quality goals

To improve and maintain quality in e-commerce, the goals are focused in three directions or general objectives:

1. **Increasing customer satisfaction** is key to the success of e-commerce, as satisfied customers not only return but also recommend the platform to others.
2. **Improving employee efficiency** is of great importance as it leads to increased business success. It plays a key role in ensuring smooth operations and delivering high-quality services
3. **Enhancing service** is aimed at providing exceptional service, that will satisfy customers and motivate them to return.

### 4.2 Efficient implementation of Kaizen with a Lean approach

Lean is an organizational approach that strives for maximum efficiency in all activities, minimizing the use of resources while simultaneously delivering top-quality products or services. Lean is not just a business model but a long-term commitment to continuous improvement, making the organization agile, adaptable, and capable of achieving exceptional results.

#### 4.2.1 Identification and Elimination of Waste

In this step, the foundation is to first define what constitutes value for the customer. To understand value, we must consider the product of the company's efforts and what the customer gains from it.

The next step is creating a value stream mapping (VSM), which visualizes all steps in the service delivery process, providing a clear picture of the arrangement and flow of activities.

Activities are categorized into three groups:

**Value-added (VA)** - activities that create customer value.

**Necessary non-value added (NVA)** - activities that don't create value but are essential.

**Non-value added (NVA)** - activities that don’t create customer value.

This categorization helps identify the steps that directly contribute to the quality and customer experience, as opposed to those that do not add value and often result in wasted time and resources. Once the third group of activities is eliminated, efforts can be focused on the remaining value-added activities (Womack & Jones, 2003).

### 4.2.2 Employee involvement

Rakuten applied Toyota's continuous improvement concept to its employees, fostering growth and improvement. Serbian online stores could enhance their businesses by adopting this approach. After identifying and mapping activities and waste, employees should be involved in proposing solutions, strengthening their sense of belonging. It's crucial to review suggestions, provide feedback, and encourage further ideas, even if not immediately implemented. Offering training, support, and recognition—through incentives, praise, or promotions—keeps employees motivated and engaged in the process.

### 4.2.3 5S

5S is a systematic approach used in Lean manufacturing to improve efficiency. It consists of five key principles: Sort, Set in order, Shine, Standardize, and Sustain.

In the context of e-commerce in Serbia, the 5S can be applied as follows:

1. Sort: Review and remove outdated or unpopular products from the online platform and organize digital documentation to ensure easy access to important information.
2. Set in order: Optimize product listings for easier customer access and streamline digital tools and workspace for better efficiency.
3. Shine: Regularly clean and maintain the online platform, ensuring all information is current and links are working, and keep digital resources well-organized.
4. Standardize: Establish standards for adding new products, packaging, and delivery processes to ensure consistency, and create guidelines for organizing digital documents and communication.
5. Sustain: Implement routines for regularly applying the 5S principles to maintain long-term efficiency, provide training on their importance, and foster ongoing awareness of organization and cleanliness.

Applying 5S in e-commerce enhances efficiency, reduces waste, and creates a more organized environment, positively impacting customer satisfaction and employee productivity.

### 4.2.4 Monitoring KPIs

KPI (key performance indicator) is a measurable metric used to track progress toward specific goals. Companies should select KPIs for conversion rates, page load times, customer and employee satisfaction, order volumes, delivery efficiency etc. By analyzing KPIs, businesses can identify areas for Kaizen improvements, focusing on small changes that boost efficiency and customer satisfaction, especially in Serbia's e-commerce sector.

### 4.2.5 Communication with customers

Effective customer communication is essential for maintaining a Kaizen culture. Regular feedback collection helps identify areas for improvement and tailor products to meet customer expectations. Direct communication allows quick issue resolution, fosters innovation, and builds trust through loyalty programs like cashback. Consistent interaction also keeps companies agile, enabling them to respond swiftly to changing customer needs.

## 5. Case study: Ananas

Ananas e-commerce is one of the leading e-commerce platforms in Serbia. Founded in 2021 by Delta Holding, to connect buyers and sellers on a regional online shopping platform. The company does not have a formalized methodology for process improvement, a structured Kaizen approach, but the philosophy of continuous improvement is ingrained in the daily activities of its employees.

**Innovation and employee engagement -** A cornerstone of Ananas's operations as a new business is innovation. Product managers gather and develop ideas based on research, user feedback, and trends, with internal teams handling technical implementation. Ananas also encourages employees to propose AI ideas to enhance business processes. Through this approach, Ananas effectively implements one of the Kaizen principles, "Empower your people".

**Enhancing customer experience -** Ananas conducts surveys and workshops to improve customer experience, with employees suggesting platform enhancements. The company place the customer at the center of every business decision, referring to them as "king" and "queen."

**Loyalty program and service development -** Ananas has developed the A+ loyalty program, which offers customers free delivery and continually works to expand and enhance the program's benefits.

**Performance indicators -** Key performance indicators monitored by Ananas include number of sessions, page views of products, gross merchandise value (GMV), average order value (AOV), number of orders, and number of users.

While Ananas does not have a formalized Kaizen methodology, it applies certain Kaizen principles through improvements and innovations in its operations. This approach enables the company to grow and maintain competitiveness in the Serbian e-commerce market. To maximize the benefits of Kaizen principles, Ananas should integrate Kaizen principles into daily operations and its corporate culture. Introducing a Kaizen culture would further enhance the company's competitiveness and ensure sustainable growth.

## 6. Conclusion

The application of Kaizen principles in e-commerce can significantly enhance operational efficiency, customer satisfaction, and overall competitiveness. By examining the success of Rakuten and addressing the challenges present in Serbia's e-commerce sector, adopting Kaizen methodologies offers substantial potential for improvement. However, a key limitation of this study lies in the absence of direct data from more Serbian e-commerce firms, which limits the practical assessment of Kaizen's implementation in this context. Financial and infrastructural constraints also need further exploration. Future research should dig deeper on how Kaizen can be adapted to Serbian e-commerce platforms. Case studies and quantitative analysis of customer satisfaction and operational efficiency would provide clearer evidence of its long-term impact and feasibility in the Serbian market.

## 7. Acknowledgments

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# FLEXIBLE BATTERY CELL TESTING OF GEOMETRICAL PARAMETERS TO IMPROVE THE SUSTAINABILITY OF BATTERIES OVER THE ENTIRE LIFE CYCLE

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***Abstract***

*Ensuring the sustainability of battery production and usage is critical in today's energy landscape. The battery lifecycle demands 100% inspection of battery cells to optimize resource utilization and minimize waste. Establishing geometrical tolerance limits is crucial due to the lack of previous empirical data. Only by combining geometrical, gravimetric, electrical, and chemical parameters can a comprehensive condition assessment of battery cells be achieved. Setting tolerance limits too narrowly leads to high rejection rates, affecting both cell production and subsequent assembly into modules and packs. A flexible cell tester that inspects the geometrical conditions of battery cells is essential. This system adapts to a rapidly changing product portfolio and functions as a mobile device. The tester is useful not only in battery production but also for state estimation for second-life applications, significantly contributing to the sustainability of the battery lifecycle. The need for the inspection of geometrical battery cell parameters is given by the product specific deviation of dimensions. As the demand for batteries grows and the need for environmentally friendly production methods increases, the cell tester ensures efficient and sustainable battery cell production and utilization. This represents a crucial step toward a more sustainable future, meeting the dual goals of efficient production and waste minimization.*

***Key words****: battery cell inspection, flexible cell tester, geometrical parameters, production efficiency, resource optimization, second-life applications, sustainable battery lifecycle, waste minimization.*

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# 1. Introduction

The automotive industry is undergoing a profound transformation driven by the global shift toward electromobility, which includes electric vehicles (EVs), hybrid vehicles, and plug-in hybrid vehicles (Wu et al., 2023). The current landscape of electromobility is marked by rapid innovation, technological advancements, and growing acceptance of electric vehicles in the mainstream market (International Energy Agency, 2024). Governments and regulatory bodies worldwide are implementing stringent emissions standards and offering incentives to accelerate the adoption of cleaner, electric transportation, leading to significant research and development efforts in battery technology, charging infrastructure, and electric vehicle design (European Commission, 2023, 2024). This transition has also catalysed a broader ecosystem transformation, with major automotive manufacturers making substantial investments in electric vehicle platforms (Volkswagen, 2024) and new entrants challenging traditional automotive giants (Dau et al., 2022). Additionally, the entire value chain, including suppliers, infrastructure developers, and energy companies, is adapting to the evolving demands of electric mobility (World Economic Forum, 2019).

Amidst this rapidly changing environment, the diversity of battery cell manufacturers, cell types, and technologies presents significant challenges (Neef et al., 2022). Variability in cell parameters, has become a critical issue, as the tolerances between cells are often high. Ensuring the homogeneity and quality of these cells is essential, especially for their use in the automotive sector. While much of the current research focuses on the electrical and mechanical parameters of battery cells (AVL List GmbH, 2024a; Rojas & Khan, 2022), the importance of 100% inspection of geometrical parameters remains underexplored. The benefits of an automated and flexible testing device specifically designed to assess the geometrical parameters of battery cells is an area that has received relatively little attention in the existing literature. Such inspection is crucial for determining the suitability of cells for integration into battery modules and packs in automotive applications. Testing involves the classification and evaluation of various parameters that impact battery cell performance. This includes not only electrical parameters but also geometrical and mechanical parameters as well as additional parameters like temperatures. (see Figure 1).

The combination of all these parameters helps with the design and optimization of the entire battery system in terms of efficient use of resources. (Tendera et al., 2022).

The primary objective of this study is to highlight the necessity and benefits of geometrical parameter inspection using a universal testing device. This device is designed to accommodate various cell types and formats, making it particularly valuable in prototype development and small-scale production. Furthermore, the flexibility of the device ensures its relevance in a future where battery cell designs continue to evolve.

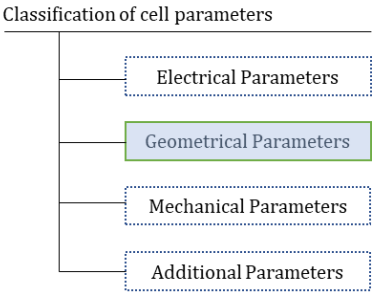


*Figure 1: Classification of cell parameters.*

## 2. Demand for a geometrical cell tester

The general need for testing battery cells can be summarized roughly in following aspects:

- High-quality products: To ensure the production and delivery of high-quality battery products, testing is crucial. Rigorous testing processes help identify and rectify any manufacturing defects or inconsistencies, contributing to the overall reliability of the batteries.
- Safety aspects: Testing plays a pivotal role in assessing the safety features of battery cells. It helps identify potential risks such as overheating, short circuits, or other safety hazards, allowing manufacturers to implement measures to enhance the safety of battery technologies. (Jaguemont & Bardé, 2023; Liu et al., 2020)
- Lifetime concerns: The lifespan of battery cells is essential to evaluate. By subjecting cells to various conditions and cycles, manufacturers can gather data on their durability and performance over time. This information is vital for designing batteries that meet or exceed the expected lifespan requirements. (Schlögl et al., 2024)
- Reuse/Recycling: For batteries intended for reuse or recycling, thorough testing is necessary. Testing helps determine the state of health of a used battery, making decisions about its suitability for second-life applications or the need for recycling. It contributes to sustainable practices within the battery industry. (Schlögl et al., 2024; Wett et al., 2024)

### 2.1 Battery specific information within battery lifecycle

Figure 2 shows a typical battery lifecycle (BLC) for the main application in an EV. A wide variety of information is generated for an energy storage device over the course of its life. Starting with the raw materials used and their origin, through the production of battery cells themselves, their subsequent assembly into battery modules and packs and their integration into the vehicle, the most basic production data has been generated. A cell incoming inspection (CII) is particularly necessary

at the interface between cell production and subsequent assembly into the overall energy storage system. Not only should the minimum requirements of geometrical specifications be checked, but also a further classification into performance classes should be carried out. The aforementioned combination of all parameters provides information about the condition of the specific cell. Clustering aims to install 'identical' cells in modules and packs in the sense of cell balancing and the integration of product data into the production process also enables process and design optimization.

This information is supplemented by data monitoring in the use phase in order to be able to make data-based decisions for potential second life applications. This requires 100% inspection to provide the specific data of each cell for the entire BLC to record condition changes.

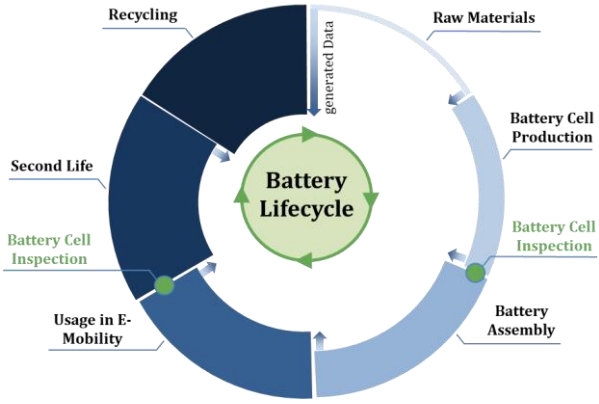


*Figure 2: Data generation in battery lifecycle.*

The data acquisition in the CII is performed from a combination of several sources. In order to be able to define tolerance limits and to generate any proper measurement values at all, the nominal data of the battery cell must be known. Based on this, the permissible deviations and required accuracies can then be defined. During the incoming inspection itself, the measurement data is acquired, which is then used to make decisions about the condition and suitability of the cell for usage in traction batteries (Figure 3).

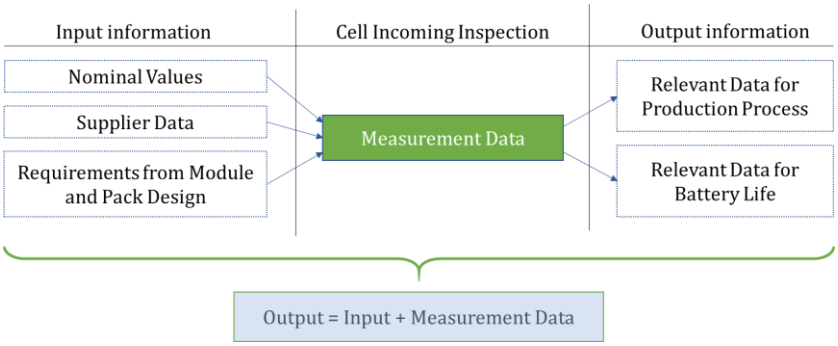


*Figure 3: Information enhancement with measurement data.*

## 3 Geometrical battery cell parameters

To inspect the geometrical parameters, an universal cell tester has been developed that is capable of testing a broad range of battery cell types and formats. This device aims to provide precise and flexible inspection of the geometrical parameters of battery cells, ensuring comprehensive quality assessment.

The battery cells analysed in this study are from various manufacturers and cover the dimensions commonly used in the automotive industry. Nevertheless the focus is on cells used in prototype and small-series production, as seen at the Battery Innovation Center of AVL List GmbH in Graz (AVL List GmbH, 2024b). The testing device is utilized to measure geometrical parameters such as length, width, thickness, and volume. These measurements are automated and performed in real-time, facilitating 100% CII.

The overall requirement on the geometrical cell tester is to inspect battery cells from different cell types and formats. In general three different cell types are used for automotive applications: cylindrical cells, prismatic cells and pouch cells. Following cell dimensions where defined to be inspected with the cell tester to cover the majority of the cells on the market (Neef et al., 2022):

- Cylindrical cells: 18650, 18700, 21700, 33100 and 4680.
- Prismatic cells with lengths of 100 mm to 600 mm, heights of 80 mm to 150 mm and thicknesses up to 50mm.
- Pouch cells with lengths of 140 mm to 600 mm, heights of 90 mm to 180 mm and thicknesses up to 20 mm.

Geometrical parameters vary from cell type to cell type due to the different design, but also differ between manufacturers (Neef et al., 2022). In addition, the geometric specifications of a battery cell are often defined with a wide tolerance range. Table 1 shows an excerpt from representative typical geometrical parameters of a cylindrical cell, their nominal values and the upper and lower tolerance limits. It is also evident that not all geometrical dimensions are quantitatively determined, like battery cell surface conditions.

*Table 1: Excerpt of geometrical parameters of an 18700 cylindrical cell.*

| Properties | Parameters | Unit | Nominal Dimension | Min. Tolerance | Max. Tolerance |
|---|---|---|---|---|---|
| **Cell Case** | Diameter (overall) | mm | 18 | 17,85 | 18,15 |
| | Height (overall) | mm | 69,72 | 69,17 | 70,27 |
| | Height (without terminals) | mm | 67,57 | 67,37 | 67,77 |
| **Terminal** | Neg. terminal diameter | mm | 9,925 | 9,85 | 10 |
| | Pos. terminal diameter | mm | 7,925 | 7,85 | 8 |
| | Neg. terminal height | mm | 0,5 | 0,425 | 0,575 |
| | Pos. terminal height | mm | 0,55 | 0,4 | 0,7 |
| | Condition (defects,…) | -- | -- | -- | -- |
| **Cell Surface** | Scratches | -- | -- | -- | -- |
| | Unevenness, bulges | -- | -- | -- | -- |

As it can be seen in Table 1, an obvious parameter to emphasize is the cell height, as the overall height has in this case a tolerance range of 1.1 mm.

In the course of the CERES project, project partner AVL List GmbH has statistically analysed an extensive data set of several 10000 cells from one cell supplier, where the overall cell height of cylindrical 18700-cells have been investigated. In order to achieve statistical significance, only batches with more than 1000 cells have been examined. Figure 4 shows the cell height deviation in two diagrams, where the cell height in mm is plotted on the respective x-axis in 0.1 mm steps. In the diagram at the left, the cylindrical cells of the same batch are colour-coded. It is evident, that each batch has a different average cell height, but a normal distribution can be identified in almost all batches. In the diagram on the right side, the battery cells of all batches are combined and the overall distribution is shown. A normal distribution can also be seen here, the cell heights vary between 69.2 and 70.3 mm. The number of cells is plotted on the y-axis, so it is clear that a majority of the battery cells analysed have a height of 69.4 to 69.8 mm.

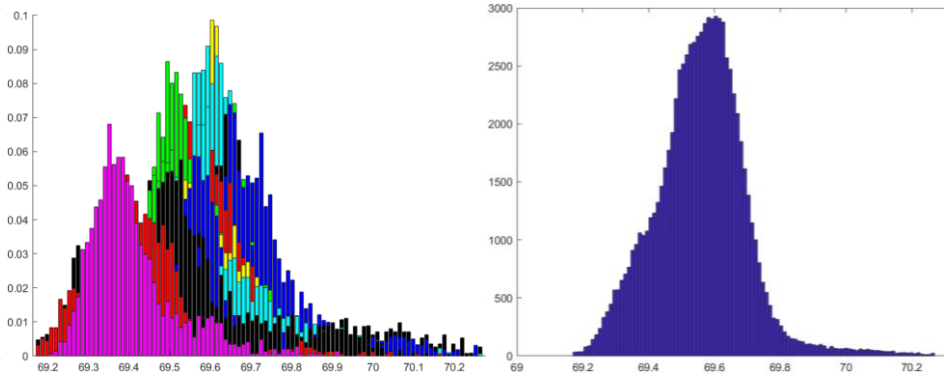


Figure 4: Cell height deviation of 18700 cells of different batches (left) and overall (right).

## 4. Discussion and Conclusion

The study found significant variability in tolerances between cells, underscoring the need for comprehensive geometric inspection. In comparison to previous studies, which have predominantly focused on electrical and mechanical parameters, this research contributes important insights into the necessity of geometrical parameter inspection, particularly concerning the suitability and traceability of battery cells. The findings suggest that geometric inspection is critical for ensuring the quality and deplorability of battery cells in the automotive sector. It allows for the selection of cells with the appropriate properties for integration into modules and packs, ultimately ensuring their successful deployment in vehicles.

This study has shown that a universal testing device for the 100% inspection of the geometrical parameters of battery cells is essential for ensuring the quality and utilization of these cells, not only for incoming inspection in the module and pack assembly but also for assessing the reusability of cells in second-life applications. This makes it possible to reduce the number of rejected cells in the production of first- and second-life applications and minimise the amount of subsequent waste. A potential limitation of this approach lies in the scalability of the testing device for mass production, as the current tests are limited to prototype and small-series production.

Future research should focus on optimizing and scaling the testing device for use in mass production, as well as integrating additional parameters to further enhance quality assurance also using artificial intelligence algorithms for failure detection. In conclusion, this study emphasizes the importance of comprehensive quality inspection for battery cells, especially in a rapidly changing and expanding market. The proposed testing device offers a flexible and future-proof solution, applicable in both prototype development and small-scale production within the whole BLC.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-092 Review paper

# AI-DRIVEN DECISION-MAKING: A REVIEW ABOUT TRANSFORMING PROJECT MANAGEMENT THROUGH ADVANCED TECHNOLOGIES

*Michael Wollweber*[1]

***Abstract***

*Artificial Intelligence (AI) has become a transformative tool in project management, enhancing decision-making processes through advanced data analysis, pattern recognition, and automation. This paper explores the foundations of AI-driven decision-making focusing on its potential in project management. Therefore, established applications for decision-making in various industries, including business, healthcare, and agriculture are highlighted. Within project management, AI's integration is primarily supportive, aiding in resource allocation, risk management, scheduling, and budget forecasting. Recent advancements in AI have improved its accuracy and efficiency, particularly in automating routine tasks and optimizing project workflows. However, AI's limitations remain evident in areas requiring strategic decision-making, interpersonal dynamics, and ethical considerations, where human judgment remains indispensable. As AI continues to evolve, the development of Explainable AI (XAI) and the shift towards predictive and prescriptive analytics are expected to further transform project management. The outlook of project management is likely to see a hybrid model where AI and human decision-makers collaborate to achieve optimal project outcomes.*

***Key words****: Artificial Intelligence, Project Management, Decision-Making, Machine Learning, Neural Networks, Explainable AI, Predictive Analytics, Ethical Considerations.*

## 1. Introduction

Artificial Intelligence (AI) has emerged as a transformative force in various domains, revolutionizing how decisions are made across industries. In project management, the integration of AI has provided sophisticated tools that emulate human cognitive processes, allowing for more efficient and accurate decision-

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making. This paper explores the question: How can AI-driven decision-making optimize project management and where are the limitations?"

To address this question the foundations of AI-driven decision-making, examining key approaches such as rule-based systems, machine learning (ML), and neural networks, each contributing uniquely to the enhancement of decision-making capabilities. Additionally, the paper delves into the practical applications of AI-driven decision-making across different sectors, including business, healthcare, autonomous systems, retail, and agriculture, highlighting how AI supports decision-making processes in these areas. As AI continues to evolve, its role in project management is also expanding, offering new ways to optimize tasks such as resource allocation, risk management, and scheduling. However, despite its strengths, AI also faces limitations, particularly in areas requiring contextual understanding, interpersonal dynamics, and ethical considerations. This paper aims to provide a comprehensive overview of AI's current and potential future impact on decision-making within project management, discussing both its strengths and weaknesses.

## 2. Foundations of Decision Making with AI

AI has revolutionized decision-making by providing sophisticated tools that mimic human cognitive processes. AI-driven decision-making is grounded in algorithms and models that process vast amounts of data to identify patterns, make predictions, and optimize outcomes. Key approaches include rule-based systems, ML, and neural networks. Rule-based systems apply predefined rules to make decisions, while ML models learn from data to improve decision-making accuracy. Neural networks, particularly deep learning models, simulate the human brain's structure to process complex data and enhance decision-making capabilities (Goodfellow, Bengio, & Courville, 2016).

AI systems in decision-making can be categorized into several approaches, each with distinct characteristics and applications, as described by Russell and Norvig (2016). Rule-based systems are among the simplest, relying on a set of pre-programmed rules to make decisions. These systems are straightforward and highly interpretable, as their logic is explicitly defined and easy to follow. This rigidity is also their main limitation, as they struggle to adapt to new data or unexpected scenarios, making them less effective in dynamic environments. In contrast, ML approaches offer greater adaptability by improving decision-making through learning from historical data. Supervised learning models, for example, are trained using labeled datasets, which allows them to make predictions or classifications based on input data. Unsupervised learning, on the other hand, works with unlabeled data, identifying patterns or groupings within the dataset without predefined categories. This ability to learn and adapt from data makes ML a powerful tool in situations where rules-based systems might falter. Neural networks, particularly deep learning models, represent a more advanced approach within AI. These models consist of multiple layers of neurons that process data in a

hierarchical manner, allowing them to excel at complex tasks such as image recognition and natural language processing. The deep learning approach is particularly effective in handling high-dimensional data, where the relationships between inputs and outputs are intricate and not easily captured by simpler models. Reinforcement learning, a subset of machine learning, takes a different approach by training agents to make sequences of decisions through trial and error. The system is rewarded for desirable outcomes, gradually optimizing its decision-making strategy. This method is especially useful in dynamic environments where decisions need to be made continuously and adaptively, as the AI system learns to maximize rewards over time (Russell & Norvig, 2016).

## 3. Applications and Implications of AI in Decision-Making: A Focus on Project Management

### 3.1 Applications of AI in Decision Making

AI is increasingly being integrated into various domains to enhance decision-making processes. Below are examples of AI applications in decision-making across different industries, along with the specific types of AI used in each case.

In business and finance, AI-driven predictive analytics is widely used in financial forecasting and risk assessment, allowing businesses to make informed decisions based on market trends, consumer behavior, and financial data. For instance, AI models can predict stock prices, assess credit risks, and optimize investment strategies. Machine learning (ML) and deep learning are predominantly used in these applications. ML models, particularly supervised learning algorithms, are trained on historical financial data to identify patterns and make predictions. Deep learning models, such as neural networks, are used for more complex tasks like sentiment analysis of financial news, which can influence decision-making (Arenas-Torres et al., 2021).

In healthcare, AI is employed to support diagnostic processes, treatment planning, and personalized medicine. An example is the AI system used at Johns Hopkins Hospital for early detection of sepsis. The Targeted Real-time Early-Warning System (TREWS) analyzes electronic health records, including vital signs and lab results, to identify patients at high risk of developing sepsis, allowing for timely intervention. The AI system uses supervised machine learning models to analyze structured data (e.g., lab results) and natural language processing to process unstructured data (e.g., clinical notes). The combination of these techniques enables the system to make accurate predictions and support clinical decision-making (Johns Hopkins, 2021).

Autonomous vehicles rely on AI to make real-time decisions, such as navigating through traffic, avoiding obstacles, and optimizing routes. AI systems in autonomous vehicles process data from sensors, cameras, and GPS to make split-second decisions that ensure safe and efficient driving. Reinforcement learning algorithms are particularly useful in dynamic environments like driving, where the

AI agent learns to make decisions through trial and error, receiving rewards for safe driving behavior. Deep learning models, such as convolutional neural networks (CNNs), are used for image recognition tasks, such as identifying road signs and detecting pedestrians (Vaswani et al., 2017).

Walmart's AI-driven inventory management system optimizes stock levels by analyzing vast amounts of data, including sales trends, customer preferences, and supply chain dynamics. The AI algorithm predicts future demand, deciding when and how much to reorder for each product, and allocates stock across stores based on local demand patterns. Walmart uses supervised machine learning models to analyze historical sales data and predict future demand. The system employs predictive analytics to optimize inventory levels, ensuring product availability while minimizing waste (Intellias, 2024).

In agriculture, John Deere's precision farming solution leverages AI to make data-driven decisions that optimize agricultural practices. The AI system analyzes data from satellite imagery, weather forecasts, and soil sensors to generate real-time recommendations for farmers on when, where, and how much to irrigate, fertilize, and apply pesticides. The AI system uses machine learning models to process and analyze environmental data (John Deere, 2021).

### 3.2 AI in Project Management Decision Making

AI has increasingly been integrated into project management tools, primarily to provide decision support rather than making autonomous decisions. Recent advancements in 2023 and 2024 have further strengthened AI's role in project management, particularly in areas like task scheduling, resource allocation, and risk management. For example, tools like Microsoft Project, Trello, and Asana have enhanced their AI-driven features, which now offer even more sophisticated predictive insights, automate routine tasks, and provide actionable recommendations based on historical project data (Tarawneh, AbdAlwahed, & AlZyoud, 2024; Taboada et al., 2023).

#### 3.2.1 Decisions That Could Be Done by AI

AI can effectively handle several decision-making areas within project management, particularly those involving data analysis, pattern recognition, and optimization. Some key decisions AI can manage include:

Resource Allocation: Recent studies highlight AI's ability to analyze the availability and productivity of team members more accurately, suggesting optimal resource allocation by considering various factors like workload, deadlines, and skill sets (Tarawneh et al., 2024).

Risk Management: AI continues to evolve in predicting potential risks by analyzing both historical data and current project variables. By identifying patterns that have led to issues in past projects, AI can now forecast risks more precisely and suggest advanced mitigation strategies, such as reallocating resources or adjusting timelines (Taboada et al., 2023).

Scheduling**:** AI's capabilities in optimizing project timelines have been significantly enhanced, especially in its ability to dynamically adjust schedules in response to changes in project scope or unexpected delays. The latest AI models offer improved accuracy by integrating real-time data analysis (Nabeel, 2024).

Budget Forecasting**:** AI's role in budget forecasting has also expanded, with newer models capable of analyzing spending patterns and comparing them with project progress to forecast budget overruns or underspends more effectively. This allows for more proactive financial management and adjustments to keep the project on budget (Taboada et al., 2023).

### 3.2.2 Decisions That Are Not Covered by AI

Despite its capabilities, AI has limitations, and certain types of decisions in project management still require human judgment:

Strategic Decision-Making: High-level strategic decisions, such as setting project goals and defining the project scope, remain beyond AI's current capabilities. These decisions require human intuition, experience, and a deep understanding of broader business contexts, areas where AI still lacks sufficient contextual understanding (Tarawneh et al., 2024).

Interpersonal Issues: Decisions involving team dynamics, conflict resolution, and stakeholder management are other areas where AI is limited. Human emotions, motivations, and the nuances of interpersonal relationships remain challenging for AI to interpret and address effectively (Mallick et al., 2023).

Ethical Considerations: AI still struggles with ethical reasoning, particularly in decisions that involve balancing the interests of different stakeholders or ensuring fairness in resource distribution. The moral framework and societal understanding required for these decisions are areas where AI remains inadequate (Woodgate, 2023).

## 3.3 Discussion about AI in Project Management

AI's integration into project management has brought about significant improvements, particularly in its ability to process large volumes of data rapidly and with high accuracy. Recent studies confirm that AI systems can now analyze extensive datasets to generate insights that would be time-consuming and error-prone if performed manually. This capability has enhanced the accuracy and reliability of project outcomes, making AI an invaluable tool for project managers (Nabeel, 2024). Furthermore, AI excels in pattern recognition, identifying correlations and trends in data that may not be immediately apparent to human managers, which allows for more predictive and preventive decision-making, reducing the likelihood of project delays or cost overruns (Tarawneh et al., 2024).

Another significant advantage of AI is its ability to automate routine and repetitive tasks, such as scheduling, reporting, and resource allocation. The latest advancements in AI have further optimized these processes, allowing project managers to focus more on strategic planning and decision-making, thereby

increasing the overall efficiency and effectiveness of project management processes (Taboada et al., 2023).

Despite these strengths, AI in project management is not without its limitations. A notable weakness is AI's lack of contextual understanding, particularly in strategic decision-making. While AI systems can process data and generate technically optimal recommendations, they often lack the broader business context that is crucial for aligning decisions with organizational goals and strategies (Tarawneh et al., 2024).

Moreover, AI systems are currently ill-equipped to handle the intricacies of interpersonal dynamics, which are vital in team management and stakeholder interactions. The nuances of human emotions, motivations, and relationships are difficult for AI to interpret and manage effectively, making it less effective in situations that require empathy, negotiation, or conflict resolution—areas where human intuition and experience remain indispensable (Tarawneh et al., 2024).

Lastly, ethical limitations present a significant challenge for AI in project management. AI lacks the moral reasoning necessary for making decisions that involve ethical considerations, such as fairness, justice, and the balancing of competing stakeholder interests. As AI continues to evolve, these ethical challenges will need to be addressed, particularly as AI takes on more significant roles in decision-making processes (Woodgate, 2023).

### 3.4 The Future of AI in Project Management

The future of AI in project management is poised to bring significant transformations, particularly in how decisions are made and implemented. Looking forward, several key trends in AI are expected to impact decision-making processes in project management. One of the most significant trends is the development of Explainable AI (XAI). As AI systems become more integral to decision-making, the demand for transparency and interpretability is growing. XAI aims to make AI's decision-making processes more understandable to humans, which is crucial for building trust in AI systems and encouraging their broader adoption in project management (Gunning et al., 2019).

Another important trend is the shift towards AI-driven predictive and prescriptive analytics. While predictive analytics forecasts future trends based on historical data, prescriptive analytics goes a step further by suggesting specific actions to achieve desired outcomes. In project management, this could mean that AI not only predicts potential delays but also recommends interventions to mitigate risks and optimize performance (Bai, Dallasega, Orzes, & Sarkis, 2021).

The future may also see the development of autonomous project management systems where AI independently handles routine and data-intensive tasks such as scheduling, resource allocation, and risk management. These systems could reduce the administrative burden on project managers, allowing them to focus on more strategic aspects of project management. However, this shift will likely change the role of project managers, who will increasingly be required to oversee

high-level decisions, stakeholder management, and ensuring that AI-driven decisions align with broader business goals (Dwivedi et al., 2021; Nabeel, 2024).

Despite these advancements, there are areas where AI might struggle, as described in the previous chapter. Some challenges will further remain. Strategic decisions, such as setting project goals, defining the scope, and making trade-offs between time, cost, and quality, require human intuition, experience, and an understanding of broader business contexts. AI lacks the capability to fully understand these complex, context-dependent factors. Moreover, decisions involving interpersonal issues, such as team dynamics and stakeholder management, are areas where AI's limitations are evident. Human emotions, motivations, and the nuances of interpersonal relationships are difficult for AI to interpret and manage effectively (Dwivedi et al., 2021).

Another critical limitation of AI in project management is its handling of ethical considerations. Decisions that involve balancing the interests of different stakeholders or ensuring fairness in resource distribution require ethical reasoning that AI currently lacks. The increasing reliance on AI in decision-making will likely raise ethical concerns, particularly around bias in AI models, fairness, and accountability. Project managers will need to ensure that AI-driven decisions are fair and unbiased, and that there is clear accountability for AI actions, which may involve developing new ethical guidelines and governance structures for AI in project management (Woodgate, 2023).

The future of project management will likely see a hybrid model where AI and human decision-makers work collaboratively, each contributing their strengths to achieve optimal project outcomes.

## 4. Conclusion

The integration of AI into decision-making processes, particularly within project management, represents a significant advancement in the way complex tasks are handled. AI's strengths lie in its ability to process vast amounts of data quickly, recognize intricate patterns, and automate routine tasks, thereby enhancing the efficiency and accuracy of project management practices. However, AI also has notable limitations, especially in areas where human judgment, intuition, and ethical reasoning are crucial. Strategic decision-making, interpersonal issues, and ethical considerations remain domains where human involvement is indispensable. As AI continues to develop, the future of project management will likely involve a hybrid model where AI and human decision-makers work in tandem, leveraging the strengths of both to achieve optimal outcomes. The ongoing development of Explainable AI (XAI) and the integration of AI with emerging technologies will further shape the landscape of project management, potentially transforming how decisions are made and implemented. Ultimately, while AI offers substantial benefits, it is essential to recognize its limitations and ensure that it complements rather than replaces human judgment in project management.

This study focuses predominantly on AI's role for decisions based on operational tasks, such as scheduling, and risk management. The human-centered areas, such as stakeholder engagement are also critical in project management and require further exploration of how AI can assist or complement decision-making in these domains. Additionally, the fast-evolving nature of AI technology must be considered. AI advancements happen rapidly meaning firstly that theoretical findings may lose relevance and secondly, the longer lasting empirical evidence from real-world AI applications, are still not available in a proper scale. Lastly, this study doesn't address the potential biases in AI algorithms. AI systems can inherit biases from the data they are trained on, leading to skewed decision-making. For future implications, researchers should explore AI's ability to support soft skills like team management, ethical considerations of AI in decision-making and longitudinal studies that track AI's integration in project management over time.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# COMPETITIVE NET-ZERO: A SIMULTANEOUS ENGINEERING APPROACH TO SUSTAINABLE PRODUCT DEVELOPMENT AND MANUFACTURING

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***Abstract***

*The European industrial landscape is undergoing a transformation driven by the dual imperatives of achieving net-zero emissions and ensuring resource efficiency, as outlined in the EU's Net-Zero Industry Act and Critical Raw Materials Act. These regulations mandate the development of net-zero technologies within the EU and the establishment of a circular economy to enhance technological competitiveness and reduce reliance on third countries. The growing demand for 'Made in Europe' products, characterized by high quality, cost-effectiveness, and sustainability, presents a multi-centric design challenge that requires integrating innovative development strategies into engineering practice. This paper advocates the adoption of Simultaneous Engineering in product design, emphasizing the parallel development of products and their manufacturing processes to improve manufacturability, cost-effectiveness, and quality while reducing time to market. It explores methods such as Robust Design and Tolerance Design to effectively manage risk and uncertainty during development and addresses the challenge of multi-centric optimization through the Design for Excellence (DfX) paradigm, which allows for the simultaneous consideration of multiple performance criteria. Finally, it highlights the need to re-evaluate engineering education, advocating for the integration of these methodologies as core competencies to equip future engineers for the challenges of a rapidly changing industry on the path to competitive net-zero.*

***Key words:*** *Robust Design, Tolerance Design, Sustainable Product Development, Design for Excellence (DfX), Simultaneous Engineering*

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# 1. Introduction

The *European Union* has set ambitious goals for the green transformation of its society, economy, and industry, with the aim of achieving net-zero emissions and enhancing sustainability across all sectors. Central to this strategy are legislative measures such as the Net Zero Industry Act and the Critical Raw Materials Act, which establish targets for the production of at least 40% of net-zero technologies, including batteries, wind power, and hydrogen, within the EU by 2030 (European Commission, 2023a, 2023b). These policies seek to reduce reliance on imports from third countries and strengthen the European value chain through competitive mass production and circular economy practices.

A key element of this transformation is the shift from linear production models to a circular economy, which aims to extend product lifecycles and recover valuable resources through strategies such as reuse, remanufacturing, and recycling (Potting et al., 2017). Early-stage product design plays a pivotal role in this transition, as decisions made during the initial design phases can significantly impact a product's environmental footprint and material efficiency (Babbitt et al., 2021). This paper demonstrates how specific design methodologies, including Tolerance Design, Robust Design, and Design for Circularity, can address key challenges in sustainable product development and manufacturing. Two use cases illustrate how these methodologies can be practically applied to enhance competitiveness and support circularity goals in the context of net-zero technologies.

# 2. Literature Review: Sustainable Product Development

Early-stage product design is crucial in shaping a product's environmental footprint, material use, and overall lifecycle management. Decisions made during this phase can determine a significant portion of a product's environmental impact, as highlighted by (Babbitt et al., 2021; Diaz et al., 2021). This chapter explores the methodologies of Design for Manufacturing (DfM) and Design for Disassembly (DfD), which together form a comprehensive approach to Sustainable Product Development (SPD).

## 2.1 Design for Manufacturing: Managing Variability and Ensuring Robustness

Design for Manufacturing focuses on optimizing product development for efficient, high-quality manufacturing processes. It includes methodologies like Robust Design and Tolerance Design, which help manage variability and uncertainty in production. Robust Design aims to create products that are less sensitive to variability, whether from manufacturing inconsistencies or environmental fluctuations (Goetz et al., 2020). By addressing these factors early in the design process, products can be made to perform consistently under various conditions, thus minimizing costly iterations later.

Tolerance Design, as discussed by (Morse et al., 2018), plays a crucial role in managing dimensional variations, setting geometric parameters, and specifying tolerance limits to ensure products meet functional requirements. Early integration of tolerancing into the design phase links product design with manufacturing processes, reducing rework and improving overall product quality. This integration aligns with the principles of Simultaneous Engineering, where the simultaneous development of products and processes enables more efficient and predictable production.

### 2.2 Design for Disassembly: Enabling Circular Economy Strategies

As Europe transitions towards a circular economy, Design for Disassembly (DfD) has emerged as a key methodology for supporting sustainable lifecycle management. The R-strategies framework (Potting et al., 2017), which includes actions like Refuse, Reduce, Reuse, and Recycle, provides a structured approach to prioritizing circularity during the design process. While traditional design practices often neglect circularity, this framework emphasizes strategies that extend product lifecycles and enhance resource recovery (Babbitt et al., 2021).

Implementing DfD principles enables products to be easily disassembled for repair, refurbishment, or recycling, facilitating higher levels of material recovery. However, as noted by (Schlögl et al., 2024), the use of complex joining techniques such as welding and adhesives can complicate non-destructive disassembly, limiting circularity potential. Overcoming these challenges requires integrating circularity considerations into the design process from the outset, as (Shahbazi & Jönbrink, 2020) suggest, by using design guidelines that make products more modular and durable.

### 2.3 Merging DfM and DfD for Competitive Net-Zero Goals

Achieving net-zero objectives while maintaining competitiveness requires a balanced approach that incorporates both DfM and DfD. Simultaneous Engineering offers a strategy to integrate these methodologies, allowing for the concurrent consideration of manufacturing efficiency and circular design principles. For example, (Demartini et al., 2023) argue that circular economy strategies, such as remanufacturing and repair, are essential for managing resource-intensive industries like electric vehicles, where supply chain redesign is necessary to accommodate circular practices. Combining Robust Design, Tolerance Design, and DfD supports SPD by enabling products to be optimized for efficient production while also considering future disassembly and material recovery. By addressing variability during the design phase and planning for circularity, this holistic approach enhances product quality, reduces environmental impact, and strengthens the economic sustainability of manufacturing processes.

### 2.4 The Need for Updated Competencies in SPD

To effectively implement these integrated approaches, there is a need for updated competencies among designers and engineers. As (Sumter et al., 2021) identify, skills such as Circular Systems Thinking, Design for Recovery, and Circular Business Propositions are crucial for aligning product development with sustainability goals. Training programs must focus on equipping designers with the ability to merge DfM and DfD methodologies while considering circularity from the initial stages of development.

## 3. Use Case 1: Battery Module Assembly Through DfM

In the assembly of traction batteries for electric vehicles (EVs), establishing reliable electrical connections between battery cells is essential for the overall performance, safety, and lifespan of the battery system. Cells are typically grouped into modules and connected in series and parallel configurations using busbars, which are welded to the terminals to ensure efficient current flow. Maintaining a consistent joint gap between the cells and the busbar is crucial for high-quality bonding and electrical conductivity. However, variations in the manufacturing process can cause deviations in geometrical dimensions, such as the total cell height, leading to inconsistencies in the joint gap (Figure 8, left). These variations must be controlled to meet the maximum permissible joint gap specified by the bonding process.

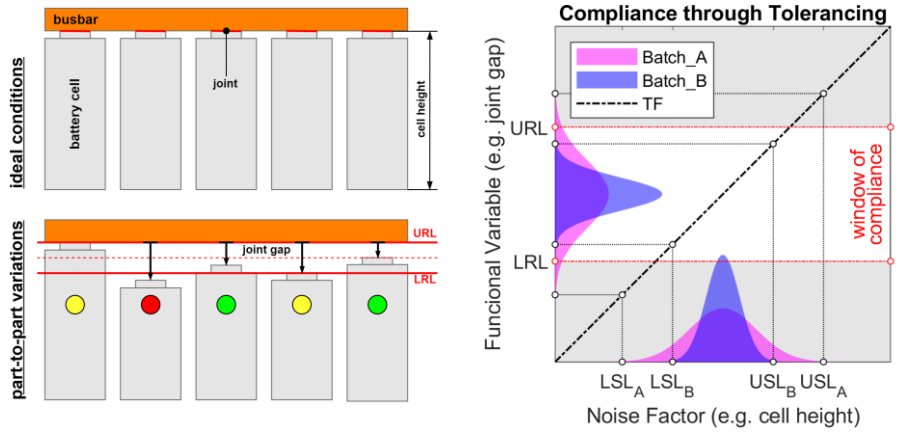


*Figure 8: Part-to-part variations in assembly (l), functional compliance via tolerancing (r)*

As part of the Design for Manufacturing (DfM) approach, one method for addressing this issue is Tolerance Design. This involves tightening the tolerance specifications for cell height in order to reduce the variability in the joint gap. Figure 8 (right) illustrates that Batch A of battery cells leads to a distribution of joint gap values exceeding the functional requirement limits. By tightening the tolerances

(Batch B), the distribution becomes narrower, allowing the joint gaps to fall within the compliance window. While this approach achieves the desired outcome, it can also result in increased manufacturing costs and higher rejection rates due to the stricter tolerances, potentially impacting competitiveness.

Alternatively, Robust Design principles can be applied to reduce the sensitivity of the joint gap to variations in cell height. Figure 9 (left) shows how introducing a modified transfer function (TF_B) with a smaller slope compared to the original (TF_A) results in a less sensitive response of the joint gap to cell height variations. This reduced sensitivity can be achieved, for example, by adding clamping pressure during the bonding process, allowing the busbar to deform and thus minimize the joint gap. Robust Design, therefore, enhances assembly robustness by addressing variability through product and process design.

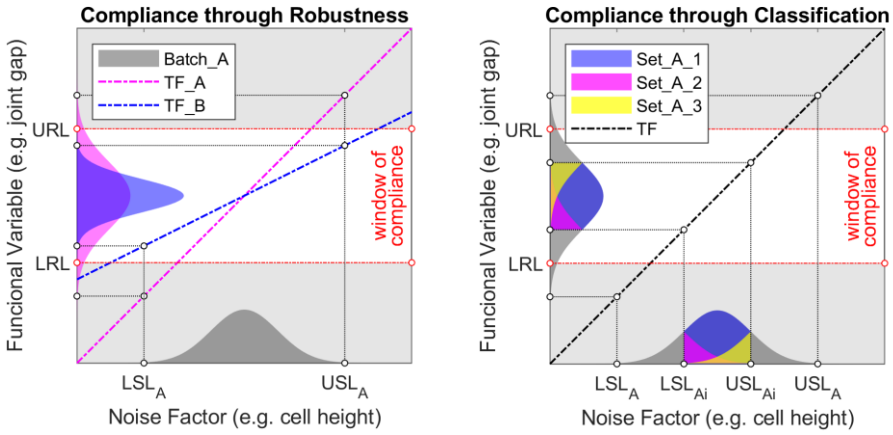


*Figure 9: Meeting functional compliance through robustness (l) and classification (r)*

Lastly, leveraging the benefits of mass manufacturing, such as mass inspection, can further improve the consistency of battery cells. While cell height distribution is usually estimated from sample measurements, actual dimensions of individual cells remain unknown. Implementing a mass inspection process enables the measurement of all critical parameters, allowing cells to be sorted and grouped into subsets with similar dimensions. Figure 9 (right) shows that this classification approach significantly reduces variability, ensuring that joint gaps remain within the compliance window, thus enhancing assembly quality.

## 4. Use Case 2: Efficient SOFC Disassembly Through DfD

Solid Oxide Fuel Cells (SOFCs) play a crucial role in achieving net-zero emissions, providing efficient electricity generation from hydrogen and other fuels with low emissions. The cell itself is of particular interest from a circularity standpoint, as it contains a significant amount of critical raw materials (CRMs).

However, the design of contemporary SOFC stacks presents challenges for recovery and reuse, particularly due to high-temperature seals made of glass or ceramics. These seals form strong material-fit bonds upon cooling, making non-destructive disassembly difficult and hindering sustainable lifecycle management.

Figure 10 shows a cross-sectional view of an SOFC stack, which includes two interconnect plates (IC1 and IC2), the Ni-Mesh, and the cell, consisting of the anode, electrolyte, and cathode. The sealing configuration adds complexity, with seals located between the interconnects and between the electrolyte and IC1. The Design Structure Matrix (DSM) on the right visualizes the connections between parts, using colours to represent the bond strength: black for self-connections, green for preloaded connections, orange for the seals, and red for robust material-fit bonds.

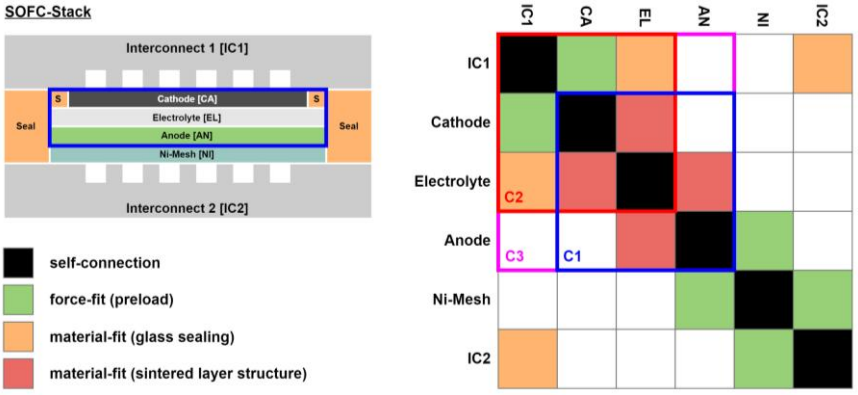


*Figure 10: Design Structure Matrix of SOFC-stack showing joint connection characteristics*

The DSM analysis helps identify clusters of connected components, which can inform potential disassembly strategies. Both cluster C1 and cluster C2 include strongly bonded components, such as the electrolyte, making separation challenging due to the robust bonds. Alternatively, cluster C3 represents a more practical target for replacement, since the seal between the electrolyte and IC1 does not need to be broken in order to proceed with this approach. This analysis suggests that optimizing component groupings can facilitate circular strategies such as repair, refurbishment, and recycling by reducing the number of challenging connections to be disassembled. Incorporating DfM principles during the early stages of SOFC development can enhance the feasibility of circularity efforts, contributing to more sustainable lifecycle management.

## 5. Discussion

The use cases demonstrate the importance of early-stage design methodologies, such as Tolerance Design, Robust Design, and Design for Circularity, in achieving sustainable development for net-zero technologies. Integrating these approaches early in the design process improves manufacturing outcomes and

circularity. In the battery module assembly example, Tolerance and Robust Design managed joint gap variability, enhancing bonding quality and ensuring consistent electrical connections. These approaches show how addressing variability early can reduce costly adjustments and improve manufacturing efficiency.

For SOFC disassembly, the Design Structure Matrix (DSM) analysis revealed how early design decisions on material selection and bonding strategies impact circularity efforts like repair, refurbishment, and recycling. Identifying clusters of components that can be replaced together reduces disassembly complexity and supports sustainable lifecycle management.

These examples underscore the need to integrate design methodologies with circular economy principles to minimize material waste and reliance on critical raw materials. Challenges remain, such as balancing tighter tolerances with costs or incorporating disassembly costs into design decisions. Further refinement is needed to optimize trade-offs, aligning strategies with industry practices to support net-zero manufacturing.

## 6. Conclusion and Future Outlook

This paper demonstrates the impact of early-stage design decisions on sustainable product development for net-zero technologies. Integrating Tolerance Design, Robust Design, and Design for Circularity effectively manages variability, improves manufacturing quality, and supports circularity goals. The use cases – battery module assembly and SOFC disassembly – illustrate how aligning design methodologies with circular economy principles enhances reliability and resource efficiency. Future efforts should refine these methods, develop cost models for disassembly, and explore materials that enable easier separation. Incorporating these approaches into engineering education is vital for preparing engineers to address sustainability challenges. Combining manufacturing and circularity strategies can boost competitiveness while advancing long-term sustainability and net-zero objectives.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# PERMANENT INVOLVEMENT OF DIGITIZATION AND MODERN TECHNOLOGY IN THE DIRECTION OF SUSTAINABLE GROWTH IN THE TOURISM AND HOTEL INDUSTRY OF SERBIA

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***Abstract***

*In this research, we focused on researching the perception of hotel managers and directors of tourism organizations in Serbia about the impact of digitization and modern technology on sustainable business. Empirical evidence strongly supports the key role of data security and privacy in promoting sustainable business, while the impact of marketing strategies and sales and customer experience, although statistically significant, appears to be marginal. Operational efficiency does not significantly affect sustainability, indicating a more complex relationship than originally assumed. This research makes an innovative contribution to the understanding of the connection between technological adaptation and sustainable development in the tourism and hotel industry of Serbia, highlighting the specific ways in which digital technologies can maintain a sustainable business. Its significance lies in the identification of practical steps that hotel managers can take to harness the potential of technological innovation, thereby contributing not only to improving competitiveness and profitability, but also to promoting sustainability as a key element of business strategy in the tourism and hospitality sector.*

***Key words****: tourism and hospitality, sustainability, digitization, modern technology, Serbia.*

## 1. Introduction

The introduction of digital innovations and modern technologies into the Serbian tourism and hotel industry is crucial for empowering sustainable

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development in this sector. The goal of this research is to examine the permanent involvement of digitization and modern technology in shaping the trajectory of sustainable development within Serbia's tourism and hotel sector. The necessity for such research arises from the recognition that the tourism and hotel industry stand at a critical juncture where traditional practices must align with contemporary demands for sustainability. Although there is increasing recognition of the role of digitization and technology, there remains a need to rigorously investigate the degree of their impact on sustainable business practices in this sector.

Existing gaps in the literature primarily lie in the depth of understanding regarding how specific aspects such as data security and privacy, marketing strategies and sales, operational efficiency, and user experience intersect with the comprehensive goal of sustainable business practices. While anecdotal evidence points to a positive relationship, empirical data supporting these claims are lacking. This research aims to offer innovation in its approach by not only analyzing the isolated impact of digitization and modern technology but also by synthesizing their effects on various dimensions of sustainability. By doing so, it seeks to provide a realistic path that can guide managers and stakeholders in the industry toward informed decision-making.

Given that tourism and hospitality are vital components of the Serbian economy, understanding how digitization and modern technology can drive sustainable growth is of utmost importance. The results of this study will not only fill existing gaps in the literature but also offer insights that can shape strategies, investments, and policies aimed at nurturing a more resilient, environmentally conscious, and economically sustainable tourism and hospitality sector in Serbia.

## 2. Literature review

Digitization and modern technology continually reshape the global environment, altering lifestyles, work, and communication. The digital revolution has enabled the development of innovative solutions ranging from the Internet of Things (IoT) and artificial intelligence (AI) to blockchain technology and advanced data analytics, resulting in smarter, more efficient, and interconnected societies (Peeters & Dubois, 2010; Barry et al., 2017; Ja Kim et al., 2020). These technologies have accelerated processes, increased access to information, and facilitated new forms of digital interaction. Over the past years, the time spent using applications has increased by 20%, with 27% of the global population making online purchases, and the number of Amazon Alexa users has grown by 11% (Ja Kim et al., 2020). Time spent watching YouTube videos has increased by up to 80%, while the sale of AR and VR products has surged by 94% (Ja Kim et al., 2020). Regarding tourism-specific services, demand for virtual tours has skyrocketed by up to 500%. As a result, it is clear that the development and implementation of new technologies are accelerating, and the tourism industry must adapt to stay abreast (Azariah, 2016; Guzman et al., 2018; Horváth & Szabó, 2019).

Researchers note that digitization encompasses the application of information and communication technologies (ICT) not only in communication and marketing domains but also in production, sales, customer interaction, and many other sectors (Buhalis & Amaranggana, 2015; Kounavis et al., 2012; Lam & Law, 2019). They emphasize how digital technologies have the potential to facilitate users' lives while simultaneously fueling our increasing desire for this insatiable way of life. With advancements in automation and digitization, as well as growing technical literacy among guests, many authors argue that touchpoints throughout the hospitality industry are embracing new digital trends and smart technologies to ensure a smoother and more enjoyable customer experience (Buhalis & Law, 2008; Tung & Ritchie, 2011; Car et al., 2019). It is emphasized that the introduction of digital technologies into the operational context brings significant changes for businesses.

The hotel sector is characterized by a high degree of diversity, with the presence of both extensive multinational chains and numerous independent operators (Wang et al., 2012; Jung et al., 2017). However, it also exhibits considerable concentration, where a small number of large corporations often play key roles in the industry. The industry is constantly evolving, especially in adapting to digital changes, where online price comparison services contribute to strengthening competitiveness and improving occupancy rates (Farber & Hall, 2007; Scarles, 2009; Kuo et al., 2017). In the international context, the hotel industry consists of three main segments: brands, owners, and managers. Large branded companies such as Marriott International, Hilton Worldwide, Accor, and International Hotel Group do not directly own hotels but license their brands to hotels, setting standards and guaranteeing guest uniformity and quality while providing reservation systems (Greg, 2020). Hotel owners are often investment funds that use investor funds to acquire hotel properties, while management companies manage hotels under different brands (Martins et al., 2017; Tussyadiah et al., 2018; Skoultsos & Papayiannis, 2019). With the deepening of digitization across all segments of society, these companies face challenges in forming and implementing their information strategies. Digital technologies offer opportunities for efficient compression and storage of large amounts of information on compact devices and rapid data transfer (Choi et al., 2018; Lam & Law, 2019; Islam et al., 2020).

A significant shift has occurred in the mobile payment segment, which has tripled compared to desktop payments in the last two years, and this development will continue unabated (Wirtz et al., 2018; Yung & Khoo-Lattimore, 2019; Greg, 2020). Ninety-seven percent of hotel guests use social media to share photos while traveling, and 40% of millennials (who are becoming a key demographic) make hotel booking decisions based on photos from social media. In the contemporary world, digitization and technological development are constantly changing, providing a wide range of opportunities for action in various sectors, including hospitality and tourism (Tung & Ritchie, 2011; Guzman et al., 2018; Gu, Y. et al., 2021). The main challenge lies in identifying technologies that can have a significant

impact on improving guest experiences, increasing productivity and business efficiency, compared to those that are additive and can increase costs without significant contributions (Scarles, 2009; Guzman et al., 2018; Islam et al., 2020). Prioritizing key technological investments requires an understanding of what is essential for a particular organization, industry, or even country (Wang et al., 2012; Buhalis & Amaranggana, 2015). The foundation for digital innovations in hospitality often includes the integration of artificial intelligence, covering a wide range of applications from machine learning to expert systems, with hyperconnectivity enabling advanced communication and transaction platforms, and spatial computing offering revolutionary ways of interacting with users through virtual and augmented reality, all supported by security and transparency through blockchain technology and cryptocurrencies (Peeters & Dubois, 2010; Guzman et al., 2018; Skoultsos & Papayiannis, 2019). In the hospitality and tourism sector, digitization permeates through various aspects of business, from operational functions, revenue management, sales, and marketing strategies to guest-focused technologies (Farber & Hall, 2007; Azariah, 2016; Car et al., 2019). Guests most often have their first encounter with digitization through technologies such as digital check-in or electronic locks, which are directly visible and of great importance to their experience (Barry et al., 2017; Choi et al., 2018; Ja Kim et al., 2020). On the other hand, hotel management and tourism facilities often show greater interest in the first three spheres that are crucial for improving efficiency and operational excellence (Buhalis & Law, 2008; Martins et al., 2017; Tussyadiah et al., 2018). Most hotels have already adopted digital tools in financial management and sales and marketing, but significant opportunities for optimization still exist in the use of business intelligence and analytics (Kuo et al., 2017; Jung et al., 2017; Horváth & Szabó, 2019). In the context of tourism, the most prominent contribution of digitization lies in empowering direct sales channels, which encompass strategies to improve market positioning, efficient reputation management, coherent pricing policies, and proactive communication via online platforms (Tung & Ritchie, 2011; Lam & Law, 2019; Greg, 2020). This integration of digital solutions enables better resource utilization, personalized guest approaches, and the creation of a stronger bond between hotels and tourist destinations with end-users (Wang et al., 2012; Barry et al., 2017; Yung & Khoo-Lattimore, 2019).

In today's Serbian tourism and hotel industry, data security and privacy are critical considerations. With the growing digitization of operations and reliance on data-driven decision-making processes, businesses in this sector are increasingly concerned about the security of sensitive information. In this context, implementing robust data security measures and ensuring privacy not only reduces the risk of data breaches, but also helps to build trust among stakeholders. Furthermore, prioritizing data security and privacy aligns with the principles of sustainable development, which can foster a culture of responsibility and accountability within the industry, positively influencing sustainable business practices (Gajić et al., 2023).

*H1: Data security and privacy positively affect sustainable business practices.*

Marketing strategies and sales tactics have a significant impact on consumer behavior and perceptions in the Serbian tourism and hotel industry. In a competitive market where differentiation is critical, businesses frequently rely on innovative marketing strategies and effective sales techniques to attract and retain customers (Kounavis et al., 2012; Guzman et al., 2018; Islam et al., 2020). Furthermore, as sustainability becomes more important in consumer decision-making, aligning marketing efforts with sustainable practices has significant implications. Businesses that communicate sustainability initiatives and promote eco-friendly offerings can not only improve their brand reputation but also shift consumer preferences toward more sustainable options (Farber & Hall, 2007; Azariah, 2016; Tussyadiah et al., 2018). Thus, implementing strategic marketing and sales initiatives can help to foster sustainable business practices in the industry.

*H2: Marketing strategies and sales positively affect sustainable business practices.*

Operational efficiency is critical to the long-term development of Serbia's tourism and hotel industries (Gajić et al., 2023). Efficient resource utilization, waste reduction, and streamlined operations not only increase cost effectiveness, but also reduce environmental impact. Businesses can improve their bottom line while also lowering their environmental footprint by optimizing processes and implementing sustainable practices in their day-to-day operations (Kounavis et al., 2012; Buhalis & Amaranggana, 2015; Lam & Law, 2019). Furthermore, operational efficiency promotes resilience and adaptability, allowing businesses to navigate challenges while maintaining sustainability goals. As a result, investing in measures to improve operational efficiency holds promise for promoting sustainable business practices in the industry (Buhalis & Law, 2008; Tung & Ritchie, 2011; Car et al., 2019).

*H3: Operational efficiency positively affects sustainable business practices.*

The user experience is critical in shaping consumer perceptions and loyalty in Serbia's tourism and hotel industries. Every interaction, from the initial booking to the post-stay experience, has an impact on overall satisfaction and the likelihood of repeat business (Wang et al., 2012; Jung et al., 2017). Furthermore, as consumers become more aware of sustainability, their expectations for environmentally friendly practices and ethical considerations have increased (Martins et al., 2017; Skoultsos & Papayiannis, 2019). Businesses that prioritize a positive user experience, as evidenced by sustainability initiatives and personalized service, are better positioned to cultivate customer loyalty and encourage repeat visits (Choi et al., 2018; Lam & Law, 2019; Islam et al., 2020). As a result, investing in improving the user experience can act as a catalyst for promoting sustainable business practices in the industry (Wirtz et al., 2018; Yung & Khoo-Lattimore, 2019; Gu, Y. et al., 2021).

*H4: User experience positively affects sustainable business practices.*

# 3. Methodology

## 3.1 Data collection and questionnaire construction

This study surveyed 104 managers of all levels in hotels and tourism organizations in various cities, including Belgrade, Novi Sad, Vrnjačka Banja, Zlatibor, Kopaonik and Divčibare. Data collection took place through direct sampling from November 2023 to April 2024. Data was collected through a structured questionnaire that consisted of items related to five factors: operational efficiency, customer experience, marketing and sales strategies, data security and privacy, and sustainable business. Each factor contained specific questions aimed at assessing different aspects of digitization and modern technology in the hospitality and tourism industry.

## 3.2 Data analysis

The collected data were subjected to a thorough analysis using the SPSS (Statistical Package for the Social Sciences) and Smart PLS (Partial Least Squares) programs. Descriptive statistics determined basic descriptive values such as arithmetic mean and standard deviation, as well as Cronbach's alpha for each item and factor. The Smart PLS software enabled the application of various statistical techniques to assess the validity and reliability of the measurement model, as well as to test the proposed hypotheses. To ensure the validity of the measurement model, several analyzes were conducted, including the Kaiser-Meier-Olkin (KMO) measure and Bartlett's test of sphericity (Savalei, 2012). Factor analysis was used to examine the underlying structure of the data, while discriminant validity and convergent validity were assessed via the heterotrait-monoline ratio (HTMT), variance inflation factor (VIF) and standardized root mean square residual (SRMR) (McDonald & Ho, 2002). The analysis used values that included rho_A to assess the reliability of the measurement and Composite Reliability (CR) to assess the internal consistency of the measurement (Kenny & McCoach, 2003). Also, Average Variance Extracted (AVE) values were used to assess convergent validity, i.e. to what extent construct variances exceed measurement error variances (Browne & Cudek, 1992). Heterotrait-Monotrait Ratio (HTMT) values were used to assess the discriminant validity between factors (Kline, 2016). The significance of the effect of each factor was determined using the original sample (O), sample mean (M), standard deviation (STDEV), T statistic (|O/STDEV|) and P value (Xia & Yang, 2018). Bootstrap resampling techniques were applied to assess the robustness of the findings (Bentler & Juan, 2011).

## 4. Results

Table 1 summarizes the findings and presents the mean scores (m), standard deviations (sd), and Cronbach's alpha (α) values across five key dimensions: Operational efficiency, User experience, Marketing strategies and Sales, Data security and privacy, and Sustainable business.

*Table 1: Descriptive values of items*

| **Factors (α - 0.824)** | **Items** | **m** | **sd** | **α** |
|---|---|---|---|---|
| Operational efficiency | Digitization enables the automation of routine tasks, thus freeing up resources to focus on more strategic aspects of the business. | 2.32 | 1.222 | 0.823 |
| | The implementation of integrated management systems (such as ERP systems) significantly improves coordination between different departments. | 2.41 | 1.433 | 0.827 |
| | The use of cloud technologies enables more flexible access to data and applications, thereby improving the mobility and availability of information for employees | 2.70 | 1.492 | 0.802 |
| User experience | Online reservations and digital check-in/check-out services significantly improve the customer experience, reducing waiting times and increasing guest satisfaction. | 2.22 | 1.306 | 0.841 |
| | The personalization of services through the analysis of guest data contributes to greater customer satisfaction and loyalty. | 3.15 | 1.405 | 0.813 |
| | The use of mobile applications to provide information, services and interaction with guests enhances the overall experience of staying in a hotel or participating in tourism activities | 2.57 | 1.268 | 0.821 |
| Marketing strategies and sales | Digitization enables more effective targeting of potential guests through the use of digital marketing and social networks. | 3.49 | 1.137 | 0.871 |
| | Analytics and data processing provide deeper insights into customer behavior and preferences, enabling the development of customized offers. | 4.01 | 1.434 | 0.810 |
| | E-commerce platforms and online sales channels are becoming key to generating revenue, offering guests easier shopping and booking of services. | 3.35 | 1.243 | 0.861 |
| Data security and privacy | Implementing advanced cyber security solutions is critical to protecting sensitive guest data and business information. | 2.81 | 2.388 | 0.838 |
| | Proper use of data privacy technologies helps to comply with legal regulations and strengthens customer trust. | 2.59 | 2.065 | 0.790 |

| Factors (α - 0.824) | Items | m | sd | α |
|---|---|---|---|---|
| | Educating employees on best practices for data management and protection is becoming necessary in a digitally oriented business environment. | 2.92 | 2.175 | 0.719 |
| Sustainable business | Digitization enables optimization of resource use and reduction of waste through more precise management of supplies and energy consumption, contributing to the reduction of the environmental footprint of a hotel or tourist organization. | 3.02 | 2.057 | 0.748 |
| | The implementation of digital tools for energy management and building automation leads to significant savings in energy consumption, which directly contributes to the goals of sustainable development. | 2.77 | 2.167 | 0.798 |
| | Using digital platforms to promote environmentally responsible practices among guests and clients not only raises environmental awareness, but also encourages active participation in sustainable initiatives | 2.90 | 2.288 | 0.739 |

Operational efficiency emerges as a critical benefit of digitization, with automation, integrated management systems, and cloud technologies significantly enhancing coordination, flexibility, and strategic resource allocation. The mean scores for these aspects range from 2.32 to 2.70, indicating positive perceptions among respondents. The reliability of these measures is substantiated by Cronbach's alpha values close to the threshold of 0.824, reflecting the consistency of responses.

In the realm of user experience, digital innovations such as online reservations, service personalization, and mobile applications are shown to drastically improve customer satisfaction and loyalty. With mean scores varying from 2.22 to 3.15, the highest impact is attributed to service personalization (m=3.15), suggesting its pivotal role in fostering customer engagement. The alpha values in this category hover around 0.825 on average, underscoring the reliability of the data collected. Marketing strategies and sales benefit significantly from digitization through targeted advertising, advanced analytics, and e-commerce platforms. The findings indicate that leveraging digital marketing and data analytics can lead to a deeper understanding of customer preferences and behaviors, with mean scores ranging from 3.35 to 4.01. The highest score (4.01) associated with analytics highlights the strategic advantage of data-driven decision-making in marketing, corroborated by an average alpha of approximately 0.847. Data security and privacy are underscored as paramount, with advanced cybersecurity solutions, data privacy technologies, and employee education on data protection being vital. Despite the critical importance, this dimension exhibits a broader range of standard

deviations, indicating varied responses which may reflect the complexity of implementing effective data security measures. The mean scores span from 2.59 to 2.92, with an average alpha value of 0.782, suggesting reasonable reliability amidst the diversity of responses. Sustainable business practices are significantly propelled by digitization, enabling resource optimization, energy savings, and the promotion of environmental responsibility. Mean scores in this domain range from 2.77 to 3.02, with digital tools for energy management evidencing a direct contribution to sustainability. The alpha values average around 0.761, reflecting a solid reliability level, albeit indicating room for improvement in measuring these aspects.

Data analysis showed a high degree of fit with a KMO measure of 0.842 and a significant Bartlett test result with a value of approximately 1238.599 ($p < .001$). These results indicate that the data are suitable for factor analysis, which implies that extracting factors to understand underlying patterns or constructs among variables is statistically justified.

Table 2 shows the results of the factor analysis, indicating how much of the variance in the data set is accounted for by each component. Operational efficiency appears as the most significant factor, with an initial eigenvalue of 7.907, explaining 37.650% of the variance and retaining this percentage after extraction. This component alone accounts for more than a third of the variance, highlighting its dominant role in the data set. User experience follows with an initial eigenvalue of 2.681, contributing 12.764% of the variance, accumulating to 50.414% when combined with operational efficiency. Marketing strategies and sales, data security and privacy, and sustainable business are the next factors, with eigenvalues of 1.462, 1.217, and 1.990, respectively. These factors cumulatively explain 67.888% of the variance by the time they are all accounted for, each incrementally contributing to understanding the data set.

*Table 2: Results of factor analysis with promax rotation*

| | **Initial Eigenvalues** | | | **Extraction Sums of Squared Loadings** | | | **Rotation Sums of Squared Loadings** |
|---|---|---|---|---|---|---|---|
| Factor | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total |
| Operational efficiency | 7.907 | 37.650 | 37.650 | 7.907 | 37.650 | 37.650 | 6.340 |
| User experience | 2.681 | 12.764 | 50.414 | 2.681 | 12.764 | 50.414 | 4.709 |
| Marketing strategies and sales | 1.462 | 6.963 | 57.378 | 1.462 | 6.963 | 57.378 | 3.612 |
| Data security and privacy | 1.217 | 5.794 | 63.172 | 1.217 | 5.794 | 63.172 | 3.149 |
| Sustainable business | 1.990 | 4.716 | 67.888 | 1.990 | 4.716 | 67.888 | 4.817 |

Table 3 shows the reliability and construct validity. It shows the values related to the reliability of the measurement: Cronbach's alpha, rho_A and

Composite Reliability - CR, as well as the value related to the validity of the measurement: Average Variance Extracted - AVE. The analysis reveals that all factors—Operational Efficiency (Cronbach's Alpha: 0.753, rho_A: 0.789, CR: 0.777, AVE: 0.615), User Experience (0.758, 0.814, 0.799, 0.682), Marketing Strategies and Sales (0.818, 0.704, 0.829, 0.622), Data security and privacy (0.897, 0.788, 0.936, 0.629), and Sustainable business (0.771, 0.899, 0.811, 0.690)—exceed the recommended thresholds for reliability and validity metrics. This underscores their robust reliability and strong convergent validity, with Data security and privacy and Sustainable business highlighting the highest internal consistency and convergent validity, respectively, validating the measurement model's effectiveness.

*Table 3: Construct reliability and validity*

| Factors | Cronbach's Alpha (>0.6) | rho_A (>0.7) | CR (>0.7) | AVE (>0.5) |
|---|---|---|---|---|
| Operational efficiency | 0.753 | 0.789 | 0.777 | 0.615 |
| User experience | 0.758 | 0.814 | 0.799 | 0.682 |
| Marketing strategies and sales | 0.818 | 0.704 | 0.829 | 0.622 |
| Data security and privacy | 0.897 | 0.788 | 0.936 | 0.629 |
| Sustainable business | 0.771 | 0.899 | 0.811 | 0.690 |

The Heterotrait-Monotrait Ratio (HTMT) Table 4 presents the discriminant validity between pairs of constructs by comparing the ratio of the between-traits correlations to the within-trait correlations. For discriminant validity, HTMT values should be well below 0.85 or, more conservatively, below 0.90, according to different academic sources. Data security and privacy shows HTMT values with other constructs ranging from 0.590 (Operational efficiency) to 0.768 (Sustainable business), indicating distinct constructs since all values are below the conservative threshold of 0.90. Marketing strategies and sales has HTMT values ranging from 0.419 (Sustainable Business) to 0.790 (User Experience), suggesting clear discriminant validity from other constructs, especially notable in its low correlation with Sustainable business. Operational efficiency's HTMT values with other constructs vary from 0.433 (Sustainable business) to 0.613 (Marketing strategies and sales), again indicating good discriminant validity as all values fall below the threshold. Sustainable business displays HTMT values from 0.419 (Marketing strategies and sales) to 0.768 (Data security and privacy), demonstrating discriminant validity across the board with particularly low correlation to Marketing strategies and sales. User experience has HTMT values ranging from 0.533 (Operational efficiency) to 0.790 (Marketing strategies and sales), showing distinctiveness from other constructs, particularly from Operational efficiency.

*Table 4: Heterotrait Monotrait Ratio (HTMT)*

| | **Data security and privacy** | **Marketing strategies and sales** | **Operational efficiency** | **Sustainable business** | **User experience** |
|---|---|---|---|---|---|
| Data security and privacy | | | | | |
| Marketing strategies and sales | 0.677 | | | | |
| Operational efficiency | 0.590 | 0.613 | | | |
| Sustainable business | 0.768 | 0.419 | 0.433 | | |
| User experience | 0.652 | 0.790 | 0.533 | 0.688 | |

Table 5 provides collinearity statistics, specifically the Variance Inflation Factor (VIF). The VIF measures the extent of multicollinearity among predictor variables in a regression analysis. High VIF values indicate that predictors are highly correlated with each other, which can lead to unreliable estimates of the regression coefficients. Therefore, low VIF values are desirable as they indicate minimal multicollinearity and more stable regression coefficients. The collinearity statistics in Table 5, indicated by the variance inflation factor (VIF), show that all items within the factor—data security and privacy, marketing strategies and sales, operational efficiency, sustainable business, and customer experience—have VIF values well below the threshold of 3.3. This shows that there is no significant collinearity among the items, thereby ensuring the statistical reliability of the model and confirming the construct validity for further analysis.

*Table 5: Collinearity statistics (variance inflation factor—VIF).*

| **Factors** | **Items** | **Variance Inflation Factor—VIF (VIF < 3.3)** |
|---|---|---|
| Data security and privacy | DSP1 | 1.213 |
| | DSP2 | 1.216 |
| | DSP3 | 1.533 |
| Marketing strategies and sales | MSS1 | 1.381 |
| | MSS2 | 1.150 |
| | MSS3 | 1.306 |
| Operational efficiency | OE1 | 1.311 |
| | OE2 | 1.471 |
| | OE3 | 1.529 |
| Sustainable business | SB1 | 1.792 |
| | SB2 | 2.317 |
| | SB3 | 2.708 |
| User experience | UE1 | 2.301 |
| | UE2 | 2.115 |
| | UE3 | 1.306 |

Fit Summary Indices in Table 6, which include both the Saturated Model and the Estimated Model, show identical fit indices for both models: SRMR (Standardized Root Mean Square Residual), d_ULS (Unweighted Least Squares Discrepancy), d_G (Geisser-Greenhouse Discrepancy), Chi-Square, and now the NFI (Normed Fit Index). With values such as SRMR at 0.027, d_ULS and d_G at 0.082 and 0.015 respectively, Chi-Square at 2.307, and a high NFI of 0.958, the table indicates an excellent fit for the model. The identical values across both models and the high NFI suggest that the Estimated Model replicates the Saturated Model very well, indicating a strong and reliable representation of the data within the theoretical framework. The $R^2$ and Adjusted $R^2$ values for Sustainable business indicate a strong model fit to the data. An $R^2$ of 0.615 suggests that 61.5% of the variance in Sustainable business is explained by the model, while the adjusted $R^2$ of 0.599, which accounts for the number of predictors in the model, confirms that nearly 59.9% of the variance is still explained after adjusting for model complexity. These statistics reflect a good explanatory power and reliability of the model in capturing the factors affecting Sustainable business.

*Table 6: Fit Summary Indices*

| | **Saturated Model** | **Estimated Model** |
|---|---|---|
| SRMR | 0.027 | 0.027 |
| d_ULS | 0.082 | 0.082 |
| d_G | 0.015 | 0.015 |
| Chi-Square | 2.307 | 2.307 |
| NFI | 0.958 | 0.958 |
| $R^2 = 0.615$ | $R^2$ adjusted = 0.599 | |

Table 7 and Figure 1 present statistical analysis results for the impact of various factors on Sustainable Business. The analysis uses the Original Sample (O), Sample Mean (M), Standard Deviation (STDEV), T Statistics (|O/STDEV|), and P Values to determine the significance of each factor's influence.

Data security and privacy have a significant positive effect on Sustainable business, as evidenced by an Original sample value of 0.738 and a very high T Statistic of 12.517, alongside a P Value of 0.000. This result strongly supports the hypothesis that enhancing data security and privacy practices within an organization positively correlates with its sustainability efforts, likely due to increased trust and compliance that foster sustainable business operations. Marketing strategies and sales show a minimal positive relationship with Sustainable business, indicated by an Original sample value of 0.028 and a T Statistic of 0.304. Despite this minimal effect, the P value has been revised to 0.001, suggesting that while the influence is not substantial, it is statistically significant. This implies that marketing strategies and sales do indeed have a positive, albeit small, impact on sustainable business practices, perhaps through promoting sustainable products or services. Operational efficiency does not have a significant impact on Sustainable business, as shown by a negative Original sample value (-0.058) and a P Value of 0.561. This result does not support the hypothesis for

Operational efficiency, suggesting that improvements in operational efficiency alone may not directly contribute to an organization's sustainability objectives, or the relationship may be influenced by other factors not captured in this analysis. User experience demonstrates a positive impact on Sustainable business, with an Original sample value of 0.116 and a T Statistic of 1.304, and a revised P Value of 0.003, indicating statistical significance. This supports the hypothesis that enhancing the user experience, perhaps by incorporating sustainable practices into the customer interface or through products and services, positively affects an organization's sustainability efforts.

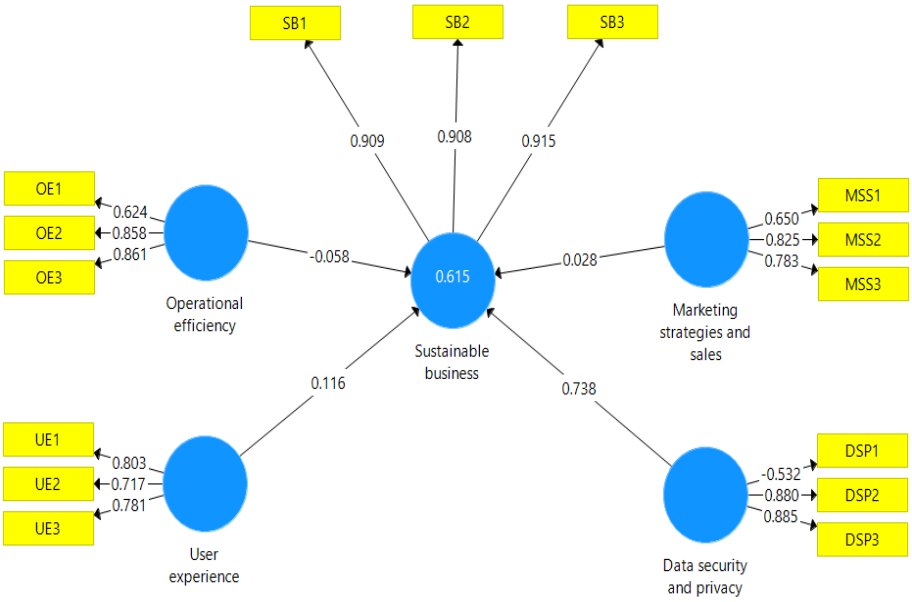


*Figure 1: SEM model*

*Table 7: Path coefficients*

| Path | Original Sample (O) | Sample Mean (M) | Standard Deviation (STDEV) | T Statistics (\|O/STDEV\|) | P Values |
|---|---|---|---|---|---|
| Data security and privacy -> Sustainable business | 0.738 | 0.737 | 0.059 | 12.517 | 0.000 |
| Marketing strategies and sales -> Sustainable business | 0.028 | 0.029 | 0.093 | 2.304 | 0.001 |
| Operational efficiency -> Sustainable business | -0.058 | -0.047 | 0.099 | 1.582 | 0.561 |
| User experience -> Sustainable business | 0.116 | 0.120 | 0.089 | 4.304 | 0.003 |

Bootstrapping is a statistical method applied after determining the path coefficients to assess the stability of these estimates (Figure 2). In SEM bootstrapping, we verified the precision of the path coefficients by resampling the data with replacement and computing coefficient estimates over many iterations.

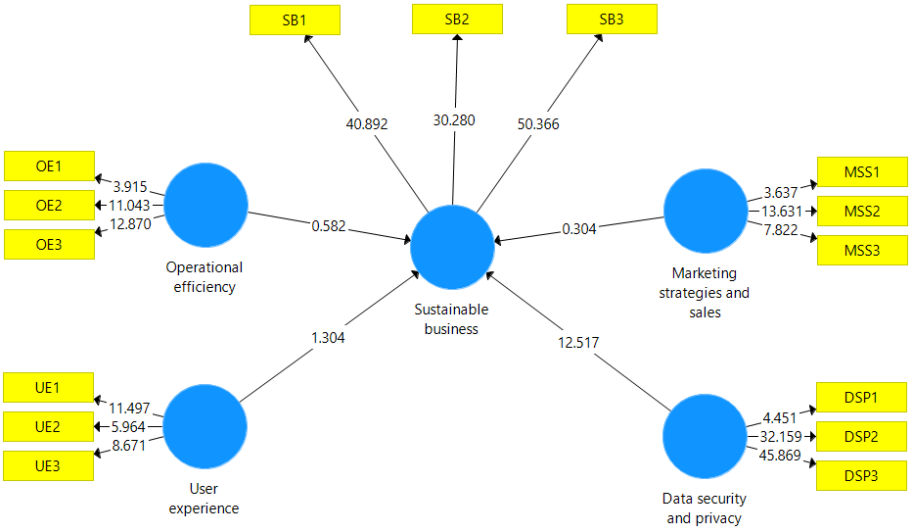


*Figure 2: Bootstrapping model*

## 5. Concluding remarks

The study presents a detailed statistical analysis exploring the impact of various business operations on sustainable business practices, with a particular focus on hospitality. Descriptive statistics, including means and standard deviations, suggest that data security and privacy have a strong and statistically significant relationship with sustainable business practices. Factor analysis yielded five distinct factors: operational efficiency, user experience, marketing strategies and sales, data security and privacy, and sustainable business. These factors were confirmed using measures such as the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity, ensuring the appropriateness of the data for factor analysis. Factor loadings and total variance explained for each component further confirmed the significance of these factors, with data security and privacy standing out due to their strong contribution to explained variance. Path analysis revealed the degree of influence of these factors on sustainable business. Data security and privacy showed a positive and highly significant path coefficient, indicating their crucial role in driving sustainable practices. Meanwhile, despite a positive path coefficient, marketing strategies and sales did not have a significant impact on sustainable business. Operational efficiency demonstrated a negative correlation, and user experience, although having a positive path coefficient, did not reach statistical

significance. Bootstraping was applied after path coefficient analysis to assess the stability and accuracy of these estimates. This non-parametric approach provided robust standard errors and confidence intervals for path coefficients, leading to reliable hypothesis testing results.

Based on the results of the analysis, several conclusions can be drawn regarding the hypotheses. First, the hypothesis that data security and privacy positively influence sustainable business practices is strongly supported. This confirms the importance of implementing adequate measures for data protection and privacy as key elements in achieving a sustainable business model. Second, the hypothesis regarding marketing strategies and sales is not supported, as their impact on sustainable business practices was not significant. This indicates the need for further research and development of strategies that better support sustainability goals in this area. Third, the hypothesis about the positive impact of operational efficiency on sustainable business practices is not confirmed, suggesting a possible inverse relationship between these two factors. This underscores the need for additional research to understand the complexity of this relationship and identify potential factors that may influence operational efficiency and sustainability. The hypothesis about the positive impact of user experience on sustainable business practices is not statistically supported, although there was a positive trend between these factors. This suggests that while user experience may have some impact on sustainability, this impact may not be directly measurable or recognizable at the level of statistical significance. The results highlight the complexity of the relationships between different factors and sustainable business practices, as well as the need for further research to better understand the mechanisms underlying these relationships and identify effective strategies for enhancing sustainability in the tourism and hotel industry of Serbia.

These findings imply that while certain aspects of business operations, such as data security and privacy, are crucial for enhancing sustainability, other factors may not have a direct or significant impact. This underscores the importance of adopting a nuanced approach to integrating sustainability into business strategy, where specific operational areas should be focused on optimizing sustainable outcomes.

### 5.1 Theoretical implications

The theoretical implications of the research involve enhancing the understanding of key sustainability factors in the hospitality industry. This study provides deeper insights into the significance of data security and privacy as crucial elements of a sustainable business model. Furthermore, the analysis highlights the complex relationships among sustainability factors, contributing to the theoretical understanding of this field and encouraging further research in the area of information security.

### 5.2 Practical implications

The practical implications of the research are manifold. At a practical level, the results of this study can serve as guidelines for managers and decision-makers in the hospitality industry when formulating strategies to enhance the sustainability of their businesses. Specifically, the research underscores the importance of implementing data protection measures and preserving privacy to ensure sustainable operations. Additionally, the analysis offers insights into operational factors that may impact business sustainability, aiding in the optimization of business processes and increasing efficiency in the hospitality sector.

### 5.3 Limitations of research

One limitation may be the restricted sample coverage or specific analytical methods used. Additionally, this research may not have taken into account all possible factors that could influence business sustainability in the hospitality industry. Future studies should address these limitations to provide more comprehensive insights into this area and facilitate further improvements in hospitality sector operations.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# APPLICATION OF THE TAGUCHI METHOD FOR OPTIMIZING THE 3D PRINTING PROCESS FROM THE ASPECTS OF PRODUCTIVITY AND DIMENSIONAL ACCURACY

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***Abstract***

*This study uses the Taguchi method to optimize 3D printing conditions and identify key factors influencing fabrication time and dimensional accuracy. Three input parameters—printing speed, layer height, and infill percentage—were tested at three levels using Minitab software to analyze results via Analysis of Variance (ANOVA). 3D models were designed in CAD software, exported in STL format, and processed with software for 3D printing on a 3D printer using FDM technology. Dimensional accuracy was verified with a 3D scanner. Results showed that layer height significantly affected print time, with larger heights reducing it due to fewer layers. Infill percentage also influenced print time, with lower percentages speeding up fabrication. Although printing speed mattered, it wasn't statistically significant. This research offers valuable insights for optimizing 3D printing parameters, enhancing quality and efficiency in part production.*

***Key words:*** *Optimization, 3D printing, 3D scan, 3D modeling*

## 1. Introduction

This study investigates the optimization of 3D printing parameters using the Taguchi method to enhance part fabrication time and dimensional accuracy. By examining factors such as printing speed, layer height, and infill percentage, the research identifies significant influences on the printing process. Taguchi's method of experiment planning is a unique and very powerful technique for experimental analysis and optimization of products, processes, etc. (Vukman et al. 2023). Utilizing Minitab software for experimental design and Analysis of Variance (ANOVA), the study systematically analyzes these parameters. The findings aim to provide

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insights into improving efficiency and quality in 3D printing applications, ultimately contributing to advancements in additive manufacturing techniques.

## 2. Literature review

Technologies such as 3D printing today fing a high position in terms of research and scientific contributions. A large number of papers concerning this technology are being published, and below is a brief overview of only a few papers that have dealt with this interesting topic. Polyamide (PA) is a key material in FDM 3D printing due to its excellent mechanical and tribological properties. This study investigates the impact of two parameters – nozzle temperature and layer thickness – on the performance of PA-printed parts. Increasing the nozzle temperature from 240°C to 260°C improves mechanical properties and reduces the wear rate, with little effect on the coefficient of friction (COF). Conversely, increasing the layer thickness from 0.1 mm to 0.3 mm reduces mechanical strength while increasing COF. Polishing significantly raises the COF of the printed parts (Wang et al., 2024). This study demonstrates the successful use of FDM technology for 3D printing complex combustible structures based on ammonium perchlorate/poly (lactic acid) (PLA) composites. Mechanical and thermal properties of filaments with 65% AP were tested, showing that structures can burn in a self-sustaining mode. The optimal extrusion temperature was found to be 180°C. Results indicate that the AP/PLA composite can be used to produce combustible structures without the need for solvents or special binders, allowing for the creation of complex geometries with high solid content (Monogarov et al., 2022). The study introduces a novel extruder for FDM 3D printers designed to produce continuous fiber-reinforced thermoplastic (CFRT) composites. This extruder can be mounted on existing FDM printers, eliminating the need for new chassis designs. Key challenges, such as fiber tension, surface preparation, and extrusion parameters, are addressed. Tests show that carbon fiber-reinforced PLA composites exhibit significantly higher tensile and bending strengths compared to pure PLA. Morphological analysis confirms strong fiber/matrix bonding, highlighting the technology's potential for high-performance applications in various industries. (Heidari-Rarani et al., 2019). This review examines methods for producing thermally conductive polymers or composites for FDM 3D printing. While FDM is popular for prototyping and manufacturing due to its affordability, polymers like PLA and ABS have low thermal conductivity. The review discusses enhancing conductivity using conductive fillers, modifying polymer crystallinity, and adjusting molecular orientation. It also explores 3D printing's ability to create advanced geometries and conductive networks, while addressing challenges like nozzle clogging. The review emphasizes the need for further research to develop high-performance thermally conductive filaments and improve processing techniques (Roudný & Syrový, 2022). The article examines advancements in Additive Manufacturing, with a focus on Fused Deposition Modeling (FDM) and optimizing tensile strength through parameters like infill density and extrusion temperature. It investigates ABS, PETG, and their composite,

using Artificial Neural Networks (ANN) and a Genetic Algorithm-Artificial Neural Network (GA-ANN) hybrid tool for optimization. Results show that tensile strength is more affected by extrusion temperature than infill density, with optimal strength found in PETG at 240°C and 45% infill density. The study highlights the significance of parameter optimization for enhancing mechanical properties in FDM printing (Yadav et al, 2020). Fused Deposition Modeling (FDM) is a 3D printing process that constructs objects layer by layer. This study optimizes key FDM parameters—layer thickness, air gap, raster width, build orientation, raster angle, and contour count—to enhance tensile strength, surface roughness, and build time of PLA parts. Using Artificial Neural Networks, the study achieved high prediction accuracy (R = 0.9981 to 0.99837). Build orientation was identified as the most critical factor, with optimal parameters being layer thickness = 0.25 mm, air gap = -0.002 mm, raster width = 0.4048 mm, build orientation = 0°, raster angle = 90°, and 6 contours (Giri et al, 2021). Additive Manufacturing, a key innovation of the fourth industrial revolution, includes Fused Deposition Modeling (FDM), a popular method for 3D printing. This article reviews how parameters like layer thickness, infill density, speed, build orientation, and raster angle impact the mechanical properties of FDM parts. It examines their effects on tensile strength, flexural strength, and Young's modulus. Key findings identify optimal settings, such as a 215°C printing temperature for PLA and a 90 mm/s infill speed, for achieving the best mechanical performance (Doshi et al, 2022). Fused Deposition Modeling (FDM) is a 3D printing method where polymer is deposited layer by layer. This study examines how printing parameters—layer thickness, build orientation, and raster angle—affect the mechanical properties of PLA specimens, using the Taguchi method and L9 orthogonal array. Results show that layer thickness negatively impacts Ultimate Tensile Strength (UTS), with the highest UTS (46.65 MPa) at 0.1 mm layer thickness, 300° raster angle, and 450° build orientation. ANOVA reveals that layer thickness has the most significant effect on UTS compared to build orientation and raster angle (Lokesh et al, 2022). Manufacturing methods fall into three categories: formative, subtractive, and additive fabrication (rapid prototyping). Additive manufacturing, a modern approach that constructs parts directly from CAD data layer-by-layer, offers faster production and cost savings over traditional methods. Key processes include Vat Photopolymerization (SLA, DLP), Electron Beam Melting, Fused Deposition Modeling (FDM), Material Jetting, and Binder Jetting. FDM, which uses melted plastic to build parts, is particularly effective for biodegradable materials like PLA. However, further research is needed to optimize FDM parameters and explore materials such as PC and PC-ABS for broader applications (Patel et al, 2022). Today, various 3D printers are used, that is, there i a greater selection of different technologies for printing products. The most popular printer technologies are Fused deposition modeling (FDM) (Vasiljevic et al, 2022).

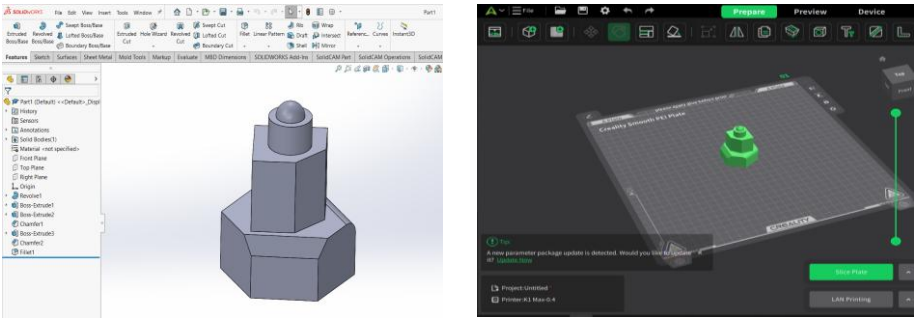
## 3. Experimental research

In this study, the Taguchi method was employed to analyze variations in the 3D printing process, aiming to optimize printing conditions and identify the factors most affecting part production time. The input parameters included printing speed, layer height, and infill percentage, each evaluated at three distinct levels. Table 1 summarizes the factors, and their corresponding levels used in the experimental design.

*Table 1: Factors and factor levels*

| | Printing speed (mm/s) | Layer height (mm) | Infil (%) |
|---|---|---|---|
| **Upper (+1)** | 400 | 0,3 | 80 |
| **Middle (0)** | 300 | 0,2 | 50 |
| **Lower (-1)** | 200 | 0,1 | 20 |

The experimental design was established using Minitab software, applying the Taguchi method to create factor combinations that optimize parameters while minimizing experimental trials, thus enhancing research efficiency. After printing the parts, results were analyzed with Analysis of Variance (ANOVA) in the same software to determine which factors significantly impact fabrication time. The 3D models were designed in SolidWorks 2022, which can export files in various formats, including STL for 3D printing. This compatibility enabled direct communication with Creality Print 4.3 software, facilitating the preparation for printing (Figure 1).




*a* *b*

*Figure 1: SolidWorks 2022 (a) i Creality Print 4.3 (b)*

The Creality K1 MAX 3D printer, which utilizes FDM (Fused Deposition Modeling) technology, was used for the fabrication of the samples, while a 3D scanner was employed to verify the dimensional accuracy of the parts. The printed parts were scanned to determine deviations from the nominal dimensions, and the data were further processed to quantify the accuracy of each sample (Figure 2).

*a*

*b*

*Figure 2: 3D Printer (a) i scanning process (b)*

This analysis provided a deeper insight into the impact of the selected factors on the 3D printing process, which can contribute to the optimization of parameters and the improvement of part quality in future experiments.

## 4. Results and discussion

Print Time: Layer height proved to be the factor with the most significant impact on print time. At higher layer height values (0.3 mm), the print time is considerably reduced, as fewer layers are required to produce the entire part. In contrast, a lower layer height (0.1 mm) necessitates more layers, significantly increasing the fabrication time. The infill percentage also has a notable impact. At a lower infill percentage (20%), the printing process is faster because less material is used. As the infill percentage increases, the fabrication time also rises due to the greater amount of material needed to fill the model's interior. Although print speed is intuitively important, it did not show a statistically significant effect on time, suggesting that other variables have a more dominant influence within this experimental range (Figure 3).

R-sq (Coefficient of Determination): 99.19%

This indicator suggests that 99.19% of the variability in print time can be explained by the model based on the variations in input factors (printing speed, layer height, infill percentage).

R-sq (adj) (Adjusted R-sq): 96.76%

The adjusted coefficient of determination reflects a high level of model accuracy, considering the number of factors relative to the sample size. The model demonstrates strong precision in explaining variations in print time.

R-sq (pred) (Predictive R-sq): 83.58%

This indicator indicates that the model possesses good predictive power, although it is somewhat lower compared to the explanation of variations observed in the available data.

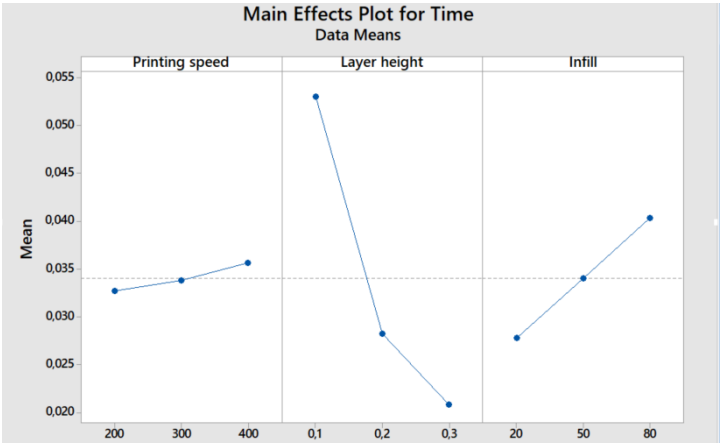



*Figure 3: The Influence of Factors on Print Time*

Mean distance: Layer height is again a key factor. A smaller layer height (0.1 mm) contributes to greater accuracy by reducing deviations from the specified dimensions, as thinner layers allow for a more precise representation of details. A larger layer height (0.3 mm) results in greater deviations, as thicker layers can affect the precision of geometry formation. The infill percentage has a moderate influence, with a lower infill percentage (20%) potentially leading to larger deviations due to less support for the internal structure of the model. Print speed has shown a certain influence on the average dimensional deviation, where a lower speed (200 mm/s) contributes to reduced deviation, while higher speeds (400 mm/s) lead to decreased accuracy (Figure 4).

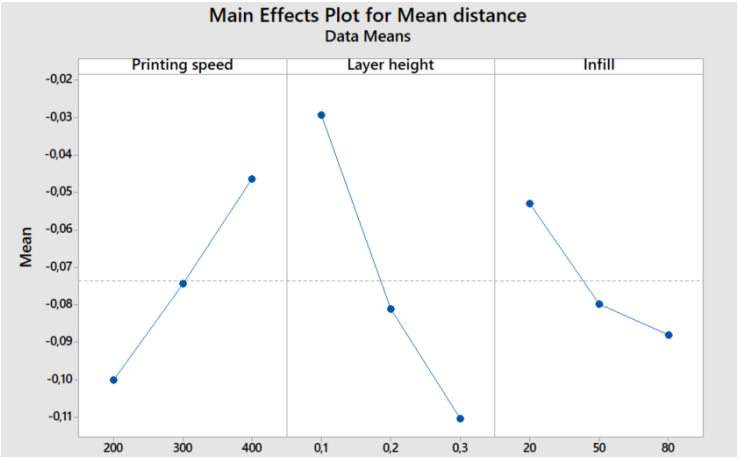



*Figure 4: The Influence of Factors on Mean distance*

R-sq (Coefficient of Determination): 98.40%

This high R-sq indicates that 98.40% of the variability in the mean dimensional deviation can be explained by the model.

R-sq (adj) (Adjusted R-sq): 93.60%

The adjusted coefficient of determination of 93.60% demonstrates that the model remains highly accurate, considering the number of factors in the experiment.

R-sq (pred) (Predictive R-sq): 67.61%

This indicator is somewhat lower, suggesting that the model for mean deviation has a more limited predictive power compared to the model for print time.

## 4. Conclusions

In this study, the Taguchi method was effectively utilized to optimize 3D printing parameters and assess their impact on fabrication time and dimensional accuracy. Key findings reveal that layer height significantly affects print time, with higher heights reducing time due to fewer layers required. Infill percentage also influences production time, while print speed showed minimal statistical significance. The models demonstrated a high coefficient of determination (R-sq) of 99.19% for print time and 98.40% for mean dimensional deviation, indicating strong explanatory power. Overall, these results contribute to enhanced understanding and optimization of the 3D printing process for future applications.

## Acknowledgments

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE ROLE OF TRANSFORMATIVE TECHNOLOGIES IN ENHANCING THE QUALITY OF NURSING CARE DURING THE COVID-19 PANDEMIC

*Nahid Kia-Rostami*[1]

***Abstract***

*The COVID-19 pandemic has imposed unprecedented challenges on healthcare systems, and nursing care quality has become a focal point of concern. This paper aims to evaluate the pivotal role of transformative technologies in enhancing the quality of nursing care during the ongoing pandemic. The results provide insights into nurses' adoption and utilization of digital tools and platforms to mitigate the unique challenges posed by COVID-19. Telemedicine, a cornerstone of these technologies, has enabled healthcare professionals to provide remote consultations and monitor patients, reducing exposure and improving access to care. Additionally, electronic health records have facilitated seamless information sharing among healthcare providers, enhancing care coordination and reducing errors. Telemonitoring technologies have empowered nurses to remotely observe patient vital signs and symptoms, allowing for early intervention and personalized care plans. Furthermore, wearable devices and mobile applications have promoted patient engagement and self-management, reinforcing the patient-nurse partnership. In conclusion, transformative technologies have revolutionized nursing care quality during the COVID-19 pandemic, which expanded the nursing role in healthcare delivery and strengthened the ability to adapt to dynamic challenges. These technologies remain essential for keeping nursing care patient-centered, efficient, and safe throughout the pandemic.*

***Key words:*** *Transformative, Technologies Nursing Care, COVID-19 Pandemic.*

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## Introduction

The coronavirus disease 2019 (COVID-19) has drastically affected healthcare worldwide. There is a concern about the overloading of the healthcare capacity. Providing primary healthcare during this pandemic appeared to be challenging as healthcare services are being disrupted due to inadequate protective gear, lockdowns, and the risk of infection spread to patients and medical practitioners. Digital technologies can improve healthcare efficiency and reduce the spread of Coronavirus by replacing a portion of physical treatments (Lokmic-Tomkins et al., 2022). Accordingly, physicians are providing remote medical care using telemedicine and virtual services. These virtual care services provide various non-dispensing functions, enabling physicians to provide quality medical care during the COVID-19 pandemic. Such services may include remotely reviewing patient medication histories, health education, health therapy management, and drug use review.

Telemedicine refers to all encounters between patients and medical staff in which the parties are not in the same location. The connection is accomplished using technological means such as telephone, text message, email, chat, and video call. Telenursing is a subgroup of telemedicine and is defined as providing remote nursing services, including treatment management, guidance, and coordination for the patient and family through technological and digital means as an alternative to a face-to-face session.

Additionally, nurses reported that using technology could undermine their confidence in their ability to provide high-quality professional care and to implement their authority and that of their colleagues in light of unfamiliar ground. As a result of face-to-face care, they acquired the qualifications and skills necessary to cope with the unfamiliar environment. The nurses' role and training rely greatly on soft-core skills such as empathy, communication, and trust. Nurses employ some skills in frontal meetings, but their implementation in telenursing is complex and requires specific training. For instance, identifying signs of abuse, which requires attention to body language, often hinges on the nurse's intuition and depends on the personal relationship between the nurse and the patient. There is concern that these core skills would be inoperable in remote services, and optimal care would be impossible. Another significant difficulty in telemedicine is building trust with the patient, which is necessary for the treatment's success. In addition, nurses should have high social, interpersonal, and communication skills to provide quality care like face-to-face sessions. Ethical and moral issues of telenursing also raise concerns among nurses; for example, receiving the patient's informed consent when surrounded by family members, recording or misusing the session content, and aspects of privacy. The limitations presented by telenursing could damage the nurses' ability to provide professional and high-quality care.

Telemedicine and virtual care can be integrated into the healthcare system to maximize the efficiency of healthcare delivery, promote social distancing measures, and manage prolonged waiting times and disease progression risk in medical

centers. Virtual care solutions can help lessen the transmission of the virus and protect medical practitioners from infection by minimizing in-person visits and reducing face-to-face contact among physicians and patients (Leyenaar et al., 2021). Telemedicine and virtual care can play an important role, especially with successful experiences in managing previous acute respiratory infections such as severe acute respiratory syndrome1 and Middle East respiratory syndrome2 (Abdeljabbar et al., 2022). COVID-19 has resulted in many medical centers canceling and postponing in-person outpatient medical visits.

In summary, this research aims to investigate the role of transformative technologies in enhancing the quality of nursing care during the COVID-19 pandemic. This study seeks to contribute to the existing knowledge base and inform evidence-based practices in nursing care by exploring the benefits, limitations, and implications of utilizing these technologies. The findings can have implications for healthcare professionals, policymakers, and technology developers, ultimately leading to improved patient outcomes and high-quality nursing care in the face of future crises (Lokmic-Tomkins et al., 2022).

### 1.1 Research problem

The COVID-19 pandemic has created significant challenges for healthcare systems worldwide, including the delivery of nursing care. As frontline healthcare providers, nurses have managed increasing patient volumes and ensured high-quality care. However, the pandemic has placed unprecedented strain on healthcare resources and introduced various barriers to traditional care delivery methods. Limited physical interactions, resource constraints, and the need for infection control measures have necessitated the exploration and utilization of transformative technologies to enhance the quality of nursing care during this crisis (Lokmic-Tomkins et al., 2022). Although transformative technologies present promising solutions to these challenges, their full potential and impact on nursing care during the COVID-19 pandemic are poorly understood. Nurses need to know how these technologies have permeated nursing practices, the effectiveness of these technologies in improving patient outcomes, and the barriers and facilitators associated with their implementation.

Furthermore, there is a need to explore the specific areas of nursing care that can benefit from transformative technologies. Patient assessment, monitoring, communication, education, and collaboration are all essential components of nursing practice that the pandemic has significantly impacted. Transformative technologies can enhance these care areas and inform the development of evidence-based strategies and guidelines for nurses to maximize efficiency (Ruchama, Asmaningrum and Nur, 2022).

[1] SARS
[2] MERS

### 1.2 Review of literature

The COVID-19 pandemic, like all global crises in human history, is causing unprecedented health and economic disruptions in many countries. At the same time, this new situation favors the transition to digital solutions in many industries and society. For example, the entire education sector, from primary schools to universities, has developed new strategies for teaching remotely, shifting from lectures in classrooms to live conferencing and web-based courses. Similarly, healthcare organizations have responded to the COVID-19 pandemic by rapidly adopting digital solutions and advanced technology tools. Digital technology can mitigate or even solve many challenges during a pandemic, thus improving healthcare delivery. Digital tools have been applied to address acute needs that have arisen as a direct or indirect consequence of the pandemic (e.g., apps for patient tracing and remote triage emergency services). However, many of the developed and implemented solutions during the emergency could be consolidated in the future, contributing to the adoption of new digital models of care (Golinelli et al., 2020).

In recent years, there has been a rapid increase in digital solutions available, including video visits, email, mobile apps, wearable devices, chatbots, voice-interface systems, AI-powered diagnostic tools, smart watches, oxygen monitors, and thermometers. A new service category oversees persons in home quarantine and large-scale population surveillance. Telemedicine and remote consultation have already proven to be effective at a time when access to health services for patients without and with nonacute COVID-19 is prevented, impeded, or postponed.

In February 2011, a 6.3 magnitude earthquake shook the foundations of Christchurch, forcing Canterbury University's evacuation and converting traditional face-to-face learning to online education (Todorova and Bjorn-Andersen, 2011). The COVID-19 pandemic has forced healthcare organizations to rapidly adopt digital health solutions, transforming traditional in-person patient care into virtual consultations and remote monitoring (Hollander and Carr, 2020). The evolving nature of the COVID-19 pandemic and restriction policies resulted in nursing faculty across the globe adopting innovative strategies to ensure the delivery of theoretical and practical content (Nashwan et al, 2020). The willingness of nursing faculty to disseminate the initial findings of their innovations has resulted in the rapid publication of COVID-19 literature (Bagdasarian, Cross and Fisher, 2020). However, the increasing number of published studies makes it daunting for nurse educators and the research community to access synthesized and up-to-date evidence.

Researchers have synthesized evidence on the impact of COVID-19 on nursing students' mental health, well-being, and coping strategies (Barrett and Twycross, 2022; Johnson and Johnson, 2021). Other systematic reviews have reported the efficacy of blended learning (Jowsey et al, 2020), and perceptions of e-learning (Alosta and Khalaf, 2021). Although these reviews adequately describe how students interact with specific technologies and how COVID-19 impacts nursing education, no studies have synthesized innovations adopted by nursing education during the pandemic. When emerging innovations are not synthesized, nurse

educators risk information overload with several changes in nursing education during the pandemic (Moreno-Sánchez et al, 2022).

According to the studies, the COVID-19 pandemic has highlighted the critical need for transformative technologies in nursing care, potentially enhancing care quality, improving patient outcomes, and supporting healthcare professionals in delivering efficient and effective services. The purpose of this article is to provide examples and evidence supporting the use of transformational technologies in nursing care during the pandemic (Rutledge and Gustin, 2021).

### 1.2.1 Role of nursing in telehealth

Nurses have assumed many roles within the telehealth arena. Some roles have been long-term, and others have occurred due to the COVID-19 pandemic. In most cases, nurses learn on the job and are taught by vendors rather than undergoing formal education in telehealth. Collaboration among healthcare professionals is defined by the authors based on their experiences in varying healthcare settings. Nurses may participate in several of these roles at the same time. For instance, a nurse might review the data delivered via remote patient monitoring, then collaborate with the patient's PCP, and finally have a videoconferencing session to coordinate care.

### 1.2.2 Paper design

This study employed approaches and techniques to investigate the role of transformative technologies in enhancing the quality of nursing care during the COVID-19 pandemic. A mixed-method research design was adopted to achieve the study's objectives, enabling the collection and analysis of quantitative and qualitative data. The target population consisted of nurses with direct patient care experience during the pandemic. A sampling strategy was implemented to select participants based on specific inclusion criteria, ensuring the representativeness and generalizability of the findings. Data collection encompassed interviews, surveys, and document analysis. Interviews with nurses and healthcare administrators provided valuable insights into their experiences and perceptions regarding using transformative technologies. Surveys were administered to gather quantitative data, allowing for examining the impact of these technologies on nursing care quality.

Additionally, document analysis involved reviewing relevant policies, guidelines, and reports related to implementing transformative technologies in nursing care during the pandemic. Ethical considerations were carefully addressed, including obtaining informed consent from participants, ensuring privacy and confidentiality, and obtaining ethical approval from institutional review boards or ethics committees. Data analysis employed appropriate techniques for both qualitative and quantitative data. Thematic analysis and grounded theory were used to identify key themes and patterns in the qualitative data obtained from interviews. At the same time, statistical software facilitated quantitative data analysis, exploring

correlations, trends, and associations between variables. Limitations of the study were acknowledged, such as the potential lack of generalizability due to the specific context of the pandemic, potential bias in self-reported data, and challenges in accessing specific populations or settings. Measures such as triangulation of data sources, member checking, and inter-rater reliability checks for qualitative data analysis were implemented to ensure the validity and reliability of the research findings. This study aims to contribute to the existing body of knowledge on the role of transformative technologies in enhancing the quality of nursing care during the COVID-19 pandemic by employing these comprehensive methodological approaches (Jnr, 2020, p. 132).

Furthermore, the research design allows for a comprehensive exploration of the topic, considering both the quantitative and qualitative aspects. Combining interviews, surveys, and document analysis can achieve a more holistic understanding of the role of transformative technologies in nursing care during the COVID-19 pandemic. Interviews provide an opportunity to gather rich and detailed insights from nurses and healthcare administrators directly involved in patient care, capturing their experiences, challenges, and perspectives on using transformative technologies. As a result of surveys, quantitative data can be collected and analyzed to identify trends, patterns, and statistical associations regarding the impact of these technologies on nursing care quality. Document analysis, including relevant policies, guidelines, and reports, ensures that the study considers the broader context and implementation of transformative technologies in nursing care during the pandemic (Jnr, 2020, p. 132).

Rigorous measures are put in place to address the ethical considerations of the study. Before consenting, participants are informed about the study's purpose, procedures, and potential risks. Privacy and confidentiality are strictly maintained with data anonymization and secure storage practices. Additionally, the study is ethically approved by relevant institutional review boards or ethics committees, ensuring compliance with ethical guidelines.

Appropriate techniques were applied to analyze the collected data. Thematic analysis and grounded theory are utilized to identify key themes, patterns, and relationships within the qualitative data obtained from interviews. The use of transformative technologies can be examined from the perspective of nurses and healthcare administrators through this approach. Quantitative data from surveys were analyzed using statistical software, enabling the examination of correlations, trends, and associations between variables, thereby providing quantitative evidence to support the study objectives (Datta and Nwankpa, 2021).

The study design has inherent limitations that should be acknowledged while conducting this research. There may be limitations due to the specific context of the pandemic, which might limit the generalizability of the findings. Additionally, potential biases in self-reported data and challenges in accessing particular populations or settings need to be considered. This study aims to provide a balanced and nuanced interpretation of the research findings by transparently acknowledging these limitations.

Various measures are taken to ensure the research's validity and reliability. Triangulation of data sources, such as interviews, surveys, and document analysis, strengthens the robustness of the findings by cross-validating different perspectives and data sources. Member checking is employed to validate the accuracy of the interpretations made from the qualitative data, ensuring alignment with the participants' views. Furthermore, inter-rater reliability checks were conducted to ensure consistency and agreement among the researchers involved in the analysis.

The role of transformative technologies in enhancing the quality of nursing care during the COVID-19 pandemic is also investigated by implementing these rigorous methodological approaches. The comprehensive methodology guarantees a comprehensive exploration of the topic, while ethical considerations, data analysis techniques, limitations, and measures are carefully addressed to ensure validity and reliability (Datta and Nwankpa, 2021).

### 1.2.3 Modeling method

The COVID-19 pandemic has brought unprecedented challenges to the healthcare industry worldwide. The surge in patients and the need for efficient care have highlighted the importance of technology in healthcare, particularly in nursing care. Transformative technologies, such as telehealth, artificial intelligence, and data analytics, have played a crucial role in enhancing the quality of nursing care during the pandemic. Telehealth uses electronic communication and information technologies to provide healthcare services remotely as a game-changer in nursing care. Telehealth has enabled healthcare providers to triage and treat patients remotely, reducing the need for hospital visits during the pandemic, decreasing the risk of transmission, and enabling healthcare providers to reach patients in remote areas where access to healthcare facilities may be limited.

Artificial intelligence (AI) has also played a vital role in enhancing the quality of nursing care during the pandemic. AI-powered chatbots and voice assistants have provided patients with information and support, such as answering questions about symptoms and treatments and helping them navigate the healthcare system. AI-powered systems have also been used to monitor patients' vital signs and detect early signs of sepsis, enabling healthcare providers to intervene promptly and potentially prevent serious complications.

Data analytics are another key technology that has enhanced nursing care during the pandemic. Healthcare providers can identify patterns and trends by analyzing data from various sources, such as electronic health records, medical imaging, and lab results. Data analytics has enabled healthcare providers to identify high-risk patients, optimize treatment protocols, and allocate resources more effectively.

Transformative technologies in nursing care have several benefits during the COVID-19 pandemic. First, transformative technologies have enabled healthcare providers to deliver care remotely, reducing the risk of transmission and improving access to healthcare services for patients in remote areas. Secondly, healthcare providers have been able to monitor patients more closely, detecting early signs of

complications and potentially preventing severe outcomes. Thirdly, healthcare providers have optimized treatment protocols and allocated resources more efficiently, improving quality and efficiency.

However, adopting transformative technologies in nursing care during the pandemic has also presented several challenges. First, there have been concerns about data privacy and security, particularly in telehealth. Second, some healthcare providers have expressed concerns about the quality of care provided remotely, suggesting that remote consultations may not be as effective as in-person consultations. Third, some concerns were expressed about the equity of access to transformative technologies, with some patients not having access to the necessary infrastructure or technology to access telehealth services.

Despite these challenges, transforming technologies played a key role in enhancing nursing care during the COVID-19 pandemic. The pandemic has highlighted the need for efficient and effective healthcare delivery, and transformative technologies have played a crucial role in enabling healthcare providers to deliver high-quality care in a challenging environment. As the pandemic continues, the use of transformative technologies in nursing care is likely to grow. Thus, healthcare providers and policymakers should address the challenges associated with their adoption to ensure that all patients benefit from these technologies.

### 1.3 Data modeling and analysis with MATLAB

MATLAB's powerful data modeling capabilities were employed to analyze large datasets generated by telehealth platforms. Machine learning algorithms developed in MATLAB helped predict patient deterioration based on real-time data, allowing for timely interventions. For instance, predictive models identified patients at high risk of developing severe symptoms, enabling nurses to prioritize care and allocate resources more effectively. AI technologies significantly enhanced decision-making processes in nursing care during the pandemic. AI-driven tools, such as natural language processing (NLP) and computer vision, assisted nurses in diagnosing and managing COVID-19 patients. MATLAB's extensive suite of AI tools facilitated the development and deployment of these applications, streamlining workflows and improving patient outcomes. Researchers have developed AI models capable of analyzing chest X-rays and CT scans using MATLAB to detect COVID-19-related abnormalities. These models provided nurses with rapid, accurate assessments, aiding in the early diagnosis and treatment of the disease. Additionally, MATLAB's NLP capabilities were harnessed to analyze clinical notes and patient records, extract valuable insights and identify trends that informed nursing strategies. The pandemic underscored the importance of data-driven decision-making in healthcare. Advanced data analytics enabled the extraction of actionable insights from vast clinical data, guiding nursing practices and policies. MATLAB's analytical tools support the development of comprehensive data models that integrate patient information, treatment protocols, and outcomes. MATLAB was instrumental in creating predictive models that informed staffing and resource

allocation in healthcare facilities. Nursing administrators could forecast surges in demand by analyzing patient admissions and outcomes patterns. Furthermore, MATLAB facilitated the analysis of patient outcomes, identifying effective treatment protocols and best practices disseminated across nursing teams.

## 2. Results

The healthcare ecosystem is undergoing a metamorphosis driven by the relentless advancement of technology. The nursing profession stands at a crossroads within this dynamic landscape. Technological solutions offer immense potential to revolutionize care delivery, optimize workflows, and, ultimately, enhance patient outcomes. As a result, the multifaceted impact of technology on nursing practices was examined, dissecting possible benefits, revealing inherent challenges, and proposing a framework for successful integration. Telehealth platforms and RPM systems are rapidly reshaping the nurse-patient interaction. Video consultations enable real-time assessments, facilitate chronic disease management, and streamline post-operative follow-up, demonstrably reducing hospital readmission rates (Table 1). RPM systems equip patients with wearable devices that continuously collect vital signs and health data to empower nurses to proactively monitor patient health trajectories and intervene promptly in the event of concerning deviations (Figure 1).

*Table 1: Impact of Telehealth on Hospital Readmission Rates*

| Control Group | Readmission Rate (Intervention) | Readmission Rate (Control) | Reduction (%) |
|---|---|---|---|
| Usual care | 12% | 18% | 33% |
| In-person visits only | 8% | 15% | 47% |

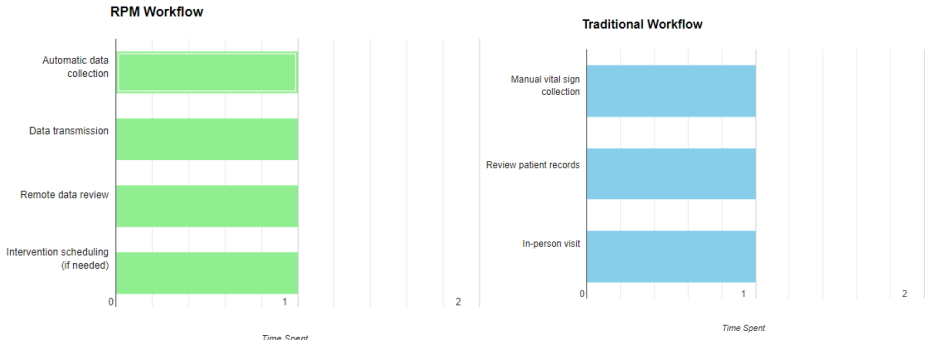


*Figure 1: The Impact of RPM on Nurse Workflows. a) RPM Workflow, b) Traditional Workflow.*

Figure 1 depicts the contrasting workflows between traditional patient monitoring and those facilitated by remote patient monitoring (RPM) systems. The traditional workflow represents a nurse's typical steps when manually collecting

patient data during in-person visits. The RPM workflow, conversely, illustrates how technology automates data collection and transmission, streamlining the process for nurses.

Telehealth platforms and RPM systems are emerged as vital tools during the pandemic. Nurses can now safely and efficiently manage non-critical cases with video consultations to mitigate the risk of nosocomial transmission for both parties and facilitate continuity of care for patients hesitant to visit hospitals. As shown in Table 2, studies have demonstrated a positive correlation between telehealth adoption and reduced hospital burden.

*Table 2: Hypothetical Data on Telehealth Impact*

| Metric | Pre-Telehealth | Post-Telehealth | Change |
|---|---|---|---|
| Hospital Readmission Rate | 15% | 10% | -5% |
| Emergency Department Visits | 20 per week | 15 per week | -5 per week |
| Nurse Time Spent on Non-Critical Visits | 30% | 15% | -15% |

Regarding the quantitative analysis, the target population, including nurses and healthcare workers who were active during the COVID-19 pandemic, was divided into two main groups: nurses working in hospitals and treatment centers directly involved with COVID-19 patients and nurses in community health centers serving non-hospital settings and caring for non-COVID-19 patients.

The questionnaire should cover various aspects of nursing care quality and the role of transformative technologies. Questions can be designed in different formats, such as multiple-choice, Likert scale, and open-ended questions.

Various methods can be employed to collect data after the questionnaire is designed and validated, including online surveys, telephone interviews, and in-person distribution. SPSS software was used to analyze the collected data and provide various tools for quantitative data analysis. Accordingly, the data were cleaned to ensure accuracy and remove incomplete or incorrect data. Descriptive statistics such as mean, standard deviation, and frequency tables were utilized to display the data. Finally, appropriate statistical tests such as t-tests, ANOVA, and regression analysis were conducted to test the research hypotheses (Tables 3 to 5).

*Table 3: Descriptive Statistics of Variables*

| Variable | N | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Care Quality | 200 | 4.2 | 0.6 | 3 | 5 |
| Role of Technology | 200 | 3.8 | 0.7 | 2 | 5 |

*Table 4: Frequency Distribution of Responses for Care Quality*

| Response | Frequency | Percentage |
|---|---|---|
| Very Poor (1) | 5 | 2.5% |
| Poor (2) | 10 | 5% |
| Average (3) | 30 | 15% |
| Good (4) | 100 | 50% |
| Very Good (5) | 55 | 27.5% |

*Table 5: Cross-Tabulation of Care Quality and Role of Technology*

| Care Quality/Role of Technology | Very Poor (1) | Poor (2) | Average (3) | Good (4) | Very Good (5) |
|---|---|---|---|---|---|
| Very Poor (1) | 1 | 1 | 1 | 1 | 1 |
| Poor (2) | 2 | 1 | 2 | 3 | 2 |
| Average (3) | 1 | 2 | 6 | 10 | 11 |
| Good (4) | 1 | 3 | 8 | 40 | 48 |
| Very Good (5) | 0 | 0 | 2 | 15 | 38 |

## 3. Discussion and Conclusions

Nursing has been at the forefront of responding to the global COVID-19 pandemic, which has undoubtedly posed unprecedented challenges to healthcare systems worldwide. In recent years, there has been an increasing awareness of transformational technologies' role in bolstering the quality of nursing care due to an overwhelming demand for healthcare services and the heightened risks frontline workers face. This comprehensive investigation aimed to evaluate the multifaceted ways in which cutting-edge technological advancements have been instrumental in fortifying the nursing profession's capacity to navigate the complexities of the pandemic effectively.

First, the implementation of telehealth and telemedicine solutions has revolutionized the delivery of nursing care, enabling seamless remote patient monitoring and consultation. Nurses have maintained continuous engagement with their patients, providing personalized care and monitoring without compromising safety protocols by leveraging advanced communication platforms and video technologies. As a result, the risk of virus transmission has been reduced, access to medical care has been improved, and vulnerable populations have been provided with the necessary care.

Second, integrating artificial intelligence (AI) and machine learning (ML) algorithms has empowered nurses to make more informed clinical decisions and optimize patient outcomes. Through the analysis of vast datasets, these transformative technologies have aided in the early detection of health deterioration, informed the development of personalized treatment plans, and streamlined the triage process. AI and ML have significantly enhanced the quality and efficiency of nursing care during the pandemic by augmenting nurses' decision-making capabilities.

Furthermore, the rapid advancements in robotics and automation have revolutionized various aspects of nursing practice. The deployment of autonomous disinfection robots, for instance, has enabled the continuous sanitization of clinical environments, reducing the risk of virus transmission and safeguarding the well-being of nursing staff. Similarly, automated medication dispensing systems and smart beds have alleviated the administrative burden on nurses, allowing them to focus more on direct patient care and addressing the unique needs of individuals.

The COVID-19 pandemic has also highlighted the crucial role of data analytics and predictive modeling in strengthening the nursing profession's preparedness and response. Nurses have been able to anticipate surges in patient volumes, optimize resource allocation, and tailor their interventions to address the evolving needs of their communities by integrating sophisticated data management and analysis tools. The applied data-driven approach was instrumental in maintaining nursing services' resilience and improving the quality of care during the pandemic.

Moreover, the proliferation of wearable technologies and mobile health applications has empowered patients to actively participate in their healthcare management. These transformative technologies have fostered stronger patient-nurse collaboration, improving self-care practices and better health outcomes by enabling real-time monitoring of vital signs, medication adherence, and symptom reporting. The level of patient engagement has been particularly crucial during the pandemic when in-person interactions have been limited.

The COVID-19 pandemic has also underscored the importance of efficient data sharing and secure communication platforms in supporting the nursing profession. The development of centralized electronic health record (EHR) systems and robust data infrastructures has facilitated the seamless exchange of critical patient information among healthcare providers, enabling nurses to access and update patient records in real time. As a result, continuity of care has been ensured, medical errors have been reduced, and nursing interventions have been improved.

In addition to the direct impact on nursing practice, transformative technologies have also played a pivotal role in supporting the well-being and resilience of nursing staff during the pandemic. The availability of virtual mental health resources, online support groups, and wellness applications has provided nurses with much-needed tools to manage stress, address burnout, and maintain their own physical and emotional well-being. Supporting the nursing workforce has been vital to maintaining the quality of care and ensuring long-term resilience.

Integrating augmented and virtual reality (AR/VR) technologies has also revolutionized nursing education and training, particularly during the pandemic when in-person interactions were limited. The immersive learning environments have enabled nursing students and practitioners to acquire new skills, practice clinical scenarios, and develop critical decision-making capabilities in a safe and controlled setting. Nursing education has been improved through this innovative approach, and seamless onboarding of new nurses has been made possible.

The integration of transformative technologies, as elucidated in the preceding sections, has significantly impacted nursing practice and holds profound implications for the future of healthcare delivery. The discussion herein synthesizes the key findings and implications derived from analyzing various technological solutions in nursing, addressing their potential benefits, challenges, and implications for practice, education, and patient outcomes.

Telehealth platforms and remote patient monitoring (RPM) systems have emerged as pivotal tools in augmenting nursing practice, particularly extending care beyond traditional clinical settings. Nurses can provide continuous monitoring,

chronic disease management, and preventive care in patients' homes by facilitating real-time video consultations and equipping patients with wearable health sensors. The mentioned technological advancements enhance accessibility to care, foster patient engagement, and empower individuals to take an active role in self-management. Furthermore, telehealth and RPM have demonstrated tangible benefits in reducing hospital readmission rates, as evidenced by the significant reductions observed in various studies (Table 4). Thus, these technologies may improve patient outcomes and reduce healthcare resource utilization.

Artificial intelligence (AI) and machine learning (ML) algorithms offer unprecedented opportunities to augment nursing practice through data-driven insights and decision-support systems. AI can assist nurses in risk stratification, early detection of complications, and personalized treatment plans by analyzing vast amounts of patient data. Moreover, AI-powered chatbots streamline administrative tasks, allowing nurses to allocate more time to direct patient care activities. However, integrating AI into nursing practice necessitates careful consideration of ethical implications, including algorithmic bias and patient privacy concerns. Future research endeavors should focus on developing ethical guidelines and frameworks to ensure equitable and responsible AI implementation in nursing.

The proliferation of big data analytics in healthcare has revolutionized nursing practice by providing actionable insights derived from Electronic Health Records (EHRs), patient wearables, and other sources. Predictive analytics enable nurses to anticipate patient needs, predict potential complications, and tailor interventions accordingly, leading to more efficient resource allocation and improved patient outcomes. However, the effective utilization of big data analytics requires nurses to possess adequate data literacy and analytical skills. Therefore, nursing education programs should evolve to incorporate interdisciplinary informatics, data science, and implementation science training to prepare nurses for the digital age.

Wearable technologies, such as smartwatches and biosensors, have emerged as invaluable tools for real-time patient monitoring and early detection of clinical deterioration. Nurses can use these devices to intervene proactively in patients' care, potentially preventing adverse events and improving patient safety. Additionally, clinical decision support systems (CDSS) offer nurses valuable guidance by integrating patient data and evidence-based practices, promoting standardized care and reducing medication errors. Moreover, robotic assistants and assistive technologies alleviate the burden of mundane tasks, allowing nurses to focus on providing high-quality, compassionate care to their patients.

Virtual reality (VR) simulation training represents a paradigm shift in nursing education, offering learners a safe and immersive environment to develop clinical skills and prepare for complex scenarios. VR simulations enhance the efficiency of skills acquisition and foster experiential learning, particularly in critical care contexts where swift and accurate decision-making is paramount. However, the widespread adoption of VR training necessitates substantial investment in

infrastructure and faculty training, highlighting the importance of organizational support and leadership in driving technological innovation in nursing education.

Integrating transformative technologies into nursing practice requires a paradigm shift in the nurse-patient relationship and care delivery models. Nurses should adapt to virtual care modalities and embrace technologies that facilitate remote communication and engagement. As technologies are adopted, ethical and data privacy concerns must be acknowledged and addressed to ensure patient confidentiality and security. Additionally, nurses should prioritize the human element of care, maintaining empathy, communication, and trust in their interactions with patients amidst the digital transformation of healthcare.

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# DESIGN AND MARKETING

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# INFLUENCE OF STIMULUS FORMAT ON VIRTUAL CHARACTER PERCEPTION

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***Abstract***

*The expansion of the implementation of virtual characters has led to their use both in the expected framework of video games and in additional areas of entertainment, marketing, banking, healthcare, and education. Content using virtual characters is available in various formats, including still images, gifs, and videos. As part of this research, an analysis of the impact of the stimulus format (pictures or videos) on the perception of likability, naturalness of appearance, and confidentiality of virtual characters was carried out. In the experimental part of the research, respondents were shown four virtual characters (two female and two male) in two formats: image and video. The respondents' task was to evaluate the likability, naturalness of appearance, and trustworthiness of each depicted character according to the Likert scale in the survey. In order to determine the influence of the stimulus format on the respondents' reactions regarding likability, naturalness of appearance, and character confidentiality, a paired samples T-test was conducted, as well as a post-hoc Wilcoxon rank test to determine the degree of variation of the results, and then a T-test of independent samples to determine the equality of the obtained results. It was determined that statistically significant differences occur with one character in the context of likability and trust and one character in the context of naturalness of appearance.*

***Key words****: virtual character, image, video, likeability, naturalness, trust.*

## 1. Introduction

When displaying different types of content, the question is often raised whether the way the content is displayed impacts the perception of it. As early as

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the 1950s, research was conducted to determine the impact of the stimulus format on the perception of different information (Fan et al., 2020). It is generally believed that video as a dynamic display format has an advantage over static images. However, this theory is not always correct. Videos fulfill most of the characteristics associated with static images, such as the ability to standardize, and are therefore often claimed to be even more helpful. Unlike static images, videos are dynamic and considered more similar to real life. Their technical elements (camera movement, editing, sound) can emphasize actions and their emotional meaning (Mikunda, 2002; Uhrig et al., 2016). The most common field of research on the impact of stimuli on perception is found in psychology. Numerous research has been conducted to determine whether there is a difference in the perception of emotions depending on the type of stimulus format. Still, images are consistently as effective and sometimes more effective than video in eliciting human emotion (Fan et al., 2020; Uhrig et al., 2016). One of the disadvantages of using video as a stimulus is the so-called frozen face effect (FFE), which occurs when the video is paused. It is believed that this phenomenon can significantly impact the perception of the likeability and attractiveness of the observed stimulus, whether it is an animated character or a person from the real world (Post et al., 2012). It was also shown that when using computer- generated facial animation, the presence of additional movements of the character had an impact on the feeling of likability, and attractiveness is associated with the amount of movement of the observed character (Knappmeyer et al., 2002; Morrison et al., 2007). However, it is interesting that this phenomenon does not occur in people from the real world. When comparing the likeability of videos of a person speaking and static images selected from videos, no differences in attractiveness ratings were found between static and dynamic face stimuli (Rubenstein, 2005; Roberts et al., 2009; Penton-Voak & Chang, 2008). What was finally established is that the ratings of static images and dynamic videos can be strongly positively correlated. It is essential to emphasize that the strength of this correlation depends on whether the same or different rater assigns the two ratings for both stimuli, whether the raters are of the same or opposite sex, and the context in which the videos were recorded. It is also pointed out that the likeability of a static face is a good indicator of the attractiveness of the same person when moving (Roberts et al., 2009).

## 2. Experimental

Since it is considered that there is a difference in the perception of the displayed content depending on whether it is marketed as a video or a static image, this research aimed to examine precisely this hypothesis. This research is based on analyzing the influence of the stimulus format on the perception of virtual characters by the respondents, focusing on the aspects of likability, naturalness of appearance, and confidentiality.

## 2.1 Methods

The primary tool for collecting respondents' reactions was a three-part survey. The first section related general information about the respondents, including gender and age. The second and third sections recorded the respondents' reactions to stimuli in the context of likability, naturalness of appearance, and trustworthiness of character. These two sections were divided so that stimuli were shown in static images in the second section, while in the third section, the stimuli were in video format.

The three evaluation parameters are according to the Likert scale from -5 (do not agree at all) to 5 (completely agree):

- P1 – likability of the character;
- P2 – the naturalness of the character's appearance;
- P3 – confidentiality of character.

To thoroughly examine the influence of the stimulus type on the respondents' reactions, we employed two statistical tests. The T-test of paired samples was used to compare the means of two related groups, while the post-hoc Wilcoxon rank test was used to determine the degree of variation in the results. Additionally, a T-test of independent samples was conducted to check for equality among the obtained results. Finally, the Eta square was calculated to determine the size of the influence.

## 2.2 Stimuli

Characters created with the help of MetaHuman Creator software were used as stimuli. A library of available characters was used as a starting point for character creation, adjusted according to needs. Four characters were created—two female and two male (Figure 1).

*Figure 1: Created characters*

The characters were shown to the respondents in two formats—static images and videos with accompanying audio. Two audio recordings were used—one for

both female characters and the other for both male characters. The video is generated so that the characters' gestures follow the audio content.

## 3. Results and Discussion

The survey group comprised 59 respondents (38 women and 21 men) aged between 18 and 25.

When analyzing the respondents' ratings, it was observed that in the context of the naturalness of the character's appearance, a higher average rating for each character was assigned to the stimuli of static images. Regarding likability and trustworthiness, the video stimuli were rated with a higher average rating for both female and male characters. In the case of the second male character, images as stimuli were rated more positively in the context of all three evaluated parameters.

In order to determine the statistical significance of the difference in responses in relation to the stimulus format, we employed a paired-sample T-test. This test allowed us to determine that a statistically significant difference in the respondents' answers occurred in only three questions out of a total of 12 analyzed (Table 1). This level of detail and precision in our research process instills confidence in the validity of our findings.

*Table 1: Paired samples t-test results*

| Pairs | N | Mean | Std. Deviation | Std. Error Difference | Sig. (2-tailed) |
|---|---|---|---|---|---|
| F1p1IMAGE – F1p1VIDEO | 59 | -1.339. | 2.411 | 0.314 | 0.000 |
| F1p2IMAGE – F1p2VIDEO | 59 | 0.322 | 1.870 | 0.243 | 0.191 |
| F1p3IMAGE – F1p3VIDEO | 59 | -1.831 | 2.743 | 0.357 | 0.000 |
| F2p1IMAGE – F2p1VIDEO | 59 | -0.186 | 1.978 | 0.258 | 0.472 |
| F2p2IMAGE – F2p2VIDEO | 59 | 0.153 | 1.981 | 0.258 | 0.557 |
| F2p3IMAGE – F2p3VIDEO | 59 | -0.017 | 2.055 | 0.268 | 0.950 |
| M1p1IMAGE – M1p1VIDEO | 59 | -0.271 | 2.476 | 0.322 | 0.404 |
| M1p2IMAGE – M1p2VIDEO | 59 | 0.068 | 2.333 | 0.304 | 0.824 |
| M1p3IMAGE – M1p3VIDEO | 59 | -0.237 | 2.231 | 0.290 | 0.417 |
| M2p1IMAGE – M2p1VIDEO | 59 | 0.203 | 2.219 | 0.289 | 0.484 |
| M2p2IMAGE – M2p2VIDEO | 59 | 1.322 | 2.569 | 0.334 | 0.000 |
| M2p3IMAGE – M2p3VIDEO | 59 | 0.153 | 2.180 | 0.284 | 0.593 |

The influence of the stimulus format on the perception of all three examined parameters - likability, naturalness of appearance, and trustworthiness of the character - was evaluated using the t-test of paired samples. A statistically significant difference was found in the perception of the first female character in the context of likeability when comparing the image (M = -0.22, SD = 2.221) and the video (M = 1.12, SD = 2.614), t (58) = -4.265, p < 0, 0005. The mean difference in likability was -1.339, while the 95 percent confidence interval extended from -1.967 to -0.711. The value of the eta square (0.19) shows that the influence of the stimulus format is large. With the same character, a significant statistical difference also

occurs in the rating of the confidentiality parameter between the image (M = -0.93, SD = 2.538) and the video (M = 0.90, SD = 2.611), t (58) = -5.126, p < 0.0005. The average difference in character confidence was -1.831, while the 95 percent confidence interval extended from -2.545 to -1.116. The effect of the stimulus format was marked as significant based on the eta squared value (0.29). When it comes to male characters, the only statistically significant difference was observed for the second male character in the context of naturalness of appearance when comparing the image (M = 0.86, SD = 2.323) and the video (M = -0.46, SD = 2.459), t (58) = 3.952, p < 0.0005. The value of the eta square (0.12) shows that the influence of the stimulus format is moderate.

The Wilcoxon Signed Rank Test was conducted to confirm the results as a post- hoc non-parametric alternative. This test confirmed the results obtained by the paired samples T-test (Table 2).

*Table 2: Wilcoxon Signed Rank Test results*

| Pairs | z | p | r |
|---|---|---|---|
| F1p1IMAGE – F1p1VIDEO | -3.967 | 0.000 | 0.36 |
| F1p2IMAGE – F1p2VIDEO | -1.218 | 0.223 | 0.11 |
| F1p3IMAGE – F1p3VIDEO | -4.486 | 0.000 | 0.41 |
| F2p1IMAGE – F2p1VIDEO | -0.916 | 0.359 | 0.08 |
| F2p2IMAGE – F2p2VIDEO | -0.006 | 0.995 | 0.0005 |
| F2p3IMAGE – F2p3VIDEO | -0.920 | 0.358 | 0.08 |
| M1p1IMAGE – M1p1VIDEO | -0.915 | 0.360 | 0.08 |
| M1p2IMAGE – M1p2VIDEO | -0.627 | 0.531 | 0.06 |
| M1p3IMAGE – M1p3VIDEO | -0.747 | 0.455 | 0.07 |
| M2p1IMAGE – M2p1VIDEO | -0.771 | 0.441 | 0.07 |
| M2p2IMAGE – M2p2VIDEO | -4.199 | 0.000 | 0.39 |
| M2p3IMAGE – M2p3VIDEO | -0.387 | 0.699 | 0.04 |

Wilcoxon Signed Rank Test revealed a significant statistical difference when analysing the attractiveness results of the first female character according to the stimulus format z = -3.967, p < 0.0005 with a large difference in results (r = 0.36). Regarding confidentiality of the same character, a statistically significant difference was observed concerning the stimulus format z = -4.486, p < 0.0005, with a large difference in results (r = 0.41). When analysing the results of the second male character, a statistically significant difference was observed in the parameter of naturalness of appearance z = -4.199, p < 0.0005 with a large difference in results (r = 0.39).

After analysing the previously obtained results, a T-test of independent samples was conducted to determine the equality of the results of the likability parameters, naturalness of appearance, and character confidentiality in the two stimulus formats (image and video). The results of this test showed that the variances were equal in 11 out of the 12 examined cases, while statistical significance was observed in three cases (Table 3).

*Table 3: Independent-samples t-test results*

| | N | Levene's Test for Equality of Variances (Sig.) | t | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|---|---|---|---|---|---|---|
| **F1 likeability** | 59 | 0.469 | -2.999 | 0.003 | -1.339 | 0.447 |
| **F1 naturalness** | 59 | 0.128 | 0.717 | 0.475 | 0.322 | 0.449 |
| **F1 confidentiality** | 59 | 0.951 | -3.861 | 0.000 | -1.831 | 0.474 |
| **F2 likeability** | 59 | 0.927 | -0.447 | 0.656 | -0.186 | 0.417 |
| **F2 naturalness** | 59 | 0.075 | 0.349 | 0.728 | 0.153 | 0.437 |
| **F2 confidentiality** | 59 | 0.275 | -0.040 | 0.968 | -0.017 | 0.425 |
| **M1 likeability** | 59 | 0.027 | -0.614 | 0.541 | -0.271 | 0.442 |
| **M1 naturalness** | 59 | 0.935 | 0.135 | 0.893 | 0.068 | 0.502 |
| **M1 confidentiality** | 59 | 0.078 | -0.510 | 0.611 | -0.237 | 0.465 |
| **M2 likeability** | 59 | 0.667 | 0.477 | 0.635 | 0.203 | 0.427 |
| **M2 naturalness** | 59 | 0.325 | 3.002 | 0.003 | 1.322 | 0.440 |
| **M2 confidentiality** | 59 | 0.788 | 0.347 | 0.729 | 0.153 | 0.440 |

The t-test of independent samples was used to compare the tests of likeability, naturalness of appearance, and trustworthiness of characters within images and videos. A statistically significant difference was observed for the first female character for the likability parameter between the picture (M = -0.22, SD = 2.221) and the video (M = 1.12, SD = 2.614), t (59) = -2.999, p = 0.003. The difference between the mean values of the features by groups (mean difference = -1.339, 95% CI: -2.223 to -0.455) was moderate (Eta square = 0.08). For the confidentiality parameter of the same character, a significant statistical difference was observed when comparing the image (M = -0.93, SD = 2.538) and video (M = 0.90, SD = 2.611), t (59) = -3.861, p < 0.0005. The difference between the mean values of the features by groups (mean difference = -1.831, 95% CI: -2.769 to -0.892) was large (Eta square = 0.15). The naturalness of the other male character's appearance also showed statistical significance when comparing the picture (M = 0.86, SD = 2.323) and the video (M = -0.46, SD = 2.459), t (59) = -3.002, p = 0.003. The difference between the mean values of the features by groups (mean difference = 1.322, 95% CI: 0.450 to 2.194) was moderate (Eta square = 0.08).

The Mann-Whitney U test was performed as a post-hoc non-parametric method to confirm the results obtained by the independent samples t-test (Table 4).

The Mann-Whitney U test confirmed the results of the t-test of independent samples. It revealed a statistically significant difference in the likeability of the first female character for the image and video (U = 1129, z = -3.318, p = 0.001, r = 0.3). Similar results were obtained regarding the confidentiality of the same character (U = 1045.5, z = -3.766, p < 0.0005, r = 0.35). Statistical significance was also observed in the naturalness of the appearance of the second male character (U = 1189.5, z = -2.987, p = 0.003, r = 0.27).

*Table 4: Mann-Whitney U test results*

| | z | p | r |
|---|---|---|---|
| **F1 likeability** | -3.318 | 0.001 | 0.3 |
| **F1 naturalness** | -0.551 | 0.582 | 0.05 |
| **F1 confidentiality** | -3.766 | 0.000 | 0.35 |
| **F2 likeability** | -0.528 | 0.597 | 0.05 |
| **F2 naturalness** | -0.280 | 0.779 | 0.03 |
| **F2 confidentiality** | -0.424 | 0.672 | 0.04 |
| **M1 likeability** | -0.511 | 0.610 | 0.05 |
| **M1 naturalness** | -0.135 | 0.892 | 0.01 |
| **M1 confidentiality** | -0.675 | 0.500 | 0.06 |
| **M2 likeability** | -0.537 | 0.592 | 0.05 |
| **M2 naturalness** | -2.987 | 0.003 | 0.27 |
| **M2 confidentiality** | -0.155 | 0.877 | 0.01 |

## 4. Conclusions

This research aimed to analyze in detail the influence of the stimulus format (pictures or videos) on the perception of virtual characters. The results showed that statistically significant differences were present only in a limited number of cases. Notably, the stimuli format had a statistically significant effect in cases of likability and trust for a female character, and in the naturalness of the appearance of a male character. These findings underscore the importance of carefully considering stimulus formats when creating virtual features, particularly in the context of communication and user interaction goals. However, it's crucial to note that in most cases, no statistically significant difference was observed between image and video formats in the perception of virtual characters. This suggests that while stimulus format may influence perception, this difference is not consistent or certain. In other words, in most cases, the perception of virtual characters does not significantly change between image and video formats. It's important to remember that the results of this research are specific to certain virtual characters, and variations in perception are inevitable depending on the context and characteristics of the target user group.

Further research could explore additional factors that may influence the perception of virtual characters in different formats, as well as a more detailed consideration of specific characteristics of characters that may have a fundamental impact on perception. Consideration of the mentioned factors can be crucial for optimizing the perception of virtual characters to achieve the desired communication and interaction with users. Such research could provide a deeper understanding of the complexity of the interaction between the stimulus format and the perception of virtual characters, which could find practical application in the design and application of virtual systems in various fields.

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# THE ROLE OF VALUE CO-CREATION IN THE BRANDING OF FUNCTIONAL URBAN AREAS: A DELPHI ANALYSIS

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***Abstract***

*This paper investigates the role of value co-creation in the branding of Functional Urban Areas (FUAs), emphasizing stakeholder participation in the branding process. FUAs are composed of smaller territorial units, necessitating collaboration and value co-creation to effectively manage and promote these regions. Using the Delphi method, international experts from academia, business, NGOs, and research institutes evaluated the thesis that value co-creation will be a defining characteristic of FUAs' branding. The research assessed the significance and desirability of this approach for developing a branding model for FUAs, examining potential barriers, supporting factors, and the impact on identified key stakeholder groups. Findings suggest that experts view value co-creation as one of the most essential elements for successful FUAs' branding, highlighting its potential to enhance stakeholder commitment and strengthen brand identity. This study provides valuable insights for both theorists and practitioners, emphasizing the need to incorporate value co-creation in FUAs' branding strategies and offering a foundation for future research and practical applications in urban and regional brand management.*

***Key words****: branding, value co-creation, Functional Urban Areas, FUA, Delphi method.*

## 1. Introduction

Functional Urban Areas (FUAs) have emerged as a strategic response to the issue of "urban sprawl," a phenomenon first identified in the 1930s in the United States. Urban sprawl was initially characterized by the spread of residential areas, low population density, and increasing commuting patterns (Squires, 2002). In contemporary urban development, FUAs reflect the decentralization of both residential and employment zones, often beyond the reach of traditional urban core

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spatial planning (Węgrzynowicz, 2022). In this context, the role of regional managers becomes crucial, as their actions significantly shape local policies and foster cooperation between local governments. Such voluntary, grassroots collaboration within FUAs enhances stakeholder engagement and facilitates the more effective implementation of urban policies (Michalcewicz-Kaniowska & Zajdel, 2023). Place branding has emerged as a critical strategy for promoting regional identity and competitiveness, aiming to enhance the participation of such key stakeholders, particularly tourists, investors, and skilled residents (Wäckerlin et al., 2020; Hanna et al., 2021).

## 2. Theoretical background

### 2.1. Functional Urban Areas (FUAs) as a Tool in Urban Development

The increasing demand for a higher quality of life has directly impacted urban space management. Agglomerations, comprising cities and their surrounding areas, offer well-developed infrastructure for access to city centres, such as fast rail systems (Gruszka, 2024). More people now prefer suburban or neighbouring municipalities for their quieter environments, away from noise and pollution (Wu & Phelps, 2011). However, this shift has led to increased commuting as smaller cities often lack sufficient employment opportunities, prompting the rise of FUAs to enhance living standards (Lityński & Hołuj, 2020).

FUAs are continuous spatial units comprising administratively distinct entities. They encompass both densely populated urban areas and their functionally connected suburban zones. These areas can include urban, rural, and mixed urban-rural municipalities (KPZK 2030). As a result, they are often characterized by spatial phenomena or conflicts, uniting regions with shared development goals and conditions. Effective collaboration between municipalities can complement or even substitute territorial-administrative reforms and governmental regulations (Kaczmarek, 2015). Integrating smaller administrative units into functionally connected zones allows for more effective strategic planning and management (Kurek et al., 2020). While local governments tend to prioritize issues like public safety or education over place promotion, the latter's long-term impact on residents' quality of life is significant (Płaszowska, 2017).

Despite the potential for conflicts, social consensus and flexible decision-making processes enable the involvement of key stakeholders—residents, tourists, investors, and local authorities within the FUA—leading to better social and economic outcomes (Andersen & Damurski, 2022).

### 2.2. Co-Creation in Place Branding

Place brands, especially in the context of FUAs, are developed through collaboration among multiple organizations, often aiming to create a unified marketing strategy based on shared values while sharing the costs and benefits of brand building. When such a brand is tied to a specific territory, it becomes known

as a "territorial brand" or "place brand," terms often used interchangeably (Rovira et al., 2022).

Place branding process is inherently more complex than corporate branding due to the involvement of multiple stakeholders, such as residents, tourists, and investors (Oleksy-Gębczyk & Niemczyk, 2020). Residents, often seen as the most crucial stakeholders, serve as intermediaries between other groups and are frequently referred to as "brand advocates" or "brand ambassadors," leveraging their close ties to the place to promote its image (Lever et al., 2023; Feng et al., 2023).

Co-creation, particularly value co-creation, is increasingly recognized as a vital component of place branding, involving various stakeholders, especially residents, in shaping the brand to ensure it resonates with the community (Hongsuchon et al., 2023). A key challenge in implementing the co-creation concept in branding is that it involves both influencing (branding) and being influenced (brand image) (Sarasvuo et al., 2022). Co-creation models often emphasize the selection of techniques that consider situational factors and agreements between stakeholders, while highlighting the importance of knowledge from both sides in shaping engagement strategies and decision-making processes (Durugbo & Pawar, 2014). The customer brand co-creation model expands on co-creation theory by identifying three key antecedents for customer brand co-creation behaviours, demonstrating that successful co-creation requires sufficient brand engagement, brand self-congruity, and category involvement (France et al., 2015). The organic view of the brand (OVB) model extends this further, advocating for a flexible brand proposition that offers direction while being continuously negotiated with stakeholders, allowing for ongoing reinterpretation of meaning and experience. As consumer involvement increases, traditional control-based branding approaches become less effective (Iglesias et al., 2017).

The concepts of co-creation, flexibility, and stakeholder collaboration are increasingly recognised as essential for developing resilient brands capable of adapting to evolving consumer expectations and dynamic market conditions. The strength of the emotional connection between the brand and its stakeholders directly influences the brand's success (Angelina & Nurlinda, 2023). Thus, understanding what motivates residents to actively advocate for their city or region becomes key in building a successful place brand (Lever et al., 2023).

## 3. Research methods

The Delphi method is a structured approach designed to facilitate communication among a group of experts, aiming to improve collective decision-making on complex issues. This method relies on iterative rounds of indirect communication, allowing participants to refine and converge their opinions without direct interaction (Matejun, 2023). This approach was chosen to assess the phenomenon identified by practitioners in a previously conducted study. In that study, individual in-depth interviews (IDIs) were carried out between April and June 2021 with representatives of 15 of the 17 Polish Integrated Territorial Investment

(ITI) offices that were operating at the time. It should be noted that these ITI offices were located within the FUAs, the core of which are the voivodeship cities, which are required to develop an ITI strategy. ITIs are a tool of the EU cohesion policy aimed at developing urban cores and FUAs through cross-sectorial projects that address the needs of both cities and surrounding areas (Szafranek, 2015), including branding and marketing initiatives of FUAs.

The conducted interviews provided key insights, including:

- Gorzów Wielkopolski FUA: "We want to involve residents even more than before. (…) We intend to further multiply these efforts."
- Katowice FUA: "Regarding territorial branding, we emphasize joint actions and management of issues that were collectively identified."
- Kraków FUA: "We strive to continuously gather and evaluate feedback in our actions. (...) Let's consciously build everything, focusing on the needs of the stakeholders."
- Lublin FUA: "I support continuous development through public consultations, involving a certain level of social participation."

Both the IDIs and the literature review in Chapter 2 highlighted the significance of value co-creation. This served as the foundation for the creation of one of the theses evaluated by experts in the Delphi study: "value co-creation (participative branding engaging stakeholders) will be the characteristic feature of the created FUA brand."

Given FUAs' complexity, successful branding requires collaboration. While stakeholder engagement in urban branding is well-researched, value co-creation in FUAs has received limited attention, warranting further study. This paper addresses this research gap by employing the Delphi method to gather insights from international experts on the role of value co-creation in the branding of FUAs, with a particular focus on stakeholder involvement in the branding process.

The study examines five key issues related to the created thesis: (1) the significance of stakeholder engagement; (2) the desirability of this approach; (3) potential barriers; (4) contributing factors; and (5) the impact on stakeholder groups. Expert selection followed established Delphi method criteria: experts needed to be directly connected to the study's focus, nationally or internationally distinguished, and from diverse fields to ensure enriched discourse (de San Eugenio Vela et al., 2013). These criteria have been adapted in this study, inviting international experts from fields such as: marketing and branding, place branding, management, urban studies, and geography. International experts were identified via Scopus and Web of Science, covering academia, business, NGOs, and research institutes. The Delphi method was employed in this study across two rounds. In both of them experts evaluated various aspects related to value co-creation and FUA branding using a five-point Likert scale, ranging from **"very high"** to **"very low"**. In the second round, in line with the method's principles, respondents were provided with the summarized results from the first round, allowing them to reconsider their responses in light of the averaged expert opinions. The first round included 81

experts, and the second round included 58 experts, representing a total of 36 different countries. According to multi-stakeholder Delphi guidelines, a sample size of 60 to 80 participants is considered sufficient, with smaller samples (20–30) suitable for single stakeholder groups (Manyara et al., 2024). Given these numbers, the sample size for this study was deemed reliable. Data was collected from July to September 2023, with participants invited via email survey links.

In employing the Delphi method, it is essential to acknowledge certain limitations associated with expert-based research. The author is aware of the fact that experts may possess biases that influence their opinions, and the consensus achieved through this method may reflect groupthink or over-conformity rather than a comprehensive understanding of the issues at hand (Lilja et al., 2011). In order to mitigate the potential for bias, efforts were made to engage experts from a range of countries and diverse professional backgrounds.

## 4. Results

The results indicate that experts recognise value co-creation as a key element of successful FUA's branding, highlighting its ability to increase stakeholder engagement and strengthen brand identity. Experts concurred in the second round of the study that participative branding, which involves stakeholder engagement, is crucial for the FUAs' brand management model, with nearly 38% of responses indicating a high level of significance. Additionally, it is considered highly desirable, as evidenced by 43% of responses rating it as very desirable.

The examined issues are expressed through indicators, which were calculated using a formula outlined in the literature (Kononiuk et al., 2021), as detailed below:

$$I = \frac{100 * n_{VH} + 75 * n_H + 50 * n_A + 25 * n_L + 0 * n_{VL}}{n}$$

where:

$n_{VH}$ – the number of responses "very high",
$n_H$ – the number of responses "high",
$n_A$ – the number of responses "average",
$n_L$ – the number of responses "low",
$n_{VL}$ – the number of responses "very low",
n – the number of responses.

The study concluded after the second round, as expert consensus was high and the changes introduced were minimal. Table 1 presents the key findings on value co-creation in the context of FUA's branding according to experts.

*Table 1: Key findings – second round*

| **Value co-creation (participative branding engaging stakeholders) will be the characteristic feature of the created FUA brand** | **Indicator level** | |
|---|---|---|
| | **Round 1** | **Round 2** |
| **Significance** | 70.7 | 72.4 |
| **Desirability** | 73.8 | 78.0 |
| **Barriers** | | |
| Limited funding | 55.2 | 54.7 |
| Task-based nature of FUAs and their ITI offices | 56.2 | 54.3 |
| Insufficient digital competences | 54.6 | 54.3 |
| Lack of supportive legal regulations | 50.6 | 52.2 |
| Distinct conflicts and differences between the aspirations and views of individual FUA's stakeholders regarding the direction of FUA's development | 66.0 | 63.4 |
| Low involvement of stakeholders in the process of building a joint brand | 67.3 | 69.0 |
| **Contributing Factors** | | |
| Additional financial support | 59.3 | 59.9 |
| Rapid development of technologies related to remote communication | 61.1 | 60.3 |
| High level of brand management competences among FUA's managers | 66.7 | 67.7 |
| High citizen awareness of belonging to a FUA | 67.0 | 67.2 |
| High interest of residents in areas distanced from city centers | 66.4 | 63.4 |
| High involvement of internal stakeholders in a jointly built brand | 76.2 | 77.2 |
| **Key Stakeholders** | | |
| Citizens | 74.4 | 73.7 |
| Tourists | 62.3 | 63.4 |
| Investors | 71.9 | 74.1 |

Based on the collected data, experts confirmed the significance and desirability of stakeholder participation in FUA's branding. Both metrics increased between Round 1 and Round 2, with desirability rising notably from 73.8 to 78.0. This indicates that experts increasingly recognized value co-creation as a desirable feature for building a successful FUA brand.

Among the barriers, low involvement of stakeholders in the process of building a joint brand was consistently highlighted as a significant issue, increasing slightly from 67.3 in Round 1 to 69.0 in Round 2. Analogously, h**igh involvement of internal stakeholders** was consistently highlighted as the most critical contributing factor, scoring 76.2 in Round 1 and rising to 77.2 in Round 2. Other barriers and contributing factors, though recognized, were considered less influential in hindering the application of value co-creation in FUA's branding. In both rounds, the lowest barrier scores were assigned to the lack of supportive legal regulations, which primarily referred to EU directives and ministerial regulations

governing the operations of ITI offices in Poland, while additional financial support was rated as the least important contributing factor.

It is important to note that the barriers and supporting factors discussed in this paper pertain specifically to the value co-creation process, rather than to the broader context of FUAs' branding. Therefore, the lack of commitment to the brand being developed is a fundamental aspect of the value co-creation, which experts identified as a significant barrier, along with a contributing factor emphasizing the crucial role of engagement in the co-creation process. The topic of barriers to place branding in FUAs is addressed in a separate article by the author (Matwiejczyk, 2024).

The role of citizens was initially rated highest in Round 1 (74.4) among key stakeholders. However, in Round 2, experts shifted their focus, recognizing investors as slightly more critical, with an indicator of 74.1 compared to 73.7 for citizens. This subtle change may reflect a broader understanding that while citizens remain essential to the branding process, the involvement of investors is also crucial for ensuring long-term sustainability and resources. Interestingly, this shift contrasts with findings from the IDIs and literature, which predominantly highlighted the role of citizens in shaping a place brand's identity, suggesting that stakeholder priorities may evolve depending on context and specific branding goals.

Notably, none of the examined factors received an indicator score below 50.0, underlining the overall feasibility of implementing value co-creation in FUA branding, despite the identified challenges.

## 5. Conclusions

The experts' consensus generally aligns with the perspectives of practitioners, particularly those from ITI offices, who emphasize the critical role of value co-creation in the branding process of complex areas like FUAs. Co-creation in branding not only enhances the brand's authenticity but also fosters emotional bonds between stakeholders and the place. These bonds are vital for building long-term loyalty and generating positive brand associations, which, in turn, strengthen the place brand's presence in the minds of residents, tourists, and investors (Jovičić Vuković, 2018). It is essential to engage these groups in the branding process, promoting a shared brand with which they can identify, ensuring that the brand is not rejected, and preventing a lack of commitment to acting as its ambassadors.

Moreover, there appears to be a slight shift in stakeholder priorities, with investors emerging as more critical in co-creating complex place brands. While the theoretical background and IDI results suggested that residents would play a dominant role as brand advocates, experts have increasingly emphasized the importance of investors, introducing a new layer of complexity to the stakeholder engagement model. It is important to acknowledge the complexity of stakeholder dynamics within FUAs, where investors often play a dual role, as many are also residents. In the case of complex entities such as FUAs, stakeholder groups are not entirely distinct. Ultimately investments are typically viewed by FUAs' managers as

a means to enhance the quality of life for residents by fostering employment opportunities. This suggests that the interests of residents and investors may align more closely than initially anticipated, rather than being in opposition.

To effectively implement co-creation in FUA's branding, the perspective must shift from viewing them merely as funding mechanisms or a collection of smaller municipalities. Instead, FUAs should be conceptualised as cohesive territorial units that form the foundation for future initiatives, particularly in branding efforts. This approach aligns with the increasing mobility of residents, requiring authorities to prioritise integration over fragmentation. Managers must be willing to relinquish some control and embrace collaboration if they aim to build a relevant brand image (Iglesias et al., 2017). Insights from ITI office staff and the Delphi study suggest that the co-creation process should begin with an objective assessment of the FUA's potential and the identification of key stakeholder groups. It is important to note that not every instance of value co-creation will be mutually beneficial, as it may lead to heterogeneous and negative brand interpretations, potentially resulting in a loss of brand equity (Sarasvuo et al., 2022).

To prevent such outcomes, regularly scheduled questionnaires—whether remote or in-person, depending on technological capabilities—can enhance stakeholder engagement by evaluating past efforts while encouraging constructive criticism and idea sharing. Additionally, activities such as exploratory walks can help align questionnaire responses with actual conditions, and regular consultations or meetings would enable stakeholders to collaboratively define shared goals. These efforts foster a sense of inclusion and ownership, making stakeholders more likely to act as ambassadors of the FUA's brand (Iglesias et al., 2017; Lever et al., 2023). The coordination of these processes should be centrally managed by the FUA's core city, with extensive collaboration from other municipalities, as highlighted by the study participants.

Finally, this research reaffirms the significance of stakeholder-driven branding strategies aimed at co-creating the brand identity. Future studies should further explore how these dynamics can be leveraged to build more resilient and competitive urban regions, with a focus on understanding the factors that drive residents to actively promote and support their place. Comparative analyses could be incorporated to assess the alignment between expert insights and practical outcomes. Additionally, further research could investigate how FUAs balance these potentially overlapping priorities—quality of life and economic returns—by investigating the nuanced dynamics between citizens and investors and their roles in long-term place branding and value co-creation strategies.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EFFECTS OF CONSUMER ETHNOCENTRISM, COSMOPOLITANISM, XENOCENTRISM, METACOGNITIVE, AND COGNITIVE CULTURAL INTELLIGENCE ON PURCHASING FAMOUS WORLD BRANDS

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***Abstract***

*The development of information technology and the liberalization of international trade in goods and services have facilitated business operations for companies in foreign markets. Based on market research, multinational companies' management obtains information about the characteristics and needs of local consumers, which is essential when formulating a quality marketing strategy. The aim of this research is to determine the influence of consumer ethnocentrism, cosmopolitanism, xenocentrism, as well as metacognitive and cognitive cultural intelligence on consumers' decision to purchase famous world brands. Empirical research was conducted using a survey method on a sample of 322 respondents, and their responses were analyzed using statistical software SmartPLS 4. The results showed that consumer ethnocentrism has a negative impact, while consumer cosmopolitanism, xenocentrism, and cognitive cultural intelligence have a positive impact on consumers' decision to purchase famous world brands, while the impact of metacognitive cultural intelligence is not statistically significant. The results of the research provide useful information that can help companies' management in formulating an appropriate marketing strategy in the market of the Republic of Serbia.*

***Key words****: consumer ethnocentrism, consumer cosmopolitanism, consumer xenocentrism, metacognitive cultural intelligence, cognitive cultural intelligence*

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# 1. Introduction

Globalization, the development of information systems, and transportation networks have led to increased interconnectedness of national economies, resulting in consumers having access to a wide range of global brands in the purchasing process (Pratono & Arli, 2020). However, various crises such as the COVID-19 pandemic, the conflict between Russia and Ukraine, the growing problems caused by the migrant crisis, and the unstable economic situation due to inflation have, to some extent, shifted from globalization trends to deglobalization trends (He & Harris, 2020). During crises, governments of all countries strive to protect their national economies, and one of the main cohesive factors that strengthens the unity of the population is consumer ethnocentrism, which is based on the belief that it is crucial to buy domestically produced goods to protect the domestic industry and maintain employment rates and the standard of living of citizens (Fernández-Ferrín et al., 2020). On the other hand, creating such a national economic policy can be a significant barrier to international trade and economic cooperation with other countries. Additionally, a certain group of people has a high level of consumer cosmopolitanism, which is based on the belief that global brands are characterized by high reliability and quality, thereby reducing the risk of a poor purchase decision by choosing well-known global brands (Šapić, 2017). Conversely, another group of people has developed a high level of consumer xenocentrism, which is based on the belief that domestic brands are completely unreliable, of low quality, and inferior in technical performance compared to famous global brands, which are their only choice when purchasing (Rojas-Mendez & Chapa, 2020). The process of globalization has significantly facilitated the organization of tourist and business travel to any country worldwide, allowing people, through visits to foreign tourist destinations and learning about the local culture, history, traditions, and customs, and by visiting operas, museums, and cultural monuments in other countries, to develop their cultural intelligence, which consists of four factors: metacognitive, cognitive, motivational, and behavioral (Frias-Jamilena et al., 2018). Metacognitive and cognitive cultural intelligence refer to the level of cultural knowledge a person possesses, as well as their understanding of various social systems in other countries (legal, economic), and they have a significant impact on consumer purchase intentions. Motivational cultural intelligence relates to the desire an individual exhibits regarding visiting foreign destinations, while behavioral cultural intelligence involves certain verbal and nonverbal skills that make it easier for a person to stay abroad. Motivational and behavioral cultural intelligence are primarily related to the field of tourism (Zdravković & Peković, 2021).

# 2. Literature review

According to Social Identity Theory (Tajfel & Turner, 1979) and Social Conflict Theory (Sherif, 1966), members of a society believe that their culture is superior in all aspects compared to the cultures of other societies. These attitudes

are further emphasized during crises when there is a need to protect the national economy. For this reason, ***consumer ethnocentrism*** was chosen as the first research variable, given the current high levels of geopolitical tensions and disagreements. Ethnocentrism belongs to the group of sociological concepts and is based on the belief of members of a nation that their culture, value system, traditions, customs, and norms of behavior are special and dominant compared to those of another nation. From this basic concept, consumer ethnocentrism has evolved, representing its economic category. It is based on the core principle that purchasing foreign products negatively affects the national economy and that it is the moral duty of every individual who desires economic prosperity and well-being in their home country to buy domestic products and services (Shimp & Sharma, 1987). Previous research (Casado-Aranda et al., 2020; Rambocas & Mahabir, 2021) has established that individuals with pronounced ethnocentric tendencies have purchasing preferences for domestically produced goods. Based on this, the first research hypothesis in the study can be formulated:

*H1: Consumer ethnocentrism has a statistically significant negative impact on respondents' decisions to purchase famous global brands.*

The advent of the internet, the development of social networks, and communication and transportation channels have made all important information about countries around the world generally accessible and have simplified the organization of travel. People can now easily travel to any country in the world. Multinational companies consist of employees who come from different cultural backgrounds, and the combination of their value systems, attitudes, thoughts, skills, and abilities represents a true intellectual capital for an organization. Additionally, people often travel to distant tourist destinations where they spend their vacations, and a certain number of students choose to complete their education at prestigious global universities (Pratono & Arli, 2020). For this reason, ***consumer cosmopolitanism*** was chosen as the second research variable in this study. Cosmopolitanism also belongs to the group of sociological concepts, based on the principle that while it is important to respect domestic culture and traditions, it is essential to broaden one's horizons, step out of the comfort zone, and enhance one's education by learning about the history and traditions of other countries (Prince et al., 2016) From this basic concept, consumer cosmopolitanism has evolved, representing its economic category based on the idea that it is necessary to buy both domestic and foreign brands, guided by rational motives and considering what each brand offers in terms of price and quality. Previous research (Prince et al., 2016; Šapić, 2017) has shown that individuals with cosmopolitan views and thinking prefer to buy foreign brands, new products, and are relatively innovative. Based on this, the second research hypothesis in this study can be formulated:

*H2: Consumer cosmopolitanism has a statistically significant positive impact on respondents' decisions to purchase famous global brands.*

Under the influence of marketing, advertising campaigns, and influencers, a certain group of people fully focuses on foreign cultures while neglecting their own. For this reason, ***consumer xenocentrism*** was chosen as the third research variable. Xenocentrism also has a sociological genesis and is based on the belief that the cultures of other countries and the value systems represented within them are dominant compared to the domestic culture and the value systems it promotes. From this basic concept, consumer xenocentrism has evolved, representing its economic category based on the idea that it is necessary to buy exclusively foreign products and well-known global brands, even if they are extremely expensive, due to their quality, prestige, and status they confer in social circles (Mueller et al., 2020) Consumer xenocentrism is a much more extreme variant compared to consumer cosmopolitanism, as it involves exclusively purchasing foreign brands. In contrast, individuals with pronounced consumer cosmopolitanism buy both foreign and domestic brands. Previous research (Mueller et al., 2020; Rojas-Mendez 2020) has established that individuals with pronounced consumer xenocentrism focus their attention exclusively on globally recognized brands. The third research hypothesis in this study can be formulated:

*H3: Consumer xenocentrism has a statistically significant positive impact on respondents' decisions to purchase famous global brands.*

Familiarity with the cultural heritage of other countries, visiting their opera houses, museums, and theaters, represents a true enrichment and, in the final analysis, can influence individuals' intentions to purchase foreign famous brands. For this reason, ***metacognitive*** and ***cognitive cultural intelligence*** have been chosen as the fourth and fifth research variables in this study. Metacognitive cultural intelligence represents a certain level of cultural knowledge that an individual possesses, acquired through formal education and experiential learning, as well as a continuous desire to enhance this cultural knowledge (Pratono & Arli, 2020). Cognitive cultural intelligence involves knowledge of foreign languages, grammar, vocabulary, customs, and behavioral norms characteristic of other countries (Frias-Jamilena et al., 2018). Previous research (Pratono & Arli, 2020; Zdravković & Peković, 2021) has shown that individuals with a high level of metacognitive and cognitive cultural intelligence frequently visit foreign countries and purchase famous global brands originating from those countries. Based on this, the fourth and fifth research hypotheses and research model (Figure 1) can be formulated:

*H4: Metacognitive cultural intelligence has a statistically significant positive impact on respondents' decisions to purchase famous global brands.*

*H5: Cognitive cultural intelligence has a statistically significant positive impact on respondents' decisions to purchase famous global brands.*

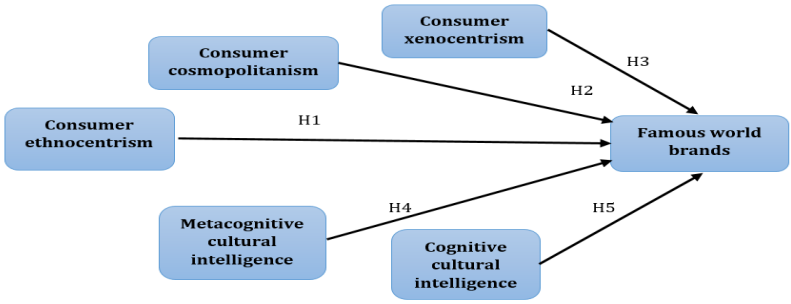


*Figure 1: Conceptual model*

## 3. Methodology and Data (discussion)

An empirical study using a survey method was conducted at the beginning of 2024. in the Republic of Serbia (Belgrade, Novi Sad) with a sample of 322 respondents. The respondents expressed their level of agreement with statements related to the research variables of *consumer ethnocentrism*, *cosmopolitanism*, *xenocentrism*, *metacognitive* and *cognitive cultural intelligence*, and *famous world brands* using a ***Likert scale*** ranging from 1 to 7. Subsequently, their responses were analyzed using the statistical software ***SmartPLS 4***. The overview of the statements used in the questionnaire is presented in Table 1.

*Table 1: Statements from the questionnaire*

| **Research variables** | **Statements** | **Source** |
|---|---|---|
| Consumer ethnocentrism | 1. I prefer domestic products.<br>2. Buying domestic products enables stable functioning of the domestic economy.<br>3. Buying domestic products contributes to the improvement of citizens' living standards. | Zdravković et al. (2020) |
| Consumer cosmopolitanism | 1. I often buy foreign brands.<br>2. I am very innovative and buy new products when they appear on the market.<br>3. I recommend foreign brands to my friends. | Šapić (2017) |
| Consumer xenocentrism | 1. I buy exclusively foreign brands.<br>2. Domestic products are inferior in quality compared to foreign products.<br>3. Global brands have excellent characteristics. | Rojas-Mendez & Chapa (2020) |
| Metacognitive cultural intelligence | 1. I have a high level of cultural knowledge.<br>2. It is necessary to continuously improve one's knowledge about different cultures.<br>3. I often communicate with people from different cultural backgrounds. | Frias- Jamilena et al. (2018) |

| Research variables | Statements | Source |
|---|---|---|
| Cognitive cultural intelligence | 1. I know the history of many countries.<br>2. I am familiar with the legal systems of other countries.<br>3. I am familiar with the rules of behavior that are characteristic of different cultures. | Frias- Jamilena et al. (2018) |
| Famous world brands | 1. Famous global brands have a high quality.<br>2. Buying well-known global brands is a matter of prestige.<br>3. I recommend to my family members to buy well-known global brands. | Rambocas & Mahabir (2021) |

*Source: Authors*

## 4. Research results

***Reliability analysis*** was implemented to determine whether the research variables are measured using clear and precise statements (Table 2).

*Table 2: Reliability analysis*

| Research variables | Cronbach's alpha | Composite reliability (rho_a) |
|---|---|---|
| Consumer ethnocentrism | 0.816 | 0.829 |
| Consumer cosmopolitanism | 0.724 | 0.805 |
| Consumer xenocentrism | 0.838 | 0.852 |
| Metacognitive cultural intelligence | 0.848 | 0.853 |
| Cognitive cultural intelligence | 0.737 | 0.744 |
| Famous world brands | 0.862 | 0.886 |

*Source: Authors calculation using SmartPLS 4 software*

The values of ***Cronbach's alpha*** and ***Composite reliability (rho_a)*** are higher than 0.70, indicating an appropriate level of correlation between the statements used to measure the research variables.

The **Structural Equation Model (SEM)** was applied to examine the effect of *consumer ethnocentrism*, *cosmopolitanism*, *xenocentrism*, as well as *metacognitive and cognitive cultural intelligence* on consumers' decision to purchase famous world brands (Table 3).

*Table 3: SEM model*

| Hypothesis | Original sample (O) | Standard deviation (STDEV) | T statistics (IO/STDEVI) | P values |
|---|---|---|---|---|
| Consumer ethnocentrism → Famous world brands | -0.302 | 0.053 | 5.710 | 0.000** |
| Consumer cosmopolitanism → Famous world brands | 0.351 | 0.067 | 7.523 | 0.000** |

| Hypothesis | Original sample (O) | Standard deviation (STDEV) | T statistics (IO/STDEVI) | P values |
|---|---|---|---|---|
| Consumer xenocentrism → Famous world brands | 0.428 | 0.050 | 8.300 | 0.000** |
| Metacognitive cultural intelligence → Famous world brands | 0.045 | 0.053 | 0.848 | 0.397 |
| Cognitive cultural intelligence → Famous world brands | 0.326 | 0.043 | 6.488 | 0.000** |

*Level of statistical significance: **0.01; R square=0.477*
*Source: Authors calculation using SmartPLS 4 software*

The coefficient of determination ***R square***, with a value of 0.477, indicates that 47.7% of consumers' decision to purchase ***famous world brands*** is explained by the given regression model. ***Consumer ethnocentrism (coefficient= -0.302, p values=0.000)*** has a negative and statistically significant impact on consumers' decision to purchase famous world brands, **confirming research hypothesis H1**. ***Consumer cosmopolitanism (coefficient= 0.351, p values=0.000)***, ***Consumer xenocentrism (coefficient= 0.428, p values=0.000)***, and ***Cognitive cultural intelligence (coefficient= 0.326, p values=0.000)*** have a positive and statistically significant impact on purchasing famous world brands, **confirming research hypotheses H2, H3, and H5**. The impact of metacognitive cultural intelligence ***(coefficient= 0.045, p values=0.397)*** on purchasing famous world brands is not statistically significant, so research **hypothesis H4 is not confirmed**.

## Conclusion

The results of the study indicated that consumer ethnocentrism has a negative impact, while consumer cosmopolitanism and consumer xenocentrism have a positive impact on consumers' decisions to purchase famous world brands. It should be noted that the impact of xenocentrism is more pronounced, as the concept is based on the principle of exclusively purchasing foreign brands, whereas individuals with cosmopolitan views buy both foreign and, to some extent, domestic brands. The results showed that cognitive cultural intelligence positively impacts consumers' decisions to purchase famous world brands, while the impact of metacognitive cultural intelligence is not statistically significant. This result can be explained by the fact that cognitive cultural intelligence is a broader concept compared to metacognitive cultural intelligence. It involves not only understanding specific cultural processes but also knowledge of the history, social systems, and cultural heritage of other countries. ***Theoretical implications*** of the study are reflected in the expansion of scientific knowledge about the impact of the mentioned variables on consumer purchase intentions, and it is particularly significant that the research was conducted during geopolitical crises and tensions. The ***practical***

***implications*** of the study are reflected in providing information to managers of multinational companies about the characteristics of the Serbian market, which can be useful in formulating relevant marketing strategies that address consumer demands. A ***limitation of the study*** is the small sample size, and ***future research*** could analyze additional variables that may significantly impact the purchase of famous world brands, such as country-of-origin image, patriotism, conservatism.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-100 Original scientific paper

# THE FUTURE OF THE NEWSPAPER INDUSTRY

*Gregor Franken*[1] *[0000-0002-6615-6230]*

***Abstract***
*Financial expenses for printed newspapers are becoming increasingly significant due to declining circulation and rising costs of printing and distribution. During the COVID-19 period, the newspaper and all print media faced a deepening crisis that has been threatening the entire newspaper industry for several years. The COVID times are over, but the crisis in the newspaper industry is not. This was followed by a paper shortage, leading to price increases. Initially, the price of paper rose due to excessive demand, and soon after, there was an increase in energy costs, which significantly impacted paper production. The advertising market changes daily and migrates to various platforms. The media world is transforming at an unprecedented speed driven by technological innovations. Readers remain loyal to the printed newspaper, but continuity is becoming an increasing challenge. New generations are coming that follow the news digitally. What future awaits the print media industry?*

***Key words:*** *newspapers, printing media, COVID-19 period, advertising, digital media.*

## 1. Introduction

The newspaper industry, once the dominant medium for public information, has changed dramatically in recent decades due to financial pressures, changing reader preferences and technological advances. Traditional print newspapers are now in a precarious position as the rise of digital platforms and the COVID-19 pandemic have exacerbated existing challenges. The industry is at a critical juncture and must grapple with how to remain relevant and profitable in a rapidly evolving world. The pandemic triggered an economic crisis that hit the newspaper industry hard: advertising revenues plummeted as companies cut their marketing budgets. Circulation also fell due to the logistical hurdles involved in distributing physical newspapers. Although the pandemic has now subsided, its lingering effects continue

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to raise questions about the future of the newspaper industry. At the same time, global paper and cardboard prices were affected by fluctuating supply and demand, particularly in China and North America.

The advent of e-commerce has led to an increased demand for cardboard packaging, which has diverted the production of paper and led to shortages. Even before the pandemic, demand for paper products, particularly newsprint, was already declining, a trend that was exacerbated in 2020–2021 when the pandemic further reduced global demand (Figure 1).

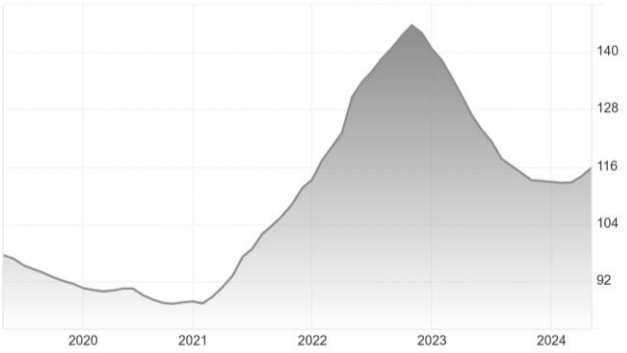


*Figure 1: Euro Area Producer prices in industry: Manufacture of pulp, paper and paperboard (Trading Economics)*

### 1.1 Paper prices

Newspaper and magazine sales plummeted and demand for office supplies fell significantly. As a result, Finnish paper giant Stora Enso closed two mills in 2021 (IBISWorld, 2024). The European energy crisis and the war in Ukraine have exacerbated the problem. Paper prices are set to increase by 65% in 2022 alone due to disruptions in the global supply chain (Maher, 2022). Ukraine supplies 10% of Europe's softwood and the conflict has brought timber exports to a standstill. Economic sanctions against Russia and Belarus and rising energy costs led to a sharp rise in paper prices until fall 2021. These combined challenges are changing both the newspaper industry and paper production, leaving their future uncertain (Sappi Graphic Papers, 2022; Kinney, 2008).

### 1.2 Declining circulation and advertising revenues

Figure 2 provides a clearer idea of how steep the decline in circulation for American daily newspapers has been in the past decades. While costs have risen, circulation numbers have plummeted. In the U.S., daily newspaper circulation dropped significantly over the past two decades. From 2020 to 2021 alone, circulation fell by 6%, continuing a downward trend that began long before the digital age (Naseer & Aubin, 2021). Readers are migrating toward digital platforms,

leaving traditional print newspapers with an aging demographic. Advertising revenues, once a cornerstone of the newspaper business, have also been in decline. Digital platforms like Google and Facebook have become dominant players in the advertising space, offering more targeted and cost-effective solutions for businesses. Consequently, print advertising has lost much of its appeal, and newspapers are struggling to attract advertisers willing to pay premium rates for space in physical publications (Newman et al., 2022). This has led to a financial "twin crisis" for newspapers: the decline of print circulation and the loss of advertising revenue. Traditional revenue models based on circulation and advertising are no longer sufficient to sustain newspapers, particularly in Western economies like the U.S. and the UK (Barthelemy et al., 2011).

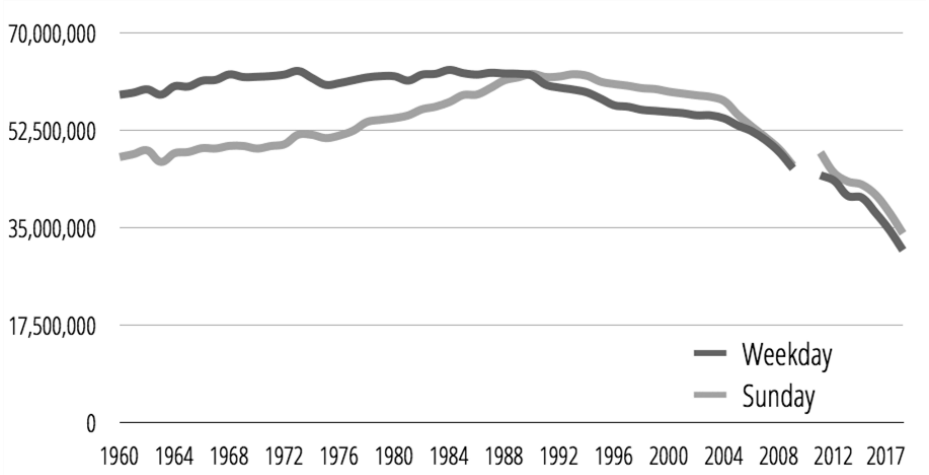


*Figure 2: Newspaper circulation in the USA from 1960 until 2017 (Naseer & Aubin, 2021).*

### 1.3 The Impact of the COVID-19 Pandemic

The COVID-19 pandemic dramatically accelerated the challenges already facing the newspaper industry. As lockdowns were implemented worldwide, newspaper sales dropped due to limited distribution channels and the closure of public spaces where newspapers were typically sold. At the same time, the demand for real-time, reliable news surged, with readers turning to digital platforms for information about the virus, government measures and health advice (Newman et al., 2020).

Despite increased digital engagement, the pandemic had a crippling effect on newspaper revenues. Advertising budgets were slashed as businesses closed or scaled back operations, and the recession triggered by the pandemic hit local newspapers particularly hard (WAN-IFRA, 2021). Many small publications were forced to shut down, leading to "news deserts" in certain regions where local news coverage was entirely absent.

### 1.4 Pandemic Long-Term Consequences and Shifts in Consumption

The pandemic's lasting impact on the newspaper industry is perhaps most evident in the acceleration of the digital shift. Many newspapers were forced to invest heavily in their online platforms, recognizing that digital content was the key to reaching their audiences during the crisis (Barthelemy et al., 2011).

Additionally, the pandemic has led to permanent changes in consumer behavior. The Reuters Digital News Report found that younger generations, in particular, are far more likely to consume news through social media platforms, aggregators, and apps, rather than through traditional print or even digital newspaper (Newman et al., 2020).

## 2. Methods

In the research, we were interested in the trends in newspaper circulation in the wider area of the region. We included in the research two of the largest newspaper publishers from each country: Serbia, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro and North Macedonia.

The research was mainly conducted in electronic form with a questionnaire where we were interested in what newspaper circulations were like before COVID-19, during the corona and later, when there were no more restrictions.

### 2.1 Results

In 2020, the year of the lockdown, the largest decline in newspaper sales will occur compared to 2019, i.e. -40%. In 2021, the downward trend due to Covid-19 continues, averaging -25% in 2020. In 2022, this decline is smaller compared to 2021 and amounts to -15%. In 2023, publishers record the same circulation figures as in the previous year, i.e. 2022. There are no differences in 2023 compared to 2022. In 2024, there is a slight decline in circulation compared to 2023 (-2%). On average, paddle sales have increased by 16.4 % over five years (Figure 3).

| Year | YoY change (%) |
|---|---|
| 2020 | -40 |
| 2021 | -25 |
| 2022 | -15 |
| 2023 | -0 |
| 2024 | -2 |

*Figure 3: Newspaper circulation in the wider area of the region from 2020 until 2024].*

## 3. Discussion

Monetizing digital content remains one of the most significant challenges for newspapers in the digital age. While digital subscriptions have shown promise as a revenue stream, the majority of readers are still reluctant to pay for online news. Publications like The New York Times and The Guardian have successfully implemented subscription models, but these cases are exceptions rather than the rule (WAN-IFRA, 2021).

The "paywall" model, where readers must pay for access to premium content, has become a popular solution for some newspapers. However, this model has its limitations, as it can alienate casual readers who are unwilling to commit to a subscription. Many newspapers have adopted a hybrid approach, offering a certain number of free articles before requiring payment. Still, the challenge remains: how to balance the need for revenue with the demand for free, accessible news.

## 4. Conclusions

Despite ongoing efforts to adapt and redesign, the newspaper industry does not have a promising future ahead of it. Global trends point to declining newspaper circulations on every continent, signaling that traditional print media are facing structural changes that will be difficult to stop. Although there are a few exceptions where circulation is stable or rising slightly, these cases are rare and of little significance on a global scale.

Even the world's biggest newspapers, long regarded as unshakeable pillars of the media industry, are seeing regular declines in circulation, suggesting that these figures are unlikely to ever return to previous levels. This is not just a transitional phase, but a reflection of wider changes in the way people consume information. The main cause of this situation is undoubtedly the internet and digitalization, which have profoundly changed the media landscape.

The emergence of a new, younger generation brings with it new patterns of behavior and media consumption. Many young people today no longer rely on print media like previous generations, but seek news and information online, where it is available in real time. For them, the concept of reading a newspaper with news that is a day old is outdated and unnecessary.

A good example of this global shift is Japan's Yomiuri Shimbun, which is known as the world's largest-circulation newspaper, but is nevertheless experiencing an annual decline of around one million copies. This trend is partly due to Japan's rapidly aging population, which is shrinking at a record pace. Japan is currently experiencing the largest population decline since data collection began, which has a direct impact on the number of print newspaper readers.

The combination of an aging population and declining birth rates, coupled with technological changes, is creating conditions in which print media is losing a significant proportion of its traditional audience. This inevitably leads to a steady decline in the readership of traditional print newspapers, one of the main reasons for the decline of the newspaper industry.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-101 Review paper

# THE FUTURE OF GENERATIVE AI IN DIGITAL MARKETING: CHALLENGES AND OPPORTUNITIES

*Marija Đaković[1], Aleksandar Rikalović[2] [0000-0003-2777-5706]*

***Abstract***

*This paper examines the impact of generative artificial intelligence (AI) in digital marketing, focusing on both opportunities and challenges. Generative AI, which creates new content such as text, images, and videos, enables improved personalization and automation in marketing. Tools like ChatGPT and DALL-E streamline content production and provide real-time, tailored interactions. However, challenges such as data privacy, ethical concerns, and lack of transparency in AI decision-making arise with the use of these technologies. This paper analyzes key AI tools in various marketing areas, evaluates their effectiveness, and discusses the ethical and legal implications of their use. While AI offers significant opportunities for innovation, responsible use and human oversight are essential for long-term success in digital marketing.*

***Key words:*** *generative artificial intelligence, digital marketing, ethical and legal aspect, challenges, opportunities*

## 1. Introduction

Artificial Intelligence (AI) plays a crucial role in digital marketing today, enabling marketers to utilize data for predictive analysis and optimize user experience (Johnsen, 2024). Digital marketing employs a wide range of strategies to connect with target audiences through digital channels, including SEO, social media, PPC advertising, and email marketing. The integration of AI into these processes allows for content personalization and campaign automation, significantly improving efficiency.

Artificial intelligence refers to technologies that enable machines to simulate human intelligence. In the context of digital marketing, AI encompasses a wide array of tools and techniques, such as data analysis, natural language processing (NLP), and machine learning. These technologies allow businesses to analyze vast amounts

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of data, predict consumer behavior, optimize customer experience, and automate marketing processes. By leveraging AI, marketers can create more personalized and efficient campaigns that drive better engagement and higher conversion rates. (King, 2019.)

Generative AI creates new content, such as text, images, or videos, based on the data it has been trained on. Unlike traditional AI, which analyzes data, generative AI produces original content, making it highly useful in creative fields. A key example is Generative Adversarial Networks (GANs), where one network generates content, and another evaluates its realism, improving the quality of the generated output over time.

## 2. AI Tools in Digital Marketing

The impact of AI tools across various disciplines is significant. These technologies enhance efficiency and creativity in many field of digital marketing. After researching over 40 AI tools (https://digitalmarketinginstitute.com/blog/what-are-the-best-ai-and-marketing-automation-tools), a table highlighting their applicitions has been complited.

*Table 1: AI tools in different fields of digital marketing*

| **Field of digital marketing** | **AI tools** |
|---|---|
| Video editing | InVideo, AI marketing automator, BeHuman,Vidiq, Create Studio, Descript, Opus Clip, Veed.io, Submagic, Get Munch, Syntesia, Supertone, |
| Graphic design | Canva, BrendMark, AdCreative, |
| Web design | Durable, Hub spot, Relume AI site builder, Dorik |
| SEO optimization | Semrush, SurferSeo, Frase, ClearScope |
| Copywriting | Copy.ai, Quillbot, ContentAtScale, ChatGPT, Journalist, Deepl, Jasper, Grammarly |
| Social media management | Notion, Inflact, FeedHive, Zapier |
| Image editing | Recraft, DALL-E, Midjourney |

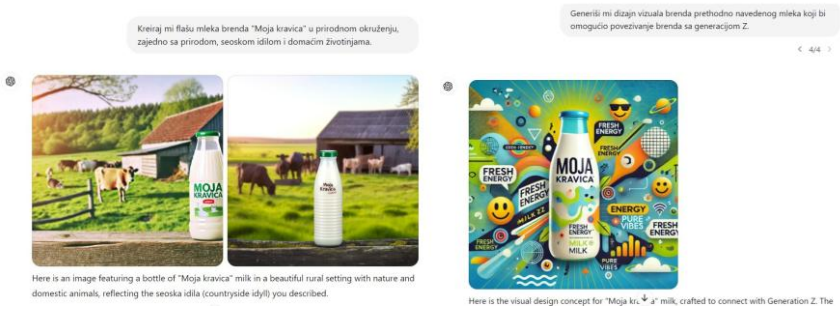
Based of frequency of use and specifty compared to other tools, one representative has been selected from each field, which is then described further

Artificial Intelligence (AI) has become an indispensable part of modern marketing strategies, offering opportunities to enhance the efficiency and personalization of campaigns (Upadhyay, M. & Chitnis, P. (2022). Modern Marketing Using AI. BPB Publications. pp. 21–30). Below, key AI tools that significantly contribute to various aspects of digital marketing are analyzed.

ChatGPT stands out as a content generation tool, offering automatic creation of high-quality text for various marketing channels, including blogs, social media, and email campaigns. One of its primary benefits is efficiency, as it significantly reduces the need for human writers and speeds up content production. ChatGPT's

real-time personalized communication enhances user engagement, making it ideal for creating tailored email campaigns that improve open and conversion rates. The tool is also available 24/7, ensuring continuous user support without requiring human agents. Additionally, ChatGPT's ability to analyze large volumes of data allows for deeper insights into consumer behavior, helping optimize marketing strategies. However, the downside is that it may lack emotional intelligence, leading to challenges when addressing complex customer issues. The pricing for ChatGPT includes a free version, while the Plus version costs $20 per month (https://chatgpt.com/).

DALL-E revolutionizes visual content creation by generating images from textual descriptions. This tool allows marketing teams to create unique images, eliminating the need for stock photos and enabling brands to establish a distinct visual identity. DALL-E's ability to quickly produce images helps brands respond swiftly to market trends, significantly reducing the costs associated with traditional visual production methods, such as hiring photographers or models. Another major advantage is DALL-E's capability to generate a wide variety of image styles, providing creative flexibility for marketing campaigns. However, quality control can be an issue, as images might not always match the desired prompt perfectly, sometimes requiring multiple attempts. The cost of generating 115 images is around $15, with access available through the ChatGPT Plus subscription (https://openai.com/index/dall-e-3/).

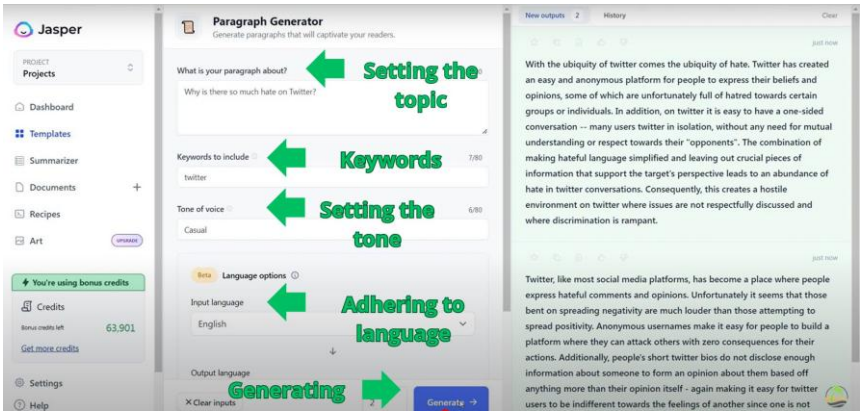



*Picture 1 - Generative AI tool DALL-E creating unique images from text descriptions, transforming visual content in digital marketing*

Canva Magic Studio extends the capabilities of the popular design platform Canva, making advanced design tools accessible to non-professional designers. The tool's Magic Edit feature allows users to easily modify images by removing unwanted objects, changing colors, and adding elements, making it an excellent choice for marketing teams looking to quickly adapt visuals. Additionally, it offers text-to-image, text-to-video, and text-to-graphics functionalities, providing a comprehensive suite for creating multimedia content. However, some limitations arise when compared to specialized tools like Adobe Creative Suite, as Canva Magic Studio may lack the fine-grained control needed for highly detailed projects. The

cost is $12.99 per month for the Canva Pro subscription, or $119.99 annually, with team plans available for larger organizations (https://www.canva.com/magic/).

Jasper is another powerful AI-driven content generator, optimized for marketing. Jasper stands out for its ability to generate SEO-optimized content while maintaining the brand's specific tone and style, thus helping improve search engine rankings and brand recognition. The tool also integrates with other platforms, including SurferSEO, HubSpot, and WordPress, making it an efficient choice for teams working on multiple platforms. Jasper's browser extension further enhances productivity by providing on-the-go support for content creation. While it offers a variety of templates to speed up content creation, there can be concerns about the authenticity of the generated content, as it might lack the emotional depth necessary to deeply connect with an audience. Jasper's pricing starts at $39 per month for the Creator plan, with the Pro plan costing $59 per month (http://www.jasper.ai).



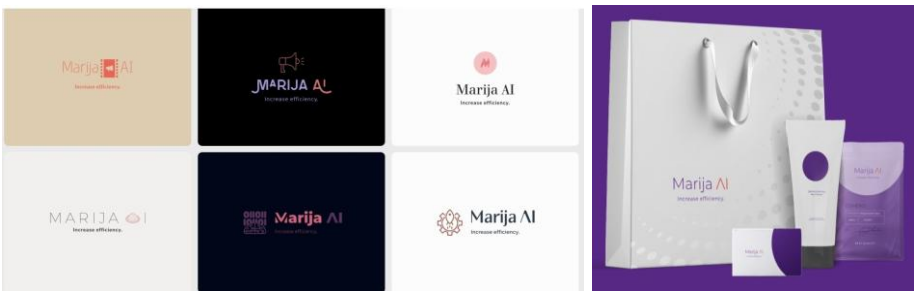

*Picture 2- Jasper AI: Enables the generation of SEO-optimized content with options to select topic, keywords, tone, and language, tailoring content to the specific needs of the brand.*

Semrush is a comprehensive tool for digital marketing, known for its keyword research, SEO analysis, and competitor tracking capabilities. With Semrush, marketers can explore relevant keywords, assess search volume, and adjust their SEO strategies accordingly. The tool also supports content creation through insights on trending topics and optimization tips, helping brands stay relevant in search engine rankings. One of its key strengths is its ability to track social media performance, allowing marketers to schedule posts and monitor competitor activity. However, the tool's complexity and high cost may pose challenges for smaller businesses. Semrush's basic subscription costs $119.95 per month, making it one of the more expensive options available (https://www.semrush.com).

Durable is designed for the automatic generation of simple websites based on minimal user input, making it a valuable tool for small businesses and startups. With Durable, companies can quickly create functional websites without needing technical expertise, significantly speeding up the process of establishing an online presence. However, the simplicity of design may limit customization options for

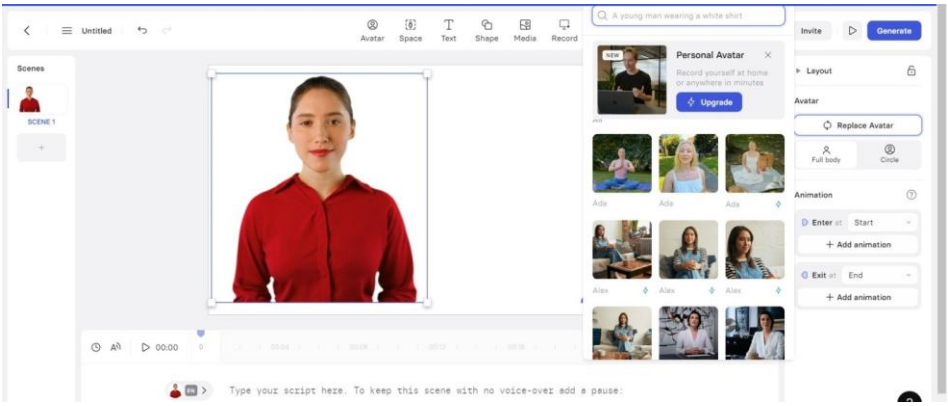
businesses that require a unique and highly personalized visual identity. Pricing for Durable varies based on the scope of use, but its scalability makes it accessible to smaller companies (https://app.durable.co/website-builder).

Brandmark.io offers an AI-powered solution for brand identity creation, including logos and other key branding elements. This tool is especially useful for businesses looking for a fast and cost-effective way to design a professional visual identity without investing in expensive designers. However, its limitations in personalization can be a drawback for companies with more specific branding needs. Brandmark.io is priced according to usage, with flexible plans for small to large businesses (https://brandmark.io/).




*Picture 3 - Brandmark.io: An AI-powered tool for creating brand identities, including logos and other key branding elements, providing a fast and cost-effective solution for businesses to establish a professional visual identity.*

Synthesia is a cutting-edge tool designed for creating video content with personalized avatars that can speak multiple languages. This tool simplifies video production for brands by eliminating the need for professional studios, cameras, or actors. Synthesia has become increasingly popular in digital marketing due to its ability to generate high-quality video content efficiently and provide customized messages for audiences. One of its standout features is the ability to create videos where virtual avatars read from a text script provided by the user. These avatars can be personalized to align with a brand's identity, allowing for more authentic communication with the audience. Synthesia also supports over 120 languages, making it ideal for multinational companies seeking to reach global markets. Users can customize not only the language but also the avatar's tone, style, and gender, ensuring that messages are both understandable and engaging for diverse audiences. The tool integrates seamlessly with platforms like PowerPoint, allowing for easy inclusion of videos in marketing presentations. However, there are limitations in terms of avatar naturalness, as some users find that the avatars still lack the expressiveness of real humans. The pricing starts at $18 per month for individual users, with more advanced plans available for larger teams and enterprises, offering more avatars, additional customization options, and higher video limits (https://www.synthesia.io/).




Picture 4 - Synthesia: AI tool for creating personalized video avatars that can speak multiple languages, simplifying video production for brands and allowing for authentic, customizable communication with global audiences.

All of these tools provide different advantages and opportunities for optimizing marketing campaigns, and their usage depends on the specific needs and resources a company can invest. By combining these tools, digital marketing becomes more efficient, personalized, and adaptable to the dynamic needs of the market.

## 3. Ethical and Legal Aspects of AI in Digital Marketing

The ethical and legal implications of using AI in digital marketing are critical areas of concern as the technology continues to evolve. One of the primary ethical challenges is the collection and use of consumer data. AI systems rely on vast amounts of personal information to make predictions and target marketing campaigns, raising concerns about privacy violations and data misuse. This issue is compounded by the fact that many consumers are unaware of how their data is being collected and used. (Ltifi, 2025).

From a legal perspective, various regulations have been introduced to protect consumer data, such as the General Data Protection Regulation (GDPR) in the European Union. These laws set strict guidelines for data collection, processing, and storage, ensuring that companies using AI must comply with stringent privacy standards. Non-compliance can result in significant fines and reputational damage (Krinjari, 2017).

Moreover, the transparency of AI decision-making processes is another ethical concern. AI algorithms often operate as "black boxes," making it difficult to understand how decisions are made. This lack of transparency can lead to biased outcomes in areas like targeted advertising, where certain groups may be unfairly excluded or misrepresented.

Companies must navigate these ethical and legal challenges by implementing clear data governance policies, ensuring transparency in AI operations, and adhering to regulatory standards. Maintaining consumer trust through responsible AI use will be key to the sustainable development of AI in digital marketing.

## 4. Challenges and Opportunities of AI in Digital Marketing

The advent of AI in digital marketing offers numerous opportunities for personalization, automation, and strategic decision-making. AI enables marketers to analyze data from multiple channels to target consumers effectively, automating repetitive tasks and providing real-time insights that optimize advertising spend and boost return on investment. AI-powered tools, such as chatbots and personalized email marketing, have proven effective in enhancing customer experience, as they streamline customer interactions and deliver timely, relevant content (Hou, 2024) and data-driven personalization (Kogan Page, pp. 25–35). These tools contribute to improved customer satisfaction by addressing consumer needs with a higher degree of personalization.

However, several challenges persist with the integration of AI into marketing. A significant concern is data privacy. AI's reliance on large datasets raises ethical questions regarding the collection, storage, and use of consumer data. According to Hou (2024), consumers have increasing expectations for brands to respect their privacy while still providing personalized experiences. The shift to a cookie-less world, where third-party data collection is limited, places greater emphasis on first-party data—data collected directly by brands. This transition compels marketers to develop strategies for collecting data in a manner that is both ethical and transparent.

Another pressing challenge is the potential for bias in AI algorithms, which can lead to unintended discrimination, particularly in targeted advertising. AI models trained on biased data may perpetuate these biases, potentially excluding or misrepresenting certain demographic groups. Hou (2024) notes that as personalization technology advances, brands must take proactive measures to mitigate bias by regularly auditing AI systems and ensuring diverse datasets to reflect a wide range of consumer perspectives.

Transparency, or the lack thereof, is also a significant challenge. Many AI algorithms function as "black boxes," making it difficult for brands to explain how certain decisions are made. This opacity can erode customer trust, particularly when consumers do not understand why specific content or advertisements are shown to them. Hou (2024) emphasizes that transparency in AI decision-making processes is essential to maintaining consumer trust. Brands that openly communicate how AI influences customer interactions are better positioned to build lasting relationships with their customers.

Despite these challenges, AI continues to offer substantial opportunities in digital marketing. Tools such as AI-driven customer segmentation and predictive analytics enable brands to scale personalization efforts efficiently, which can lead to

higher engagement rates and improved customer loyalty. Additionally, as technology evolves, the cost of AI solutions decreases, making them accessible to smaller organizations and allowing a broader range of companies to leverage these tools for innovative marketing strategies (Hou, 2024). Data-driven personalization. Kogan Page, pp. 25–35).

In conclusion, while AI presents complexities in terms of data privacy, bias, and transparency, its potential to revolutionize digital marketing remains vast. Marketers who successfully navigate these challenges and prioritize ethical practices will be well-positioned to capitalize on the opportunities AI offers, particularly in creating scalable, personalized experiences that resonate with consumers.

## 5. Discussion and Conclusion

The future of AI in digital marketing offers immense possibilities for innovation, efficiency, and personalized customer experiences. As AI technologies evolve, businesses are increasingly able to deliver hyper-personalized marketing content, analyze vast datasets in real-time, and automate complex campaign management processes. These capabilities, driven by tools such as ChatGPT and DALL-E, enable more dynamic consumer interactions, allowing companies to optimize their marketing strategies based on immediate feedback and changing market trends.

One of the most significant opportunities presented by AI is the automation of repetitive tasks, freeing marketers to focus on higher-level strategic initiatives. Tools like AI-powered chatbots have already demonstrated the power of AI in enhancing customer engagement through real-time, personalized communication. This leads to better customer satisfaction and loyalty, as companies are able to provide more timely and relevant content tailored to individual preferences. Additionally, AI tools allow businesses to optimize advertising budgets and improve ROI by targeting the right audiences more effectively.

However, despite these advantages, there are challenges that cannot be overlooked. Data privacy remains a critical concern, as AI systems rely heavily on large datasets to function effectively. Marketers must ensure compliance with regulations such as the GDPR to protect consumer data and maintain trust. Furthermore, the lack of transparency in AI decision-making, often referred to as the "black box" problem, can lead to unintended consequences such as biased outcomes in targeted advertising. Brands that fail to address these issues risk damaging their reputation and losing customer trust.

The ethical implications of AI are equally important. While AI tools can significantly enhance efficiency, marketers must remain cautious of over-reliance on AI-driven insights. AI lacks the emotional intelligence and creativity that human marketers bring to the table. Therefore, the human element in marketing will continue to play a crucial role, particularly when it comes to understanding complex consumer needs and crafting emotionally resonant campaigns.

In conclusion, while AI will undoubtedly shape the future of digital marketing, businesses that successfully combine AI technologies with human creativity and ethical responsibility will be the most likely to thrive. Companies that navigate the challenges of data privacy, transparency, and bias while leveraging the full potential of AI-driven tools will lead the way in the next generation of marketing strategies. As AI continues to mature, its role in enhancing the customer experience will grow, but human oversight and creativity will remain essential in ensuring the sustainable and responsible use of these powerful technologies.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# RESHAPING THE FUTURE OF PREPRESS WITH ARTIFICIAL INTELLIGENCE

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***Abstract***

*Innovations in artificial intelligence (AI) are shaping the future of almost every industry, and the printing industry is no exception. Applications of AI in the printing industry can be found in prepress optimization, production automation, variable data printing, quality control, predictive maintenance, customer engagement, workflow improvement, and waste reduction. Prepress is the first, crucial and critical stage in the printing process where files are prepared for the actual printing process. It has always been adaptable to changes due to technological requirements and improvements. The introduction of AI in the production phase of prepress has already demonstrated numerous benefits, such as seamless file management, comprehensive preflight checks, advanced PDF editing and automation of repetitive and time-consuming tasks such as file conversion, layout adjustments, trapping and color correction. AI-powered color management systems, which are essential in prepress, are becoming more sophisticated and can predict and compensate for color differences between different substrates and devices. Although the benefits of AI in prepress are obvious, there are still certain challenges and considerations, including the initial investment, data security, complexity of integration and lack of expertise. This paper aims to explore the integration of AI elements in prepress applications and provide a comprehensive overview of the benefits, challenges and future prospects in this area.*

***Key words:*** *prepress, artificial intelligence, enhanced efficiency, enhanced quality.*

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# 1. Introduction

Printing can be described as a complex process consisting of a combination of graphic technologies that allow graphic elements (drawings, images, text elements, etc.) to be displayed attractively and in high quality on various substrates such as paper, cardboard, fabric, plastic, etc., from a single poster to tens of thousands of copies of a packaging, magazine or book (Liang et al, 2023; Lechene, 2024). The origins of printing lie in history and in wood block printing in China, while in Europe the invention of the wooden press with movable type by Johannes Guttenberg in the 15th century revolutionized book production and provided the unique opportunity to reproduce books in large quantities (Lechene, 2024). We have come a long way from this type of book printing to modernized, technologically extremely complex and advanced large-scale industrial printing processes such as flexographic printing, offset printing, gravure printing, screen printing and personalized, high-quality and fast digital printing. With each of these printing processes, we can print on virtually any type of material and produce graphic products such as books, flyers, posters, newspapers, T-shirts, etc. In the 21st century, advances in printing technology have gone even further, enabling numerous new areas of application, including printed electronics, optics and additive manufacturing.

In all printing processes, the ink is transferred to the substrate using a printing plate, with the exception of digital printing, where the printing plate is omitted. In order to deliver a high-quality printed product, the critical part of the process is the prepress stage, where all the necessary steps are taken to adequately perform plate making or direct digital printing. In this sense, the critical aspects are color proofing and correction, color separation, screening, the RIP process and more (Liang et al, 2023). There is no room for error because today's competitive market demands a high-quality, cost-effective, versatile and fast-delivery print product. Automation of prepress workflows has brought significant advances, but the introduction of artificial intelligence solutions is a real game changer in prepress processes.

## 1.1 Artificial intelligence and its deployment in graphic industry

Artificial intelligence (AI) refers to a technology that enables a computer or a robot to perform tasks in the same manner as a human, equipped with its characteristic intellectual processes such as the ability to learn, reason, discover meaning, generalize, perceive, use language or learn from past experiences (Tomić et al., 2022; Copeland, 2024). Solutions based on artificial intelligence (AI) are used daily in all printing processes, from prepress and printing to quality control and customer engagement, to ensure higher print quality, cost-effectiveness and efficiency. According to the nature and applicability in graphic processes, these solutions are mostly based on machine learning and vision applications (image processing and machine vision) (Tomić et al., 2022).

AI has opened up an extraordinary opportunity to increase innovation, efficiency and improve results in the graphic arts sector, from designers (automated design suggestions, image enhancement, customized designs) to prepress operations (automated proofreading, color correction, file optimization, trapping), in the printing process (predictive maintenance, quality assurance, optimized ink usage, workflow automation) and in sales (chatbots and virtual assistants, automated follow-ups, efficient quote generation) (Bracamontes, 2023).

Many manufacturers of state-of-the-art digital printing machines for commercial, high-speed and large-format applications are integrating AI solutions alongside cloud and automation technologies to improve color reproduction quality, accuracy, efficiency and profitability (Packaging Europe, 2024). These AI-driven features can automatically determine print settings based on file content, simplify preflight reports and improve image resolution. In addition, AI features help with ink management by predicting ink usage and optimizing inventory levels. They also automate job preparation tasks and, combined with cloud technology, enable remote printing and on-demand production, reducing manual effort and increasing productivity so that operators with different skills can efficiently process different print jobs (Kwality Labels, 2023; Packaging Europe, 2024).

One of the key benefits of artificial intelligence (AI) in the printing industry is its ability to automate repetitive and labor-intensive tasks. AI systems can manage prepress operations such as font identification, color corrections and image scaling, allowing employees to focus on more creative and strategic tasks. In addition, AI-powered software can dynamically analyze and adjust colors in real time, ensuring consistency and optimal print quality. In addition, AI can detect errors during the printing process and independently stop or change processes to minimize them. This automatic quality control reduces both waste and production costs. AI also facilitates the integration of printed materials with digital technologies. For example, when a user scans a printed code or image, AI can trigger an augmented reality experience on their smartphone or tablet, increasing user interactivity and engagement by bringing the printed content to life (Bracamontes, 2023; Kwality Labels, 2023; Gokulnath, 2024).

Graphic design software's manufacturers are incorporating AI in order to provide assistance to designers and others involved in creative industry in generating more visually appealing and market relevant materials, including packaging design, ensuring higher level of functionality and sustainability (Kwality Labels, 2023).

The application of AI in 3D printing is leading to the production of more complex and efficient 3D prints, accelerating the design process, and increasing the accessibility of 3D printing to a broader audience (Kwality Labels, 2023).

## 2. Harnessing AI for enhanced efficiency and quality in prepress

Prepress is a very important phase in the printing process as it involves the digital preparation of the files to be printed according to the requirements of the printing technology used. It includes all the necessary steps to ensure that the digital files are ready for printing and that the final output meets the desired quality standards: defining the correct format of the files, checking text and graphic elements, managing colour corrections, assigning colour profiles, improving image quality, checking proofs, etc. It is essential that these tasks are carried out properly to ensure the accuracy, consistency and quality of the final printed product. They are sometimes quite repetitive and time-consuming, which affects the overall efficiency of the printing process. The introduction of automation and AI technologies in prepress by streamlining the labour-intensive processes has led to exceptional time and cost management, increased productivity, innovation and creativity, delivering the best results to customers (Bracamontes, 2023; Gokulnath, 2024). Most of the benefits of AI integration in prepress are seen in proofreading, layout adjustments, colour corrections, black generation, file optimisation, trapping, product presentation, better workflow automation, customisation and cloud-based collaboration (Tongkai et al, 2021; Bracamontes, 2023; Gokulnath, 2024).

### 2.1 Proofreading

AI algorithms can be successfully used for so-called proofreading in the prepress stage to recognise errors in the layout, graphics or text. They are trained to look for unsightly text forms, such as separated words at the end of line breaks, lines that are too long or too short, inappropriate text spacing (line spacing, tracking and kerning), images with insufficient resolution (i.e. less than 300 dpi), etc. (Bracamontes, 2023).

### 2.2 Colour correction

High-quality printing is characterised by highly accurate colour reproduction, where precise colour management is essential. AI-driven tools and software solutions are of utmost value when it comes to predicting how colours will appear on the substrate and adjusting them in prepress to ensure consistency and accuracy in production. AI-based colour management systems will be even more advanced in the future when it comes to predicting and adjusting colour disparities on different substrates and devices (Bracamontes, 2023; Adroit, 2024).

### 2.3 File optimization

AI can automatically adjust files for an optimal print format and thus guarantees results of the highest quality (Bracamontes, 2023).

### 2.3 Trapping

Trapping is a prepress technique used to compensate for registration errors in all printing techniques. It involves creating a slight overlap between neighbouring colour areas to avoid gaps that can occur due to misalignment during the printing process. Trapping is one of the most important processes in prepress as it helps to avoid unnecessary overlaps or problems that could affect registration. AI can help by ensuring precise alignment and minimising the risk of errors (Bracamontes, 2023).

### 2.4 Incorporating augmented reality (AR) and virtual reality (VR) technologies in printing products

The prepress industry is exploring new frontiers with Augmented Reality (AR) and Virtual Reality (VR) technologies, transforming the way we interact with printed materials. AR enhances tangible proofs by superimposing digital content like videos and animations, making the review process more dynamic and engaging. In marketing, AR adds interactive layers to printed materials, creating a richer consumer experience. VR, on the other hand, offers immersive environments where designers can virtually walk clients through designs, providing a better sense of how they will appear in real life. These advancements are also opening new opportunities in marketing, training, and education (Androit, 2024; Gokulnath, 2024).

### 2.5 Cloud-based collaboration

Cloud-based collaboration is an emerging trend in the prepress services industry, driven by the need for real-time teamwork. Cloud computing offers numerous benefits, including improved accessibility, enhanced data security, and real-time collaboration. With cloud-based tools, designers, editors, and clients can simultaneously work on the same files from anywhere with an internet connection, resulting in smoother workflows, better communication, and faster project completion. Additionally, features like version control prevent loss of changes or accidental overwriting. Combined with AI technology, it enables prepress technicians and designers to collaborate remotely on projects globally, further boosting its growth (Androit, 2024; Gokulnath, 2024).

### 2.6 Customization, printing on demand, short-run printing and sustainability

The growing demand for personalized and distinctive items has increased the popularity of personalized printing, pushing prepress services to offer more responsive and flexible solutions. Variable Data Printing (VDP) enables large-scale, high-quality, customizable printing, requiring prepress services to handle complex data sets and ensure seamless digital printing processes. Additionally, on-demand printing is becoming more prominent due to the need for faster turnaround times and reduced inventory costs, driving prepress providers to adopt more agile and

adaptable workflows. Just-in-time printing further minimizes waste and storage expenses by producing materials as needed, necessitating workflow optimization. Short-run printing, a similar trend, allows for smaller print quantities, making it cost-effective and beneficial for small businesses. Finally, sustainability is a growing focus, with manufacturers adopting eco-friendly materials and processes to reduce waste and their carbon footprint (Androit, 2024; Gokulnath, 2024).

## 3. Use of AI-supported solutions in printing processes: Challenges and opportunities

It is obvious that AI offers a multitude of benefits for the printing process. But we cannot overlook the fact that there are also a number of challenges that we should consider.

Some of the benefits of AI for the printing process are the following:

*Increased efficiency and reduced production time*, resulting in cost savings and faster turnaround times. In addition, AI has the potential to manage and optimise the entire print production workflow, from prepress to postpress. By automating processes and providing better visibility of performance, AI supports management decision-making and ensures even greater efficiency throughout the production cycle (Kwality Labels, 2023; Sodaal, 2024).

*Value creation through print personalisation*, where AI can be used to analyse large amounts of customer data and enable a higher level of print personalisation, meeting the growing demand for variable data printing (Kwality Labels, 2023; Sodaal, 2024).

*Sustainability by optimising print jobs and minimising errors,* which helps to reduce waste. In addition, AI can perform predictive maintenance, which extends the life of printing equipment and reduces the environmental impact associated with the manufacture and disposal of machines. Unlike traditional methods of component replacement, which are based on average operating life, AI can analyse the performance of devices to predict when certain parts will fail. This enables more precise replacement and reduces unnecessary downtime and waste caused by unwarranted component replacement (Kwality Labels, 2023; Sodaal, 2024).

*Less repetitive tasks and more creativity* through the ability to automate repetitive tasks, allowing employees to focus on more complex and creative aspects of the printing processes. This allows creative professionals to focus on design and innovation, resulting in more imaginative and engaging print materials and allowing operators to focus on higher value-added activities (Kwality Labels, 2023; Sodaal, 2024).

*Ensuring high print quality and competitive advantage* by analysing the quality of print output in real time, identifying and fixing print quality issues as they arise, thereby reducing waste costs and offering more efficient and cost-effective services that attract more customers and give the company an edge over the competition (Kwality Labels, 2023; Sodaal, 2024).

AI considerations, especially in prepress, are mainly related to the fact that AI tools can occasionally misinterpret the design, so human supervision is still essential. Other challenges include high implementation costs, workforce reorganisation and data security (Bracamontes, 2023; Kwality Labels, 2023).

## 4. Conclusions

Technological development in the printing industry is far-reaching, with artificial intelligence (AI) being the latest transformative development to augment human expertise. The integration of AI has led to advances in automation, personalisation, optimisation, sustainability, productivity and cost efficiency, while enabling data-driven decision-making. This shift allows professionals to focus more on creativity and innovation and deliver better results to clients while saving costs and time. Although challenges such as implementation costs and workforce adaptation remain, the potential for growth and innovation is significant. With increasing access to AI-driven solutions, the print industry is poised for a major transformation that will revolutionise design, production and marketing. The synergy between AI and print promises a future of greater efficiency, customisation and competitiveness, with the full potential of AI yet to be realised.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ANALYSIS OF THE USE OF SOCIAL MEDIA MARKETING WITH AN OVERVIEW ON GRAPHIC DESIGN ON THE EXAMPLE OF TREBINJE WINERIES

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***Abstract***

*Nowdays, social media (SM) and online advertising have become key tools for building and promoting a brand. This is very important for local entrepreneurs, such as wineries in Trebinje (Bosnia and Herzegovina), who want to increase visibility and reach a wider audience. This paper explores the use of SM with an overview on graphic design, analyzing the existing strategies that wineries in Trebinje use for promotion. Through a case study of 19 members of the Association of Winemakers and Vinegrowers "Vinos" Trebinje, the paper analyzes how visual identity and advertising design on SM affect brand perception and user engagement. Attention is paid to the creative aspects of graphic design, including the analysis of the use of basic graphic design elements (text and typography, photography, illustrations, colors, etc.) which contribute to creation of an attractive and recognizable brand. The methodology includes qualitative analysis through the case study of 19 wineries, analysis of content published on SM, as well as design analysis. Quantitative analysis is conducted to quantify user engagement through descriptive statistical analysis and analysis based on SM metrics. The results of the research indicate that wineries which use consistent and high-quality graphic design achieve significant levels of user engagement and a more positive perception of the brand. A comparative analysis of different wineries has identified best practices and proposes recommendations for improving online presence.*

***Key words:*** *social media, online advertising, graphic design, wineries, engagement.*

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# 1. Introduction

Wine is increasingly recognized as a means of enjoyment, relaxation, and social interaction (Molina et al., 2015). As it becomes more present in everyday life, the interest in visiting wine regions is growing, which is increasing their global popularity. SM, which has revolutionized marketing communication, is becoming key in the wine industry, as is the case in Trebinje.

Winemakers and vineyard owners in Trebinje play a crucial role in the development of tourism and the demand for local products, which has led to the growth of other sectors in the city. Trebinje is known for wines such as Žilavka and Vranac, with a large number of vineyards and wine cellars spanning around 550 hectares, producing approximately 2,970,000 liters of wine annually (Strategy for the Development of Agriculture and Rural Areas of the City of Trebinje 2023-2027; Ministry of Agriculture, Forestry, and Water Management of the Republic of Srpska).

Modern consumers increasingly interact with brands through SM, which they also use for customer services and contact with businesses (Egaña et al., 2021). The effective use of SM can improve marketing processes and customer relationships. The digital form of communication poses a challenge for media, where graphic designers play a key role in creating promotional content. Graphic design on SM is essential for visibility, engagement, and the success of marketing campaigns (Tantuah & Thori, 2022).

The goal of the research is to analyze the use of SM and online advertising on platforms such as Facebook and Instagram, with a focus on graphic design. Through a case study of 19 members of the "Vinos" Trebinje Winemakers and Vineyard Owners Association, the research explores how visual identity and design influence brand perception and user engagement. The methodology involves a combination of qualitative and quantitative approaches, including content and design analysis on SM, as well as statistical data analysis.

# 2. Literature Review

## 2.1 Social Networks

SM are internet applications based on Web 2.0 technologies, which allow users to create and share content (Canovi & Pucciarelli, 2019). The focus of this paper is on platforms such as Facebook and Instagram, which enable the creation of personal and business profiles for connecting, communicating, and building relationships with other users. Businesses use these tools to share information, promote products and services, and engage in direct communication with consumers. SM has become essential for increasing the visibility and competitiveness of companies.

According to research (Obermayer et al., 2022), the main reasons for using SM are sharing general information (58.5%), direct communication with customers

(57.8%), and sharing marketing messages (53.4%). Small businesses use these tools to build a regional image, attract customers, and increase profits.

The expansion of SM significantly impacts large organizations, as well as small and medium-sized enterprises (SMEs). Research shows that SM strategies are particularly beneficial for SMEs due to their flexibility and low costs compared to traditional media (Galati, 2017). Social media, in fact, offers inexpensive promotional options with relatively low costs compared to those required for communication in non-virtual media.

### 2.2 Social Media Marketing and Graphic Design

In the 21st century, significant changes in the understanding of the role of graphic design and its impact on consumer communications and marketing have emerged as a result of globalization, ethnocultural identification, hyper-consumption, and the expansion of the digital space (Kosarevska, 2023). The media industry, faced with the transition to digital communication, is challenged with the need for innovative graphic design to remain relevant and maintain its market presence.

Practice and research show that visual content plays a key role in engaging consumers. Graphic design shapes the visual presentation, text, and uses various marketing tools, and can be seen as the visual realization of the advertising message. Design creates a harmonious image of the advertising message, incorporating aesthetic elements such as colors, tones, composition, and originality (Walker, 2017). Besides aesthetic features, the ethno-stylistic aspect is also important. Marketing generates interest in the brand, while design visually conveys that interest, making it the face of the brand (Satria & Tantuah, 2022).

There are three ways of processing information: (1) representational, where verbal and non-verbal information are processed separately; (2) referential, where visual communication activates the verbal system and vice versa; and (3) associative, where text and images can trigger mental cues. SM and visual design offer brands numerous touchpoints for engaging consumers.

### 2.3 Theory of Design

Effective branding through graphic design helps the brand stand out on the market, create a strong emotional connection with consumers and increase brand recognition over time. The process typically involves research, brainstorming, sketching, refining and finalizing the design, often in collaboration with the client, to ensure the design accurately reflects the brand's values and message.

Branding through design has evolved with the development of technology and changes in consumer behavior, and several relevant theories have significantly influenced this process (Firdaus, et al., 2023):

1. **AIDA model**. This model suggests that advertising should attract attention (Attention), create interest (Interest), cause desire (Desire) and finally lead to action (Action). In graphic design branding, this means that

designers must create visually appealing and striking designs that evoke emotions and encourage the consumer to learn more about the brand.

2. **Golden Circle theory**. Popularized by Simon Sinek, this theory suggests that the most successful brands start communicating with their "why"—the purpose, cause, or belief that drives them—rather than focusing solely on their products or services. In graphic design branding, this means that designers should create designs that communicate the value and purpose of the brand, not just the features or benefits of the product.
3. **Gestalt theory**. It focuses on the way people perceive and organize visual information, suggesting that people tend to perceive visual elements as a whole rather than as separate parts. In branding through design, this means that designers should create designs that are visually coherent and convey a clear message, rather than relying on disjointed elements.
4. **Color theory**. Colors play a key role in branding because they can evoke different emotions and associations in the viewer. For example, blue is often associated with trust and reliability, while red can evoke excitement and passion. Designers must carefully choose colors that align with the brand's values and message.

### 2.4 Trends in Social Media Marketing and Graphic Design

Contemporary trends in social media marketing focus on the use of advanced platforms to promote brands and products. One of the main trends is the growing popularity of video content on platforms like YouTube, Instagram, Facebook and TikTok, as it allows brands to capture attention and engage audiences (Maitri et al, 2023). Live streaming is particularly important, as it enables interaction with users in real time (Sedej, 2019; Dewobroto&Enrica, 2021).

Also, the influence of influencers is becoming increasingly important in expanding the reach and building the credibility of brands through authentic promotions (Azhar et al., 2022). "Stories" on Instagram, Facebook and Snapchat, as well as the use of technologies such as AR and VR, offer new ways to engage audiences (Rustiawan et al., 2023; Sudirjo et al., 2023). Content personalization and automated support via chatbots are becoming more common, while users are also creating content that helps build brand trust (Khan et al., 2019). Accordingly, data management and privacy protection become priorities, while companies must adapt their strategies to remain relevant in a rapidly changing world.

Contemporary trends in graphic design are constantly changing and improving. Different approaches, such as minimalism, geometric shapes, bright colors, asymmetrical layouts, as well as illustrations, organic textures and moving graphic elements, are becoming more and more popular (Abbaset al., 2024). However, it is important to remember that the basic purpose of design is effective communication and providing an adequate experience to the target audience. When following trends, it is necessary to take into account the identity and goals of the brand or project.

### 2.5 The wine industry in Bosnia and Herzegovina

Wine production in Bosnia and Herzegovina is concentrated in the river basins of the Neretva and Trebišnjica rivers, predominantly in the southern part of the country. Regionalization since the 1970s has identified two main wine regions: Northern Bosnia and Herzegovina. Due to its mild climate, Herzegovina is the primary and only significant producer of grapes and wine in the country. The region is known for indigenous grape varieties such as Žilavka, Vranac, and Blatina, which are well-adapted and produce high-quality wines unique to this area (Nurković, 2017).

Viticulture in Bosnia and Herzegovina is characterized by the presence of small vineyards, usually ranging from 0.3 to 0.4 hectares, with very few exceeding 10 hectares. These small vineyards are mostly family-owned, and there is no official registry of grape and wine producers. By 1990, Bosnia and Herzegovina had 5,781 hectares of vineyards, with 24.5 million European vines planted on American rootstocks. Of this, 5,691 hectares were in Herzegovina (98.4%), while 90 hectares were in Northern Bosnia (1.6%) (Nurković, 2017).

## 3. Results

The research methodology employs a combined qualitative and quantitative approach. In the first phase, the research encompasses the analysis of engagement (on Facebook: the number of posts, photos, videos, events, surveys; on Instagram: photos, videos, carousel posts), design analysis (photos and graphic design), descriptive data (number of likes, comments, shares, number of followers), and the nature of posts (photo, video, graphic) for 19 members of the Association of Winemakers and Vinegrowers 'Vinos' Trebinje (BiH). This phase evaluates the level of engagement, providing a more realistic picture of this indicator. In the second phase, engagement calculations are performed through descriptive statistical analysis.

SM data includes a total of 927 posts over the past 3 years, distributed as 527 on Facebook (56.85%) and 400 on Instagram (43.15%). The data analysis period was from August 20, 2021, to August 20, 2024, while data collection was conducted manually from July 2024 to August 2024 (see Tables 1 and 2).

*Table 1: Engagement on wineries' posts on Facebook (n=19)*

| The Association of Winemakers and Vinegrowers "Vinos" Trebinje | Posts | Photos | Videos | Graphics | Events | Comments | Shares | Likes |
|---|---|---|---|---|---|---|---|---|
| Tvrdoš Monastery Cellars | 0.03 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| Vukoje 1982 Cellars | 7.00 | 11.59 | 0.20 | 0.78 | 0.24 | 38.78 | 1.57 | 863.00 |
| Andjelić Cellar | 1.39 | 5.00 | 0.00 | 0.22 | 0.00 | 3.52 | 1.39 | 62.04 |
| Petijević Wine Cellar | 8.47 | 11.94 | 1.63 | 0.31 | 0.00 | 2.14 | 2.76 | 225.00 |
| Sekulović Wine Cellar | 2.14 | 1.73 | 0.31 | 0.31 | 0.00 | 8.36 | 0.82 | 54.33 |
| Popovac Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| The Association of Winemakers and Vinegrowers "Vinos" Trebinje | Posts | Photos | Videos | Graphics | Events | Comments | Shares | Likes |
|---|---|---|---|---|---|---|---|---|
| Berak Wine Cellar | 7.46 | 10.45 | 0.00 | 0.75 | 0.00 | 6.72 | 0.75 | 137.31 |
| Tarana Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lečić Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bojanić Wine Cellar | 2.15 | 6.92 | 0.15 | 0.00 | 0.00 | 2.46 | 2.54 | 112.77 |
| Runjevac Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dabić Winery | 4.26 | 4.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.38 |
| Korać Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Marić Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aćimović Wine Cellar | 0.16 | 0.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.88 |
| Vera Winery | 0.43 | 0.43 | 0.14 | 0.00 | 0.00 | 0.29 | 0.14 | 3.74 |
| Dostić Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dračevo Wine Cellar | 0.51 | 0.85 | 0.00 | 0.00 | 0.00 | 0.51 | 0.51 | 29.32 |
| Đelmo Winery | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Table 2: Engagement on vineries' posts on Instagram (n=19)*

| The Association of Winemakers and Vinegrowers "Vinos" Trebinje | Posts | Photos | Graphics | Videos | Carousels | Comments | Shares | Likes |
|---|---|---|---|---|---|---|---|---|
| Tvrdoš Monastery Cellars | 0.59 | 0.27 | 0.00 | 0.05 | 0.27 | 0.00 | 2.51 | 41.39 |
| Vukoje 1982 Cellars | 1.34 | 1.02 | 0.13 | 0.17 | 0.05 | 1.96 | 0.83 | 287.23 |
| Andjelić Cellar | 0.69 | 0.35 | 0.10 | 0.05 | 0.15 | 2.23 | 0.69 | 69.84 |
| Petijević Wine Cellar | 6.08 | 2.86 | 0.00 | 1.48 | 1.74 | 3.82 | 7.64 | 481.94 |
| Sekulović Wine Cellar | 1.74 | 0.87 | 0.19 | 0.39 | 0.29 | 2.89 | 5.11 | 6.17 |
| Popovac Wine Cellar | 0.30 | 0.20 | 0.00 | 0.10 | 0.00 | 0.40 | 0.30 | 34.73 |
| Berak Wine Cellar | 2.42 | 1.61 | 0.12 | 0.23 | 0.46 | 1.04 | 4.72 | 224.05 |
| Tarana Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lečić Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bojanić Wine Cellar | 0.81 | 0.52 | 0.04 | 0.00 | 0.26 | 5.43 | 1.44 | 170.21 |
| Runjevac Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dabić Winery | 2.90 | 1.04 | 0.04 | 0.17 | 1.65 | 3.12 | 10.18 | 284.45 |
| Korać Wine Cellar | 3.78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Marić Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aćimović Wine Cellar | 0.19 | 0.05 | 0.00 | 0.00 | 0.14 | 0.19 | 0.61 | 26.16 |
| Vera Winery | 4.59 | 2.58 | 0.16 | 0.64 | 1.21 | 4.27 | 7.33 | 158.21 |
| Dostić Wine Cellar | 0.14 | 0.00 | 0.00 | 0.14 | 0.00 | 0.27 | 0.96 | 47.81 |
| Dračevo Wine Cellar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Đelmo Winery | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

### 3.1 Wineries' Facebook and Instagram activity

The descriptive analysis of the sample of 19 wineries shows that 4 wineries do not have an Instagram account (of which 1 has a private account), while 7 do not have a Facebook account. Tables 3 and 4 provide an overview of the wineries' activities on Facebook and Instagram. In total, the wineries have 18,740 followers,

with 71.37% (Mean=1348.632; Sd=1920.112) on Instagram and 28.63% (Mean= 813.947; Sd=1920.852) on Facebook. The winery with the highest number of followers is Vukoje (4900 followers on Facebook and 8355 on Instagram), while the winery Korać has the lowest number of followers (185 on Instagram and 0 on Facebook).

The extent of rich content in posts plays a crucial role in attracting potential customers and retaining existing ones. Vukoje Winery had the highest number of posts (343 on Facebook and 112 on Instagram), while Tarana Winery had 0 posts. On Facebook, posts were most commonly in the form of "Photos" with a total of 934 photos (Mean=49.158; Sd=131.710), "Graphics" (Mean=2.632; Sd=8.681), and "Videos" (Mean=1.737; Sd=4.175), while "Events" posts were rare with only 12 posts (Mean=0.667; Sd=2.828).

*Table 3: Descriptive data of Facebook effort for Trebinje wineries*

| | Average | Min | Max | Standard deviation |
|---|---|---|---|---|
| Followers | 813.947 | 0 | 4900 | 1290.852 |
| Posts | 27.7368 | 0 | 343 | 78.984 |
| Photos | 49.158 | 0 | 568 | 131.710 |
| Videos | 1.737 | 0 | 16 | 4.175 |
| Graphics | 2.632 | 0 | 38 | 8.681 |
| Events | 0.667 | 0 | 12 | 2.828 |
| Comments | 112.105 | 0 | 1900 | 433.722 |
| Shares | 9.579 | 0 | 77 | 19.864 |
| Likes | 2543 | 0 | 42287 | 9645.714 |

On Instagram, wineries primarily expressed themselves through "Photos" posts, with a total of 226 photos (Mean=11.895; Sd=20.787), and "Carousels" posts with 102 posts (Mean=5.368; Sd=9.587), while "Graphics" posts were only 20 (Mean =1.053; Sd=2.527). Photos are key to capturing attention, while event promotions increase interaction with users, potentially resulting in a larger follower base and engagement with existing ones. Graphic design helps wineries visually stand out, convey the brand message, and communicate effectively with the audience, thereby enhancing engagement and user loyalty.

Posts were shared a total of 700 times on Instagram (Mean=36.842; Sd= 57.186) and 182 times on Facebook (Mean=9.579; Sd=19.864). This increases content visibility, providing an advantage for brand promotion and recognition, which may impact sales (Coursaris et al. 2016; Egaña et al. 2021).

Additionally, a total of 927 posts received 2130 comments on Facebook (Mean=30.211; Sd=49.517) and 574 comments on Instagram (Mean=112.105; Sd=433.722). Comments influence public opinion and brand awareness, which may affect purchase intentions (Carah 2014; Egaña et al. 2021).

Posts received a total of 96,465 likes, with 48,317 likes on Facebook (Mean=2543; Sd=9645.714) and 48,148 likes on Instagram (Mean=2534.105; Sd=5577.332).

*Table 4: Descriptive data of Instagram effort for Trebinje wineries*

| | Average | Min | Max | Standard deviation |
|---|---|---|---|---|
| Followers | 1348.632 | 0 | 8355 | 1920.112 |
| Posts | 21.421 | 0 | 112 | 31.7146 |
| Photos | 11.895 | 0 | 85 | 20.787 |
| Graphics | 1.053 | 0 | 11 | 2.527 |
| Videos | 2.789 | 0 | 17 | 4.951 |
| Carousels | 5.368 | 0 | 38 | 9.587 |
| Comments | 30.211 | 0 | 164 | 49.517 |
| Shares | 36.842 | 0 | 235 | 57.186 |
| Likes | 2534.105 | 0 | 23998 | 5577.332 |

# 4. Discussion

## 4.1 Correlation Between Engagement and Social Media Metrics

Pearson correlation was used to analyze the relationship between engagement metrics and SM metrics in the Facebook sample (Table 5):

- **Published photos and number of comments**: the correlation between the number of published photos and the number of comments on winery posts is very high ($r=0.963$; $p<0.01$). This indicates a very strong positive relationship, meaning that as the number of published photos increases, the number of comments also significantly increases. Therefore, photos have a substantial impact on user engagement, as evidenced by the increase in comments;
- **Graphic design and number of comments**: the correlation between graphic design in posts and the number of comments is extremely high ($r=0.993$; $p<0.01$). This nearly perfect correlation suggests that higher-quality graphic design or its presence significantly increases the number of comments on posts;
- **Number of shares and published photos**: the correlation between the number of shares of posts and the number of published photos is high ($r=0.951$; $p<0.01$), while the correlation between the number of shares and graphic design in posts is also high ($r=0.874$; $p<0.01$). These results indicate that both factors, photos and graphic design, strongly influence content sharing, with photos having a slightly stronger effect;
- **Number of likes and published photos**: the correlation between the number of likes and published photos is high ($r=0.971$; $p<0.01$), while the correlation between the number of likes and graphic design in posts is even higher ($r=0.992$; $p<0.01$). These results indicate that both factors significantly impact the number of likes, with graphic design having a stronger influence than photos;
- **Number of followers and published photos/graphic design**: the correlation between the number of followers and published photos is high

(r=0.832; p<0.01), while the correlation between the number of followers and graphic design in posts is also high (r=0.808; p<0.01). These correlations suggest that visually rich content attracts and retains more followers, which can be crucial for increasing engagement and building the brand.

- **Number of shares, likes and published video content:** the correlation coefficient between the number of shares (r=0.52; p<0.05) shows a medium positive association, which means that a higher number of shares implies a higher level of interaction with the content. This statistically significant association indicates that users are more likely to share content they perceive as relevant or interesting, which increases brand reach and visibility. On the other hand, an even stronger correlation (r=0.65; p<0.01) between the number of likes and published video content suggests that the video format causes more significant positive reactions from the audience. which leads to more likes compared to other types of content.

*Table 5: Pearson correlations of the metrics on Facebook (n=12)*

| | *Followers* | *Posts* | *Photos* | *Videos* | *Graphics* | *Events* | *Comments* | *Shares* | *Likes* |
|---|---|---|---|---|---|---|---|---|---|
| Followers | 1 | | | | | | | | |
| Posts | 0.802** | 1 | | | | | | | |
| Photos | 0.832** | 0.99** | 1 | | | | | | |
| Videos | 0.484* | 0.668** | 0.623** | 1 | | | | | |
| Graphics | 0.808** | 0.983* | 0.977** | 0.537* | 1 | | | | |
| Events | 0.816** | 0.969** | 0.969** | 0.477* | 0.994** | 1 | | | |
| Comments | 0.785** | 0.973** | 0.963** | 0.489* | 0.993** | 0.999** | 1 | | |
| Shares | 0.829** | 0.911** | 0.951** | 0.654** | 0.874** | 0.872** | 0.843** | 1 | |
| Likes | 0.785** | 0.981** | 0.971** | 0.523* | 0.992** | 0.998** | 0.998** | 0.856** | 1 |

*Note:*p <0 .05, **p < 0.01*

Pearson correlation was used to analyze the relationship between engagement metrics and SM metrics in the Instagram sample (Table 6):

- **Published photos and number of comments**: the correlation between published photos and the number of comments is high (r=0.797; p<0.01), while the correlation between graphic design in posts and the number of comments is slightly lower (r=0.748; p<0.01). This suggests that although both factors significantly contribute to user engagement through comments, photos have a somewhat greater impact;
- **Number of shares and published photos/graphic design**: the correlation between the number of shares of posts and the number of published photos is moderate (r=0.511; p<0.05), while the correlation between the number of shares and graphic design in posts is lower (r=0.251; p>0.05). Photos have a greater impact on content sharing compared to graphic design, but both factors show weaker associations with sharing compared to other forms of engagement;
- **Number of likes and published photos/graphic design**: the correlation between the number of likes and published photos is high (r=0.948;

p<0.01), while the correlation between the number of likes and graphic design in posts is also high (r=0.920; p<0.01). Both photos and graphic design have a very strong impact on the number of likes, with photos having a slightly greater effect;

- **Number of followers and published photos/graphic design**: the correlation between the number of followers and published photos is moderate (r=0.616; p<0.01), while the correlation between the number of followers and graphic design in posts is lower (r=0.442; p<0.01). This indicates that Instagram users respond more to posts containing photos, while graphic design has a lesser impact on attracting new followers.
- **The number of shares, likes and published video content:** the correlation coefficient between the number of shares (r=0.52; p<0.05) shows a medium positive association, which means that a higher number of shares implies a higher level of interaction with the content. This statistically significant association indicates that users are more likely to share content they perceive as relevant or interesting, which increases brand reach and visibility. On the other hand, an even stronger correlation (r=0.65; p<0.01) between the number of likes and published video content suggests that the video format causes more significant positive reactions from the audience. Video content is more dynamic and interactive, leading to more likes compared to other types of content.

*Table 6: Pearson correlations of the metrics on Instagram (n=14)*

| | *Followers* | *Posts* | *Photos* | *Graphics* | *Videos* | *Carousels* | *Comments* | *Shares* | *Likes* |
|---|---|---|---|---|---|---|---|---|---|
| Followers | 1 | | | | | | | | |
| Posts | 0.777** | 1 | | | | | | | |
| Photos | 0.871** | 0.956** | 1 | | | | | | |
| Graphics | 0.909** | 0.757** | 0.894** | 1 | | | | | |
| Videos | 0.56* | 0.881** | 0.837** | 0.578* | 1 | | | | |
| Carousels | 0.219 | 0.633** | 0.393 | 0.063 | 0.482* | 1 | | | |
| Comments | 0.83** | 0.765** | 0.797** | 0.748** | 0.531* | 0.385 | 1 | | |
| Shares | 0.373 | 0.713** | 0.511* | 0.251 | 0.499* | 0.961** | 0.474** | 1 | |
| Likes | 0.933** | 0.871** | 0.948** | 0.919** | 0.694** | 0.288 | 0.818* | 0.422 | 1 |

*Note:*p <0 .05, **p < 0.01*

## 4.2 Analysis of Wineries' Brand Presentation Consistency and Design Quality

Statistical analysis has shown that the number of graphic posts on both SM platforms is negligible compared to the posted photos—only 70 graphic posts (7.55%) out of 927 posts and 1,262 photos and carousels. This situation somewhat complicates the analysis and indicates significant inconsistency in design quality, both at the level of the Winemakers' Association and individual winery profiles.

***Vukoje Winery.*** **Inconsistency in design:** Vukoje is one of the largest wineries in terms of wine production and SM activity, with 455 (49.08%) of the total 927 analyzed posts. There is a large variation in design practice, ranging from well-designed posts that adhere to graphic design principles to amateur treatments of

visual materials. Inconsistencies in typography, color palettes, logo application, and the relationship between illustrated and textual material suggest that posts often lack a clear concept. **Photographic material:** photos range from private images of the owner to professional photos that are occasionally hired, further contributing to inconsistency.

***Vera Winery.*** **Consistency and quality:** in contrast to the previous example, Vera Winery shows high consistency in implementing design ideas and the quality of photographic material. Although there are no clearly defined marketing campaigns, the winery uses attractive photos with subtle color palettes, discreet logo application, and representative presentation of products and vineyards. These characteristics add extra quality to their SM posts.

***Other wineries.*** **Graphic posts:** graphic posts appear sporadically and often follow some intermediate pattern between the mentioned examples. **Photographic material:** Petijević Winery stands out for its active promotion with a dynamic approach, while Sekulović Winery demonstrates professionalism in product and event photography, with only one top-designed post but only 39 posts in three years.

***Overall impression.*** **Informal approach:** posts on SM by the 19 analyzed wineries, 8 of which do not use SM at all, are often managed by the owners without a clear idea other than achieving online visibility. The engagement of professional designers and photographers is rare, which significantly affects consistency in maintaining and building a clearly defined visual identity for the wineries.

## 5. Conclusions

This research analyzed the use of SM platforms by wineries that are members of the "Vinos" association from Trebinje over the past three years, covering 927 posts and utilizing user-generated engagement metrics, along with an additional analysis of graphic design. The results highlight the importance of user interaction with posts, identifying which types of content achieve the greatest impact on each platform. On Facebook, the highest interactions are achieved through photos, graphic design, and event-related posts, while video content records a lower level of engagement. On Instagram, the most effective content includes photos, graphic design, and videos, while carousel posts achieve a lower level of interaction. This underscores the crucial role these networks play in the promotion of wineries.

The lack of strategy and professional support in the form of designers and photographers leads to inconsistency in the visual identity of brands, which can negatively affect the perception of wineries and their long-term online image. Furthermore, the fact that eight out of 19 wineries do not use SM at all opens up opportunities for improving their presence and marketing effectiveness in the digital environment.

It is recommended that wineries focus their efforts on creating and sharing high-quality photographs and graphic materials to increase their visibility, engagement, and build a recognizable brand on SM. Specific tools for content creation, such as Canva or Adobe Spark, are recommended to help wineries design

visually appealing posts without needing professional design skills. Additionally, social media scheduling and automation tools like Hootsuite or Buffer would enable them to improve their posting consistency and gain better insights into the statistical data on campaign performance. Wineries should be more proactive in using SM to promote events such as wine tastings, wine tours, and special dinners, as these can enhance engagement and brand visibility while attracting new audiences. It has also been observed that special promotions and discounts are not sufficiently organized (with only one promotion from Vinarija Dabić in collaboration with the dairy company Perffeto Plus from Nevesinje), while the use of attractive visual materials can attract more attention and increase sales.

Interactive elements like surveys and quizzes can improve relationships with followers and provide better insights into their preferences. Although video content currently sees lower engagement on Facebook, high-quality videos showcasing the wine production process, vineyard presentations, and brand stories can contribute to better brand representation and attract a larger number of followers.

It is also important to note that wineries need to develop a strategic approach concerning brand consistency. Consistent visual identity and communication on social media help strengthen brand recognition and build consumer trust. Regularly monitoring performance and adjusting strategies based on analytical results will help wineries build long-term relationships with a wider audience.

Furthermore, including a detailed step-by-step guide to building brand consistency across platforms would provide concrete guidance. This guide should include steps such as: **Defining the visual identity** - choosing colors, fonts and photo styles that match the brand: **Creating visual templates** – using tools like Canva to create templates that can be applied to all posts: **Regular monitoring and analysis of performance** - using analytical tools to understand what types of content work best and how to adapt them to the needs of the audience; **Adjusting strategies** – based on data analysis, wineries should regularly adjust their strategies to optimize their presence and engagement on networks.

This approach would give wineries concrete steps they can follow to achieve consistency in their branding and improve their online marketing.

It is also important to emphasize the segment on innovations in the wine industry, which refers to: **The use of AI technologies to generate content** that allows wineries to automate processes such as creating visual and textual materials, analyzing trends in real time and personalizing communication with consumers. **The introduction of the AR filter** represents an innovative way of connecting consumers with the brand. For example, wineries can allow users to "try" different wine bottles through AR filters or experience virtual wine tours from the comfort of their homes. **Influencers in the wine industry** can play a key role in product promotion, especially among younger generations who prefer authentic and recommended products. Hiring micro-influencers, who have a smaller but more loyal circle of followers, can be an effective way to build trust and increase sales.

In addition to recommendations for improving social media presence, it is crucial to highlight how brand awareness and customer loyalty can be successfully

built through digital interactions. These processes, coupled with social media practices such as user engagement and quality content creation, directly contribute to the long-term building of a recognizable brand in the wine industry.

What is recognized in this research is the comparison of engagement based on the size of the wineries, where smaller wineries had a higher level of interaction with users compared to larger wineries. The three-year analysis observed that wineries published more content on Facebook, while they had a higher number of followers on Instagram, indicating the need to adapt communication strategies to better reach target groups on these platforms.

The study's limitations include a small sample size and inconsistency in wineries' content posting, so the results cannot be fully generalized. This leaves room for further research within the wine industry. Future studies should focus on a deeper understanding of the impact of different types of visual and marketing content on user engagement and brand perception.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE USE OF ARTIFICIAL INTELLIGENCE IN CREATIVE ADVERTISING CAMPAIGNS

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***Abstract***

*The rapid advancement of Artificial Intelligence (AI) has revolutionized numerous industries, with advertising being one of the most significantly impacted. This paper explores the transformative effects of AI technologies on advertising strategies, practices, and outcomes, particularly in the creation of creative advertising campaigns. By analyzing a wide range of relevant literature in the field, the study aims to understand the current trends, methodologies, and effectiveness of AI-driven campaigns. Additionally, practical examples from leading companies are examined to illustrate how AI technologies are being implemented in real-world scenarios to enhance creativity, target audiences more effectively, and measure campaign success. This research contributes to the growing body of knowledge by providing a comprehensive overview of AI's role in modern advertising, offering valuable insights for marketers and academics interested in the integration of AI in creative processes. The findings are expected to highlight the transformative potential of AI in advertising and suggest best practices for leveraging these technologies to maximize campaign impact.*

***Key words:*** *artificial intelligence, advertising, marketing communication, creativity.*

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# 1. Introduction

The integration of artificial intelligence (AI) in creative advertising campaigns has emerged as a transformative force within the marketing landscape. Theoretical frameworks and practical applications illustrate how AI technologies enhance creativity, optimize audience targeting, and measure campaign success. This paper explores the theoretical underpinnings of AI in advertising, supported by empirical evidence and case studies from leading companies.

# 2. Theoretical background

Theoretical perspectives on advertising creativity emphasize the importance of emotional engagement and originality. Advertising creativity significantly influences customer loyalty, particularly when advertisements evoke positive emotions, thereby enhancing their attractiveness and memorability (Nurlibna, 2024). This aligns with findings that creative advertisements bridge the gap between products and target audiences, facilitating voluntary engagement through innovative designs and emotional evocation (Shen et al., 2020). The role of creativity in advertising is further supported by research indicating that creativity acts as the "soul" of advertisements, essential for their effectiveness (Shen et al., 2020).

AI technologies have revolutionized the creative process in advertising by enabling the generation of personalized and interactive content. discusses how digital technology allows for the creation of personalized print ads that enhance consumer engagement, demonstrating that creativity remains relevant in today's market (Thakkar, 2023). This is complemented by the study of Wang et al. (2021), who explore how intrinsic motivation and emotional appeals in advertisements can significantly influence purchase intentions, suggesting that AI can be harnessed to tailor messages that resonate with consumers.

Practical applications of AI in advertising are exemplified by leading companies that have successfully implemented AI-driven strategies. For instance, AI-generated content (AIGC) technologies have been utilized to optimize ad creatives, as seen in Yang's research on real-time advertising systems, which highlights the impact of creatives on click-through rates (CTR) (Yang, 2024). This capability allows companies to dynamically adjust their advertising strategies based on real-time data, enhancing both creativity and effectiveness.

The synergy between AI and digital marketing has been explored by Logalakshmi (2023), who emphasizes that AI enhances the efficiency of marketing campaigns, optimizes customer targeting, and facilitates seamless interactions. This is particularly relevant in the context of neuromarketing, where AI applications can analyze consumer behavior and preferences to create targeted campaigns that yield long-term brand value (Papić et al., 2023). The ethical considerations surrounding AI in advertising are also crucial (Mogaji et al., 2020) in the context of potential biases inherent in AI systems that could adversely affect vulnerable customers.

The effectiveness of AI in enhancing advertising creativity is further supported by empirical studies that demonstrate the positive effects of creative advertising on consumer behavior. For example, increased advertising creativity enhances perceived product value, influencing consumer intentions to engage with brands (Aichner & Shaltoni, 2019). Similarly, research by Papić et al. (2023) illustrates how AI can facilitate sustainable marketing campaigns by optimizing resource allocation and targeting, thereby enhancing overall campaign effectiveness.

AI's role in measuring campaign success is underscored by the ability to analyze vast amounts of data to derive actionable insights. The work of Zhou et al. (2020) introduces a neural model for evaluating creativity in advertising, providing a framework for understanding how consumers perceive and respond to creative content. This model can be instrumental in refining advertising strategies based on consumer feedback and engagement metrics.

The collaborative potential of AI in creative processes is also noteworthy. A framework for modeling interaction in human-AI co-creative systems was proposed by Rezwana & Maher (2023), emphasizing the importance of communication channels between humans and AI to enhance collaboration quality.

The aforementioned findings highlights the necessity for further in-depth research into how AI can effectively augment human creativity in advertising contexts.

## 3. The analysis of practical examples: AI & Creative campaigns

Practical examples from leading companies are analyzed to demonstrate the application of AI technologies in real-world contexts, aimed at enhancing creativity, optimizing audience targeting, and improving the measurement of campaign success.

**Heinz A.I Ketchup** is an award-winning campaign for *Winner of a 2023 Clio Gold Award for Product/Service* (Rethink, 2023). This creative campaign was launched alongside the release of the DALL-E 2 image generator powered by artificial intelligence. The campaign creators leveraged the growing popularity of this technology, asking the question, "What does ketchup look like?" The generated images consistently resembled a Heinz ketchup bottle. Based on these results, Heinz decided to create a global campaign where users on social media shared their unique and intriguing results from the prompt "What does ketchup look like?" Heinz then utilized all the AI-generated images to produce promotional ads, billboards (Fig.1), and eventually curated a gallery featuring user-generated images, both in the metaverse and a physical exhibition. The campaign achieved global success, generating 850 million user interactions.

*Figure 1: Heinz A.I Ketchup*

**The "Have A(i) Break"** campaign by Kit Kat was inspired by research conducted by Google DeepMind, which revealed that even artificial intelligence performs better when given a break (CourageInc., 2024). Researchers found that the phrase "Take a deep breath and solve the problem step by step" was the most effective in improving AI performance. The agency Courage connected this finding with Kit Kat's iconic message "Have a break," adding the phrase "Have a break, then..." to a series of AI prompts (Fig. 2). The improved and more accurate responses demonstrated that Kit Kat's "Have a break" ethos, or in this case "Have an 'AI' break," resonates even with artificial intelligence.

*Figure 2: Have AI Break. Have a Kit Kat.*

A creative campaign **Your Skills are irreplaceable** was launched in Belgium in 2023, to promote the IMPACT HR platform, which specializes in construction job recruitment (Business Today, 2023). A humorous billboard was placed on a busy street, emphasizing that not all skills can be replaced by artificial intelligence (Fig. 3). Interested candidates could apply for construction jobs by scanning a QR code on the billboard. This innovative approach combined AI with a non-traditional method to promote an HR agency.

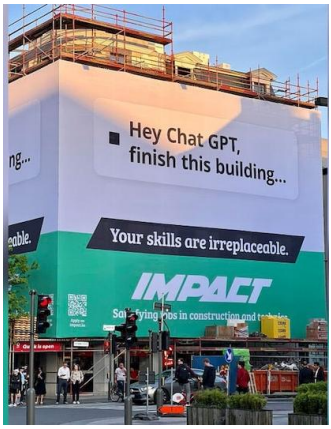


*Figure 3: Your Skills are irreplaceable - IMPACT HR*

Nutella launched the **"Nutella Unica"** campaign, utilizing an algorithm to design 7 million unique labels (Possaible, 2023). Each label featured a combination of lines, shapes, dots, and zigzag patterns, generated by a program ensuring no two labels were identical (Fig. 4). The campaign, launched in February 2017, resulted in a quick sellout of all products. The algorithm also generated a custom ID code for each label to guarantee its uniqueness. This campaign demonstrates how AI can enhance creative processes in the design industry, showcasing the potential of intelligent automation.

*Figure 4: Nutella's AI-Designed Labels Campaign*

**Nike and AKQA** created a virtual match between Serena Williams from 1999 and 2017 using advanced AI technology and machine learning. By analyzing archival footage, they modeled Serena's playing style from different periods, including decision-making, shot selection, responsiveness, recovery, and agility. Launched two days after Serena announced her retirement, the campaign showcased the results of a year-long study through a virtual match between the two versions of Serena. The live broadcast on YouTube garnered over 1.69 million views, with the campaign achieving over 12 million media impressions and generating 1,082%

more organic views compared to other Nike content. This campaign set a new benchmark in sports analytics, offering deeper insights into the evolution and performance of athletes and won an award as *Best in Category - Digital Design2023* (PremiersDesignAwards, 2023).

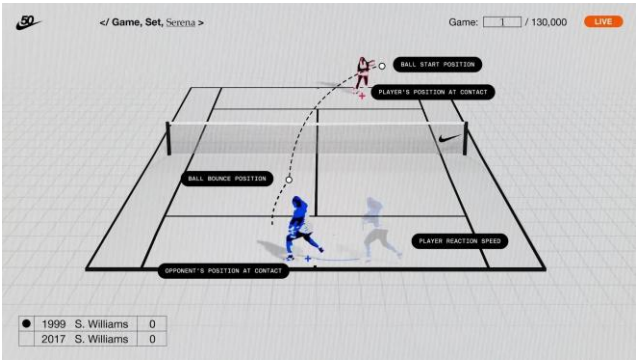


*Figure 5: Nike's "Never Done Evolving"*

## 4. Concluding remarks

The integration of AI in creative advertising campaigns presents a multifaceted opportunity for enhancing creativity, optimizing audience targeting, and measuring campaign success. The theoretical foundations and practical applications discussed herein illustrate the transformative potential of AI in the advertising industry. As companies continue to explore and implement AI-driven strategies, the landscape of advertising creativity will undoubtedly evolve, leading to more engaging and effective campaigns. However, the literature and practice has often ignored the negative implications of AI for the interaction between digital marketing and vulnerable customers. Therefore, ethical considerations of using AI in advertising are crucial for ensuring fairness, transparency, and accountability in marketing practices. These factors foster consumer trust and help prevent discriminatory practices that could arise from biased algorithms. Future research could analyze cases of misguided AI application in advertising to draw conclusions and establish ethical frameworks for creative communication.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# MARKETING IN IT INDUSTRY: AN ANALYSIS OF GRADUATES' COMPETENCIES AND CAREER PATHS

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***Abstract***

*The importance of marketing in the IT industry cannot be overstated, since it helps the identification and fulfilment of customer needs through tailored technological solutions. Well-educated marketing professionals are essential for the IT industry to develop effective communication strategies and foster strong customer relationships for all stakeholders. In order to better prepare graduates for the multidisciplinary problems of the IT industry, this article highlights the need for higher education institutions, particularly those offering business-oriented study programs, to modify their curricula to incorporate both marketing and IT disciplines. Therefore, this study investigates the readiness of marketing graduates for employment in the IT sector by analyzing their employment status, experiences, and skill sets. Through a focus group of the best marketing graduates from the Faculty of Technical Sciences' Engineering Management study program, we evaluate the competencies they possessed upon entering the workforce and identify gaps in their preparation. The results provide insights into the types of roles these graduates occupy, the challenges they encounter, and the additional skills required to succeed in the tech industry. This study provides valuable information for educators and industry professionals to better align business-oriented degree programs that have a marketing module with the demands of the IT industry.*

***Key words:*** *marketing, IT industry, students, employability, competencies, skills.*

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# 1. Introduction

The integration of marketing concepts and courses into IT and engineering higher education is increasingly recognized as essential for preparing graduates for the complexities of the modern job market. This necessity stems from the evolving nature of the workforce, where technical skills alone are insufficient for success. This research indicates that graduates must possess a blend of hard and soft skills, with the latter being particularly critical in fields such as IT and engineering. For instance, emphasize that soft skills significantly enhance employability, suggesting that graduates should actively develop these competencies alongside their technical training (Basir et al., 2022).

The empirical section of this paper presents the findings from a focus group composed of Engineering Management graduates from the Faculty of Technical Sciences. Specifically, the analysis focuses on the competencies and career paths of top-performing graduates from the Engineering Marketing and Multimedia module.

# 2. Theoretical background

The theory highlights the importance of addressing soft skill gaps in the digital employment market, indicating that students often lack the necessary interpersonal skills that are crucial for success in technology-driven environments (Ramos-Monge, 2023). These findings indicate that students lack key soft skills, particularly social intelligence, stress management, and self-awareness, which are crucial for success in both academic and professional settings, as well as for adapting to the digital employment market. The soft skills researchers highlight as most critical for (digital) employability (e.g. Mekala et al., 2020; Qadir et al., 2020) are the same ones students recognize as their weaknesses, based on previous failures (Milić et al., 2023).

Rashid (2003) explored factors influencing employability from employers' perspectives, identifying poor English proficiency, lack of self-confidence, critical thinking, and innovation skills as key barriers. However, Ting et al. (2017) found that employers are still willing to hire graduates with only average English proficiency if they possess strong communication skills, which are shown to enhance employability. Work experience gained through internships and creative enterprise courses significantly enhances graduate employability. This is consistent with earlier studies showing that practical experience improves employability (e.g. Chavan & Carter, 2018).

While academic performance may not be the strongest predictor of graduate employability, it still plays a key role in creating a positive impression on potential employers (Basir et al., 2022).

Moreover, the demand for soft skills in the IT industry is underscored by studies that reveal employers prioritize these attributes when hiring. For example, argue that soft skills have become a crucial determinant of long-term job success, surpassing traditional technical skills (Ramalingam et al., 2021). Subject knowledge

and technical skills are no longer the primary determinants of employability; instead, soft skills are essential for long-term career success. Consequently, Higher Education Institutions (HEIs) globally face pressure to produce graduates with the right skill set for the job market (Ramalingam et al., 2021). This sentiment is echoed by several authors (Finch et al., 2013), who identify problem-solving and communication as key skills that employers assess during the hiring process, reinforcing the need for HEIs to incorporate these elements into their curricula. The integration of marketing principles can further enhance students' understanding of market dynamics, customer relations, and strategic thinking, which are invaluable in the IT sector (Milić et al., 2023). The results of the previous research (Spajić, 2024) which includes the review of curriculum from European IT universities and the practices at Faculty of Technical Sciences align in the view that studying marketing subjects is significant for the career development of future IT engineers.

In terms of employability factors for business students, research consistently highlights the importance of soft skills, including communication, teamwork, and leadership, as essential for securing and maintaining employment (Loday & Drukpa, 2021). This is particularly relevant in the context of the IT industry, where collaboration and effective communication are paramount. Additionally, students' perceptions of their employability are closely linked to their soft skill development, suggesting that educational strategies should focus on enhancing these competencies (Yao & Tuliao, 2019). Furthermore, Fadhil & Ismail (2021) have examined the impact of soft skills on employability in the technology sector, since selecting the best candidates will improve performance and lead to business success. This research revealed that communication, attitude, integrity, learnability, motivation, and teamwork are strongly correlated with employability, making these soft skills crucial for success in Malaysian technology firms. This aligns with the findings that a well-rounded skill set that includes both technical and soft skills is essential for graduates to thrive in the labor market (Hurrell et al., 2012). The emphasis on soft skills is not only a response to employer demands but also a recognition of the changing nature of work, where interpersonal interactions and adaptability are increasingly valued. Connell et al. (2014) have concluded that while ICT competencies are important, they must be complemented by soft skills essential for effective customer interactions and autonomous, flexible work teams, which positively influence job quality outcomes.

In summary, the integration of marketing concepts and soft skills training into IT and engineering higher education is vital for enhancing graduates' employability. The evidence suggests that a curriculum that balances technical knowledge with soft skills development will better prepare students for the challenges of the modern workforce, particularly in the IT industry.

## 3. Research methodology

A survey of one group of IT students at FTS (Milić, et al., 2023) reveals a shift in the perception of soft skills, with students recognizing the importance of non-

technical skills for the industry, while considering their own skills underdeveloped. Secondary research, curriculum reviews from European IT universities, and FTS practice concur that marketing studies are crucial for the career development of future IT engineers (Spajić et al., 2024). To fully understand the student-faculty-business relationship, this research should monitor the performance and satisfaction of FTS graduates in IT companies. IT firms in Novi Sad, Serbia acknowledge the value of marketing, applying branding and positioning strategies, with FTS graduates holding key roles in both IT and marketing sectors (Spajić et al., 2024).

To gain insight into the competencies and career paths of FTS *Engineering Management* students, focus group research was conducted. The participants, all top-performing graduates from the *Engineering Marketing and Multimedia* module, represented various IT companies in Novi Sad with diverse work experience.

Table 1 provides an overview of general information about the respondents who participated in the research.

*Table 1: General information about focus group participants*

| No. | Company name | The name of position | Length of employment in IT | Finding the first job in IT |
|---|---|---|---|---|
| 1 | *Symphony* | Employee Experience Strategist | 2,5 y | During the studies |
| 2 | *Hybrid Digital* | Lead Performance Marketing Manager | 3 y | 3 mo |
| 3 | *ARS Embedded Systems* | Communications manager | 1,5 y | During the studies |
| 4 | *Devoteam* | Marketing Specialist | 7,5 y | 3 mo |
| 5 | *Vega IT* | Lead Marketing Manager | 5 y | 1,5 y |
| 6 | *Continental Automotive Serbia* | Head of Plant Communications | 1 y | 1 mo |
| 7 | *Inviggo* | Marketing manager | 2 y | During the studies |
| 8 | *Solflare* | Office manager/HR associate | 7 y | During the studies |
| 9 | *Schneider Electric* | Employer Branding Associate | 1,5 y | 3 mo |
| 10 | *Valcon* | Social media manager | 0,5 y | 6 mo |
| 11 | *Vega IT* | Marketing manager | 3,5 y | 1 y |

The average employment in the IT industry of respondents is 3.5 years, and the average time they've spent looking for a marketing job in IT industry is 4,18 months, although it can be noted that the third of the respondents found employment during their studies, mostly in the final years of undergraduate and master's studies.

For this research, a questionnaire consisting of two parts was used. The first part focused on the quality of the *Engineering Marketing and Multimedia (EMM)* module, and the second part addressed the overall quality of the study program. The

qualitative and quantitative data from this research provide a solid foundation for further studies. A portion of the results is presented below.

## 4. Research results

The research aimed to assess the alignment between the knowledge and skills acquired in the *EMM* module at EM FTS and the actual demands of the IT industry. It explored which competencies are most applicable in professional roles, identified skill gaps among graduates, and highlighted the top technical and soft skills required for success in IT marketing. The aim was to identify curriculum improvements and additional training needs for graduates entering the workforce.

All respondents emphasized the critical role of soft skills for employment in the IT industry, particularly in marketing roles, and identified the following as the most essential: *Communication, Analytical, Organizational and Leadership skills, Team work, Adaptability and flexibility, Creative thinking, Presentation skills, Critical thinking, Proactivity and self-initiative, Customer relations, Design Thinking, Transparency and integrity, Curiosity and constant improvement*.

The technical skills expected from EM FTS graduates in marketing roles it IT sector are summarized in Table 2.

*Table 2: Review of technical skills of marketing graduates in IT industry*

| **Technical skills** | **The examples of software or tools** |
|---|---|
| **Adobe programs** | Photoshop, Illustrator, Adobe Premiere Pro |
| **Microsoft Office** | Word, Excel, PowerPoint |
| **Digital marketing tools** | Google Analytics, Matomo, SEO tools, E-mail marketing: Mailchimp, Pardot |
| **Project Management software** | Asana, Trello, Jira, Teamwork, Miro |
| **Content Creation tools** | Canva, CapCut. |
| **Social Media Marketing** | Google Ads, Facebook Ads, Meta, Hootsuite, FB Creator Studio, Semrush, Google Tag Manger, Google Analytics, Google Ad Manager, Facebook Ad Manager, LinkedIn Campaign Manager |
| **Content Management Systems** | Umbraco, Salesforce, HubSpot. |
| **G-suite** | Gmail, Google Calendar, Google Tag Manager, Google Drive (Docs, Sheets, Slides…) |
| **Product development technologies** | Flutter, Node.js, React, React Native. |
| **Graphic design** | Figma, Photoshop, Illustrator. |

In addition to the identified skills, respondents highlighted foundational knowledge in IT terminology, English language, copywriting, camera operation, and basic photography as essential, and lead generation as a primary skill.

As a part of this research, the participants in the focus group were asked the following question: How likely is it that you would recommend a colleague with a bachelor/master's degree in Engineering Management, FTS for employment in your (or another) company? This simple question (How likely is it that you would recommend [Organization X/Product Y/Service Z] to a friend or colleague?) measures customer perception and is a widely used metric in customer experience programs that assesses customer loyalty through their likelihood of recommending a business (Qualtrics). It is called Net Promoter Score (NPS) and is measured via a single-question survey, with scores ranging from -100 to +100, where higher scores are preferred. Respondents rate from 0 (not likely) to 10 (extremely likely), placing them into one of three categories to determine the NPS score (Reichheld, 2003):

- **Promoters** (9 or 10 scores) - typically loyal and enthusiastic customers.
- **Passives** (7 or 8 scores) - satisfied with a service but not happy enough to be considered promoters.
- **Detractors** (0 to 6 scores) - unhappy customers, unlikely to buy again and may discourage others from doing so.

According to NPS formula: **NPS = % of Promoters ( — ) % of Detractors**, our research participants are a “world-class promoters” (table 3).

*Table 3: Net Promoter Score for EM FTS-Mktg students*

| NPS categories | Score | % of respondents | Total |
|---|---|---|---|
| Promoters | 10 | 64,3% | **92,9** |
| | 9 | 28,6% | |
| Passives | 8 | 7,1% | 7,1 |
| | 7 | 0% | |
| Detractors | 0 to 6 | 0% | **0** |
| | | | **NPS=92,9%** |

Bain & Company suggests the following scoring framework (Reichheld, 2003): NPS>0 is good, NPS>20 is favorable, NPS>50 is excellent, and NPS>80 is world-class. A major limitation of this result is the small sample size, consisting primarily of respondents generally satisfied with their employment and work environment. This parameter requires ongoing measurement and monitoring, and future research should include a larger group of EM-FTS alumni.

## 5. Discussion and conclusions

The soft skills identified in this research align closely with those found in previous studies reviewed in the theoretical background section. However, during the focus group discussions, participants noted that some important technical skills were lacking upon entering the workforce, requiring additional training in areas

such as lead generation, graphic design, advanced project management tools, and product development technology. Additionally, all participants indicated that foundational knowledge of IT terminology would be beneficial, though it was universally lacking upon entering employment.

To address these gaps, improvements to the *Engineering Marketing and Multimedia* module within the *Engineering Management* program at FTS could involve revising the course structure and enhancing the curriculum. Introducing elective courses in information technology and project management may be an effective response to current trends in the IT industry.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# RELATIONSHIP OF QUALITY, PRICE AND TOILET SOAP CONSUMPTION

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***Abstract***

*The goal of the research was to identify the characteristics of soap according to the criterion of their importance for the consumer, that is, the customer, and to examine the interdependence of quality, price and consumer habits, that is, consumption. The first part of this research included the procurement and laboratory analysis of the quality of commercial soaps for washing hands on the domestic market. The second part of the research was a survey of the population to collect data based on which consumer habits and implicit values that consumers attach to toilet soaps were assessed. Also, the survey included key indicators of the consumer's living standard as an influencing factor in the consumer's decision when choosing any type of product and/or service. The research results show that consumers use liquid soap more often, and they make purchases mainly in consumer goods stores. Factors that show the greatest influence on the customer's decision when choosing soap are the ratio of quantity and price, price and the smell of the product. For the majority of consumers, the fact that the soap is made on a natural basis is of great importance, and about 70% of respondents are ready to spend more money on soap to contribute to the preservation of the environment. The obtained results can serve as a basis for developing a strategy for increasing the participation of this type of product in the market and consequently improving the quality of the manufacturer's business.*

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*Key words: soap, quality, consumer habits, price.*

## 1. Introduction

Globalization and advancements in communication and transportation technology enable consumers to access a wide range of products and services from other countries, leading companies to constantly compete for survival in the market. Increasing competition results in a continuous examination of customer expectations, needs, desires, and brand preferences by retailers (Kalaimahal & Kumaradeepan, 2019), but also complicates consumers' decision-making regarding purchases (Adis et al., 2017).

The consumer's decision to purchase a product depends on numerous factors (Krishnan & Nandhini, 2017), which can be categorized into two groups: internal and external factors. Internal factors are psychological and include personal factors (age and life cycle stage, occupation and economic status, personality and self-image, lifestyle and values) and mental processes (motivation, perception, learning, memory, beliefs, and attitudes). External factors include geographical factors (geographical area, climate, relief, population density, ecology), demographic factors (population size and gender, age structure, marital status and household types, educational and ethnic structure of the population), economic factors (macroeconomic conditions (general economic conditions, growth rate, inflation, unemployment), consumer purchasing power, consumer willingness to spend, consumer spending structure), sociological factors (culture, social factors (roles and statuses, reference groups, family), and situational factors (Aleksić et al., 2012).

In the research by Rizvi et al., (2023), it is noted that factors such as perception, personality, learning, communication, attitude, belief, motivation, culture, family, social class, and promotion influence consumer behavior when purchasing soap. The study by Kumar and Reddy (2017, p. 4362) shows that the reliability of skin soap, freshness, fragrance, hydration effect, packaging, brand, and side effects are the most important factors when buying soap. To attract customers, international soap manufacturing companies primarily focus on six common factors: price, brand reputation, relaxation, all-natural ingredients, fragrance, and good health (Chowdhury, 2015).

The brand holds significant importance and is considered a powerful mental shortcut in purchasing (Shehzad et al., 2014). The decision to buy is largely influenced by the brand name, which should be unique, distinct from other names, easily memorable, and appealing to consumers (Alamgir, 2010). The concept of a brand encompasses the customer's perception and opinion of the performance of a specific product brand (Veljković & Đorđević, 2010) and represents a combination of names, symbols, and designs. A brand influences the creation of trust, conviction, and consistency among customers, generating a sense of security in the purchasing process (Gundarapu, 2020). If customers believe in the quality of a brand, it provides

them with a reason to become loyal to that brand (Alamgir, 2010). Research shows that consumers generally prefer to purchase branded soaps (Katiyar & Katiyar, 2014).

Consumer interest in purchasing products, specifically bath soap, is influenced by both the characteristics of the soap and the packaging of the product (Tjahyanti, 2014). The main message of the packaging focuses on attracting consumers' attention through symbols, logos, and text that are visually appealing (Assali, 2016). As noted in the research, the color of the packaging and the background image significantly impact consumer behavior when buying soap (Akhter & Nur-al-ahad, 2021).

Product quality is defined as the ability of a product to perform its functions while also satisfying the needs or desires of consumers (Nadhifah & Adinugraha, 2020). The quality of soap is assessed based on its non-irritating effects on the skin and the effectiveness of cleaning, determined by physicochemical characteristics such as the content and type of surfactants, sodium chloride content, other additives, and pH value (in liquid soaps). For solid soaps, the most important characteristics include total fatty matter, free alkalis, total alkalis, moisture content, pH, as well as factors like the strength and purity of the alkalis used, the type of oils/fats, and the completeness of the saponification reaction (Mwanza & Zombe, 2020). Many consumers consider price as an indicator of product quality. Price represents the monetary value of goods, and there are two categories: objective or actual price and perceived price, which reflects an individual's belief about how much an item costs based on its quality (Mashao & Sukdeo, 2018).

Soaps are cosmetic products used to maintain skin health and hygiene by removing layers of dead cells present on the human body's skin (Fazal-ur-Rehman & Akram, 2018). It is estimated that simple handwashing and maintaining hand hygiene leads to a reduction in the incidence of infectious diseases, saving millions of lives each year (Ahuja & Patil, 2017). For hygiene purposes, both solid (bar) soaps and liquid soaps are used today. Due to easier dosing and quicker dissolution compared to solid soaps, liquid soap formulations are gaining increasing popularity.

Solid soaps are defined as alkaline salts of higher fatty acids that are soluble in water (Habib et al., 2016). They are formed by the degradation of fats, i.e., esters of higher fatty acids, through the action of alkalis, resulting in the release of glycerol. This process of soap formation is known as saponification (Arasaretnam & Venujah, 2019). The cleaning ability of soaps is attributed to their specific molecular structure, consisting of hydrocarbon chains (hydrophobic part) attached to a carboxyl group (hydrophilic part). The removal of dirt from clothing and human skin is caused by the hydrocarbon chain's affinity to dissolve grease (dirt) and the carboxyl groups ability to dissolve in water (Adane, 2020). Several factors influence the chemical characteristics of soap: the type and purity of the alkalis, the type of oil used, the completeness of the saponification reaction, and the age of the soap (Betsy et al., 2013).

Liquid soaps are washing agents based on synthetic surfactants (tensides) and auxiliary components. The main ingredients of liquid soaps are surfactants,

particularly anionic types (sodium laureth sulfate, sodium lauryl sulfate, and other sulfates) (Bratovcic et al., 2018). This type of hand soap is preferred over solid soap because it is more convenient to use and helps maintain hygiene by preventing the spread of germs from one person to another (Widyaningsih et al., 2018). Additionally, solid soap is intolerant to hard water and forms scum with calcium and magnesium ions (Awang et al., 2001).

The aim of this research is to analyze consumer habits regarding soap purchases, to be determined which factors most influence the decision to buy soap and to examine the relationship between price and quality, where quality will be assessed by determining the physicochemical composition of commercial soaps available in the domestic market.

### 1.1 Materials and methods

The experimental part of the work consisted of two parts. The first part refers to the procurement and laboratory analysis of soaps purchased in commercial markets from the territory of Bosnia and Herzegovina. The second part of the experiment consists in surveying respondents and processing the survey, which contains opinions on consumer habits related to the analyzed soap samples. A total of 200 respondents were surveyed, 100 of them live and 100 online via Google Forms. Most questions are designed so that respondents cross out their answers. Some of questions were designed so the respondents expressed their answers through ratings from 1 to 5, where 1 represents the least and 5 the highest degree of agreement with the stated predication.

15 different soap samples were analyzed, of which 10 were solid and 5 were liquid soaps (Table 1). The samples were assigned labels, shown in Table 1. The same table indicate the soap's price and the quantity of the product marked on the package. Table 2 lists the tested characteristics of the soaps.

*Table 1. Soap samples*

| Sample mark | Amount of soap indicated on the package | Price of soap on the market (BAM) | Price of soap (BAM/kg) |
|---|---|---|---|
| 1s | 100 g | 1.00 | 10.00 |
| 2s | 100 g | 1.50 | 15.00 |
| 3s | 87 g | 1.45 | 16.67 |
| 4s | 75 g | 1.05 | 14.00 |
| 5s | 75±2 g | 2.20 | 29.33 |
| 6s | 120 g | 2.45 | 20.42 |
| 7s | 90 g | 0.70 | 7.78 |
| 8s | 75 g | 1.70 | 22.67 |
| 9s | 100 g | 1.15 | 11.50 |
| 10s | 100±10 g | 8.20 | 82.00 |
| 1l | 500 mL | 4.35 | 8.09 |
| 2l | 400 mL | 1.65 | 3.99 |

| Sample mark | Amount of soap indicated on the package | Price of soap on the market (BAM) | Price of soap (BAM/kg) |
|---|---|---|---|
| 3l | 500 mL | 1.00 | 1.95 |
| 4l | 500 mL | 0.95 | 1.93 |
| 5l | 1000 mL | 1.65 | 1.56 |

*Table 2. Tested characteristics of soap samples*

| Characteristics of solid soaps | Characteristics of liquid soaps |
|---|---|
| total alkali (%) | density (g/cm$^3$) at 20 °C |
| free alkali (%) | NaCl (%) |
| fatty acid (%) | total surfactant (%) |
| NaCl (%) | anionic active matter (%) |
| moisture (%) | pH |
| pH | |

## 2. Results

The results are presented tabularly and graphically, via diagrams. Table 3 and table 4 show the results of the physicochemical analysis of the tested samples.

### 2.1 Results of physicochemical analysis of soaps

*Table 3. Results of physicochemical analysis of solid soaps*

| Sample mark | Total alkali (%) | Free alkali (%) | Fatty acid (%) | NaCl (%) | Moisture (%) | pH |
|---|---|---|---|---|---|---|
| 1s | 1.80 | 0.00 | 38.15 | 0.49 | 4.85 | 7.70 |
| 2s | 11.97 | 0.00 | 57.51 | 0.35 | 8.98 | 11.35 |
| 3s | 11.70 | 0.03 | 79.39 | 0.41 | 5.09 | 11.40 |
| 4s | 11.47 | 0.00 | 78.30 | 0.73 | 7.22 | 11.10 |
| 5s | 10.86 | 0.05 | 68.98 | 0.00 | 5.43 | 11.20 |
| 6s | 7.44 | 0.00 | 39.06 | 0.00 | 18.62 | 10.80 |
| 7s | 11.66 | 0.04 | 76.96 | 0.47 | 9.71 | 11.10 |
| 8s | 11.71 | 0.00 | 77.02 | 0.44 | 4.75 | 11.00 |
| 9s | 11.72 | 0.00 | 76.10 | 0.44 | 5.67 | 10.70 |
| 10s | 9.67 | 0.00 | 76.64 | 0.00 | 8.89 | 10.80 |

*Table 4. Results of physicochemical analysis of liquid soaps*

| Sample mark | Density (g/cm3) | Total surfactants (%) | Anionic surfactants (%) | NaCl (%) | Moisture (%) | pH |
|---|---|---|---|---|---|---|
| 1l | 1.075 | 10.74 | 4.55 | 0.88 | 88.39 | 3.80 |
| 2l | 1.035 | 9.01 | 4.47 | 1.92 | 89.08 | 6.91 |
| 3l | 1.025 | 6.33 | 3.58 | 2.23 | 91.45 | 6.66 |
| 4l | 0.985 | 6.08 | 3.15 | 1.88 | 92.04 | 7.40 |
| 5l | 1.060 | 3.44 | 3.56 | 5.65 | 90.91 | 5.45 |

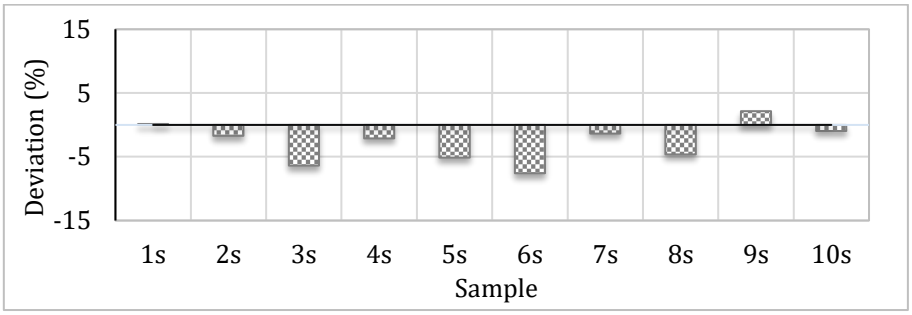



*Figure 1. Deviation of soap mass from the declared value*

## 2.2 Results of the population survey

The results of the respondent's survey on consumer habits related to soap are presented in tabular (Tables 5 and 6) and graphical form (Figure 2-4).

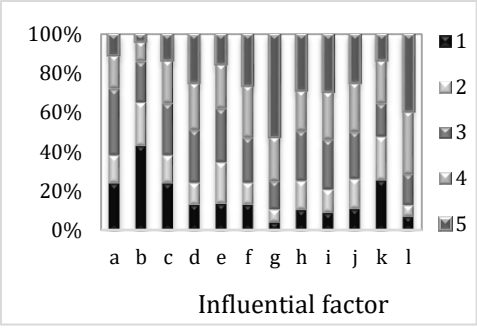
*Table 5. The results of the respondent's survey*

| *Age of the respondents* | % | | *Level of education* | % |
|---|---|---|---|---|
| 18-24 | 19.6 | | high school (3 years) | 9.8 |
| 25-34 | 27.0 | | high school (4 years) | 33.7 |
| 35-44 | 16.6 | | tertiary education | 3.1 |
| 45-54 | 21.5 | | bachelor | 29.5 |
| 55-64 | 12.9 | | master | 11.0 |
| 65 and over | 2.4 | | doctorate | 12.9 |
| *Monthly household income* | % | | *Number of members in the household* | % |
| do 500 BAM | 3.1 | | 1 | 6.8 |
| 500-999 BAM | 16.5 | | 2 | 22.0 |
| 1000-1499 BAM | 17.8 | | 3 | 23.3 |
| 1500-1999 BAM | 25.1 | | 4 | 34.4 |
| 2000-2499 BAM | 16.6 | | 5 | 7.4 |
| 2500 BAM and more | 20.9 | | 6 and more | 6.1 |

*Table 6. Survey results*

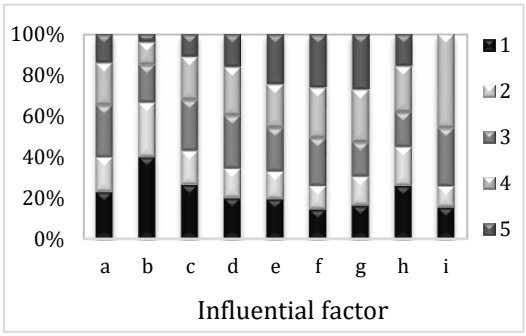
| Which toilet soap do you buy more often? | **%** |
|---|---|
| Solid | 62 |
| Liquid | 38 |
| Where do you buy toilet soap? | **%** |
| In consumer goods stores | 91.5 |
| In specialized sales facilities | 8.5 |
| Do you pay attention to the origin of the product? | **%** |
| Yes | 49.5 |
| No | 50.5 |

| Do you prefer a domestic product? | % |
|---|---|
| Yes | 56.5 |
| No | 43.5 |
| Are you ready to buy more expensive toilet soap just because you will contribute to preserving the environment? | % |
| Yes | 69 |
| No | 31 |
| Do you buy and use the same soap for a long time? | % |
| Yes | 72.5 |
| No | 27.5 |
| Do you know a domestic soap manufacturer or brand? | % |
| No | 43 |
| Hellena | 37 |
| Violeta | 4 |
| Dr Pasha | 4 |
| Other | 2 |
| Answered incorrectly | 10 |




a-brand;
b-TV advertising or other forms of advertising;
c-nice packaging
d-functionality and design of the bottle and cap;
e- appearance and color of content;
f- package size;
g-you analyze the price/quantity ratio;
h-current price action;
i-the price of soap;
j- the sign that the soap is made on a natural basis;
k-I pay more attention to reading the declaration on the packaging;
l-perfume

*Figure 2. The influence of various factors on the decision to buy liquid soap*




a-brand;
b-TV advertising or other forms of advertising;
c- nice packaging;
d-soap size; e-current price action;
f- the price of soap;
g- the sign that the soap is made on a natural basis;
h-I pay more attention to reading the declaration on the packaging;
i- perfume

*Figure 3. The influence of various factors on the decision to buy solid soap*

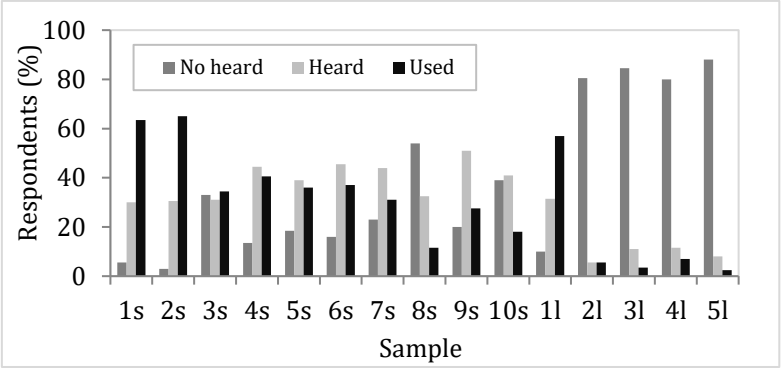



*Figure 4. Have you heard or used the mentioned soap?*

## 3. Discussion

Article 28 of the Regulation on the Safety of Consumer Products, enacted by the Ministry of Health and Social Welfare of the Republic of Srpska in 2015, defines that cosmetic products that are removed from the skin or hair after a short period must have a pH value ranging from 3 to 12. Considering this provision, it can be noted that all samples meet this quality parameter. The experimentally determined pH values of the solid soap samples fall within the basic range, specifically between pH 8.5 and 11.0 (Mijaljica et al., 2022). An exception is sample 1s, which falls into the category of so-called Syndets, representing a mixture of synthetic surfactants (Paudel et al., 2022). Given that the physiological acidity of the skin corresponds to

a pH value of 5.5, it can be said that liquid soaps act less aggressively on human skin, as they are mildly acidic to neutral.

After completing the saponification process using the hot method to obtain solid soaps, sodium chloride is added to isolate or precipitate the soap from the soap solution. Although most of the salt is removed, a certain amount of sodium chloride remains in the final products, as indicated by the test results (up to 0.73% NaCl). In the cold process of soap production, sodium chloride is not added for isolation, which is reflected in the absence of chlorides in handmade soaps (Table 3).

Unlike solid soaps, sodium chloride is added to liquid soaps to increase viscosity and reduce the cost of these formulations, and the thickening effect depends on the concentration of the present surfactants. The sodium chloride content in liquid soap samples varies. The lowest sodium chloride content is found in sample 1l, while the highest is determined in product 5l. The sodium chloride content is appropriately correlated with the content of anionic surfactants. Specifically, the content of anionic surfactants is generally inversely proportional to the sodium chloride content. The content of active ingredients in these products, i.e., anionic surfactants, is not defined by the Regulation. However, a certain minimal content is necessary to fulfill the basic function of these products, which depends on the type of active substance and the content of other components, and this is defined by each manufacturer during the development phase.

The moisture content in solid toilet soaps ranges from 4.75% to 18.62%. In liquid soaps, water is the main filler, present in the highest concentration, and in these tested samples, its content is greater than 88%.

Under real conditions, the saponification reaction is not complete, so alkaline substances that have not chemically bonded to triglycerides (unbound, free) are often present in final products even after their removal. Free alkalis prevent the soap from leaving a greasy residue and can cause a feeling of itchiness on the skin (Habib et al., 2016). They are particularly undesirable in soaps for kids; however, sample 3s, which is a soap for kids, shows the presence of free alkalis at 0.031 %w/w.

Since the content of fatty acids is a crucial characteristic of soap quality, a higher fatty acid content in soaps results in products that are more suitable for dry skin. A fatty acid content above 80% is particularly beneficial for dry skin, making it moist and smooth (Arasaretnam & Venujah, 2019). Sample 6s is a glycerin soap and has a lower fatty acid content due to the presence of glycerol, which contributes to the overall mass of the sample.

Before determining the chemical characteristics of solid soaps, the consistency of the information about the soaps weight showen on the product packaging was examined against the weight obtained by weighing on a digital scale in the laboratory (Figure 1). Over time, soaps can lose weight while in storage due to the evaporation of water and other volatile components they contain. Soaps that include volatile substances as components will have lower quality, as these components can easily evaporate and lead to a reduction in quality (Arasaretnam & Venujah, 2019). It can be observed that 8 out of a total of 10 soap samples show a

negative deviation, meaning they have a lower weight than indicated on the packaging. This suggests that purchasing solid soaps in a store results in receiving less product than the customer believes they are getting.

If the costs are expressed in BAM/kg, it can be observed that solid soaps are more expensive than liquid soaps, which correlates with the content of active ingredients. Specifically, liquid soaps have a much lower content of active matter, and a significantly higher water content (over 88%) compared to solid soaps. The price of the soap sample marked as 10s is more than 80 BAM/kg, which is 52 times higher than the price of the cheapest soap tested. Considering that an average use consumes about 0.7 g of solid soap and about 1.8 g of liquid soap, it can be stated that liquid soaps last longer, as evidenced by the range of doses (230-590 uses), while the range for solid soaps is lower (110-170 uses). Examining the prices of liquid soaps and the content of total active ingredients, a certain correlation can be observed: as the content of active substances increases, so does the price of the soap.

Samples 5s, 6s, 8s, and 10s are handmade soaps intended for washing the face and hands, and they are priced higher compared to most samples, which can be partly justified by presence of natural ingredients. Goat milk in sample 5s is rich in vitamins and minerals that nourish the skin and contains lactic acid and alpha hydroxy acids, which effectively remove impurities and dead skin cells off the face. Glycerin in sample 6s provides more moisture than regular toilet soaps and ensures high hydration for the skin. Sample 8s is formulated with activated charcoal, a component known for its adsorbing and antibacterial properties, contributing to more effective removal of impurities and excess sebum, as well as improving the overall condition of the skin. Sample 7s, an antibacterial hand soap, helps prevent the spread of infectious diseases that can be transmitted by dirty hands.

Out of a total of 200 respondents, the largest group is those aged between 25 and 34 years, representing 27%. This is followed by respondents aged 45 to 54 years (21.5%), 18 to 24 years (19.6%), 35 to 44 years (16.6%), and 55 to 64 years (12.9%). The smallest group consists of respondents over 65 years old (2.4%). Depending on age, a persons attitude toward a particular soap may vary.

The survey results showed that 62.5% of respondents live in households with incomes less than 2000 BAM, and the main influencing factor on soap purchases was the consideration of the quantity-to-price ratio. This confirms that household income affects consumption patterns and that consumers with lower incomes tend to choose more affordable products (Štulec et al., 2017).

Of the total number of respondents, 56.5% have completed at least higher education, indicating that the respondents are predominantly highly educated. On the other hand, about 50% of those surveyed pay attention to the ingredients listed on the soap packaging. This suggests that a person's level of education also influences their decision-making process when making purchases. A well-educated person can analyze the ingredients listed on the soap packaging, whereas a less educated person may struggle to do so due to a lack of knowledge (Wijesundera & Abeysekera, 2010).

The research results show that consumers more frequently use liquid soaps, which is also noted in other studies (Klimaszewska et al., 2022). They tend to make purchases in general retail outlets, while a very small percentage of respondents buy soap in specialized stores.

Almost half of the respondents do not pay attention to the origin of the soap when making a purchase, as evidenced by the fact that 43% could not name a single manufacturer or soap brand produced in Bosnia and Herzegovina (Figure 2). Of the remaining 57%, 10% of respondents mentioned soap names or manufacturers that are produced outside of Bosnia and Herzegovina. The most recognized domestic soap brand is Hellena (37%), while the brands Violeta, Dr Pasha, Dita, Mystery, and Alpino are less known to respondents (a total of 8%).

More than half than half of the respondents prefer domestic products when making purchases, which contrasts with research indicating that consumers in developed countries tend to prefer domestic products over foreign ones. In contrast, consumers in developing countries show a greater preference for foreign products compared to domestic ones (Kalaimahal & Kumaradeepan, 2019).

Most respondents (73%) tend to purchase and use the same soap for an extended period, indicating trust and brand loyalty that develops over time. Brand loyalty among toilet soap users in Dhaka is moderately high, with 63% of consumers being loyal to a particular brand (Mahmud & Gope, 2012). One of the most important factors influencing soap brand loyalty includes product characteristics such as scent, skin care benefits, and antimicrobial properties, although availability of the toilet soap also has a significant impact (Shanmugapriya & Sethuraman, 2014). Consumers in Bosnia and Herzegovina primarily consider the quantity-to-price ratio, current sales promotions, and scent when purchasing solid soap. The PCA analysis in the study indicates that customers particularly focus on price (Chowdhury, 2015). The diagrams (Figures 3 and 4) show that all off the mentioned factors have varying degrees of influence on the consumer's purchasing decision regarding soap.

TV advertising, along with other forms of advertising, contributes the least to the decision-making process regarding soap purchases among all examined parameters, which is also shown in other studies (Mahmud & Gope, 2012).

Current trends indicate an increasing demand for the use of natural ingredients in personal care and cosmetic products (Vidal et al., 2018), which has proven to be a very important and influential factor in soap purchases in our research as well. This study aligns with results showing that around 70% of respondents are willing to spend more on soap if it contributes to environmental protection, also a finding supported by other studies (Klimaszewska et al., 2022).

In general, respondents are much less familiar with the examined liquid soaps, and considering that liquid soaps are purchased more frequently, it can be concluded that consumers use other liquid soaps that are not covered in this research. The liquid soap sample 1t is an American multinational brand that is, by far, the most used among all other liquid soaps examined, ranking alongside the two solid soap brands, 1s and 2s. Brand recognition, as a significant dimension,

contributes to the increased value created for consumers (Veljković, 2010). The survival of a brand in the market primarily depends on consumers, who serve as the ultimate measure of brand value. However, the survey results regarding the influence of various factors on soap purchasing decisions showed that brand has a limited impact. On the other hand, the most recognizable global brands are the most frequently purchased soaps. This indicates that respondents may not have a sufficient understanding of the concept of branding.

## 4. Conclusions

The research results showed that consumers use liquid soaps (62%) more often than solid soaps (38%). Most consumers are loyal to a particular soap, and a large percentage of consumers pay attention to the origin of the product (49.5%) and give preference to soaps produced in Bosnia and Herzegovina (56.5%). The toilet soaps that are bought the most are world-renowned products, which shows that the brand still has a great influence on the purchase of soap. Toilet soaps with a recognizable name are generally defined by the highest content of active substances and a higher price, which indicates a great interaction between price and quality. When buying toilet soap, customers consider the ratio of quantity and price, immediate action and the smell of the product the most. For the majority of consumers, the mark that the soap is made on a natural basis is of great importance when buying soap, which is in agreement with the results indicating that about 70% of respondents are ready to spend more money on soap if it will contribute to the preservation of the environment.

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# THE IMPORTANCE OF GRAPHIC DESIGN IN PLANNING URBAN GREEN SPACE

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***Abstract***
*The rapid growth of cities and the modern concept of economy impact the urbanization process. Furthermore, urbanization has created negative consequences in urban green space and requires new solutions for urban planning. For urban planners, the planning and maintenance of urban green space must become an emphasis in the master plan. What new perspectives can graphic representation contribute to the design of urban green space in the master plan? This paper provides answers by researching how statistical analysis can affect master plan reformation to maintain and improve urban green space. In this paper, we study this topic through the applied R software environment for statistical computing and graphics. Based on the result, we suggest a tool for urban planners to improve green spaces using statistical analysis with graphic representation in master plans.*

***Key words:*** *statistical analysis, graphic design, urban green space, master plan*

## Introduction

The rapid growth of our cities and modern concepts are affecting city planning. Furthermore, urbanization in the 21st century has led to negative consequences for urban ecosystems, and natural resource solutions for the future development of cities are required. According to goal 11 of the 2030 Agenda for Sustainable Development, adopted by the United Nations in 2015, global development requires sustainable city and community planning strategies. Moreover, strategies should incorporate new criteria for promoting growth and enhancing the quality of urban green spaces in urban areas. In 2020, Judy Bush published an article: The Role of Local Government Greening Policies in the Transition towards Nature-based Cities, which defined the role of city authorities

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in increasing initiatives for the development of urban green spaces in planning. New approaches involve combining strategic planning with innovative design and active community involvement (Bush, 2020).

Planning is one of the elements in the growth of urban green spaces. The most powerful tool available to planners is land use (Campbell, 2018). According to Campbell, the role of urban planners is to promote the essential vision of sustainable development. Green areas are fundamental for sustainable cities and communities (Kvartnik-Pruc and Trembecka, 2021). Through research, the authors identified that the domains of land use policy are not coherent with the green space policy. In the post-socialist sustainable transition, land policy has a significant role in the post-socialist transformation (Vujošević & Petovar, 2006). Post-socialist crises reflect in the chaotic urban development, resulting in the weakness of the state as a central entity and, on the other hand, the arbitrariness of management in market conditions (Stanilov, 2007). Furthermore, urban planners focus on land-use-oriented planning that supports market-oriented issues (Nedović-Budić, 2001).

Urban planners "need to redefine their role from reactive guardians who serve the interests of the political and economic elite to active defenders of public interests." Stanilov (2007, p. 424). The presence and quality of green spaces in cities (Bocconcino & Vozzola, 2022), understanding and measuring urban dwellers view-based exposure to greenery (Yu, Yu, Song, Wu, Zhou, Huang & Mao, 2016) are at the center of the urban planning policies. Graphic representations can help urban planners understand the dynamics of change in the planning area and trends that are likely to influence the success of the proposed development and identify balance competing demands and pressures (Meeda, Parkyn & Walton, 2007).

### 1.1 Methods

Belgrade has been chosen as a post-socialist city in the former Yugoslavia for a study focusing on changes in urban green spaces within master plans. We examined changes in the physical environment by analyzing population, housing, built-up, and green spaces. Using the R software environment for statistical computing and graphics in master plans, we demonstrate change, correlation, and interaction of urban parameters. Correlation tests help to evaluate the correlation between population growth and housing growth and between population and green space growth. Another, using multiple regression tests, we analyze the built- up and green space growth. On the other hand, we test the interaction between green growths per population in existing/newly planned urban environments. The data was collected from the Republic Institute of Statistics, local databases such as the Belgrade City Administration, and the Urban Planning Institute of Belgrade.

## Results

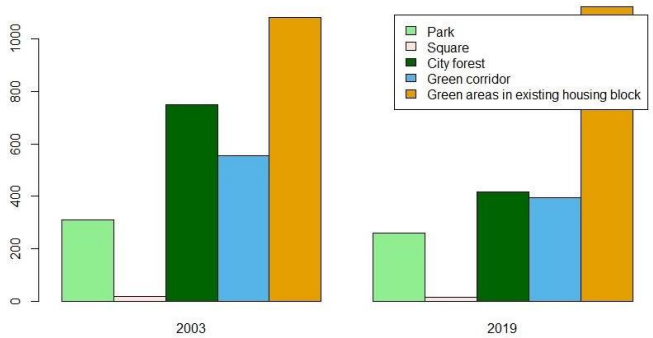


*Figure 1: Graphic presentation of urban green space in master plan*

Figure 1 illustrates the changing urban green area from 2003 to 2019, showing a significant decrease in city forests, green corridors, and parks. In the case of the presence of forests and public green spaces, in further planning elaboration than the established norms, they must be preserved as a fixed element of the green system of the city. Based on the data collected from the Master Plan of Belgrade (Official Gazette of the City of Belgrade, 27/03, 11/2016, 20/16, 110/2019), a graph clearly shows the decrease in urban green areas.

According to the Master Plan of Belgrade (Official Gazette of the City of Belgrade, 20/16), urban planners defined the highest percentage of housing. Due to specific parameters, we conducted a correlation test to examine the relationship between population growth and housing growth using data collected by the Statistical Office of the Republic of Serbia.

*Table 1: Data on population and housing growth rate*

| | **Population growth rate (%)** | **Housing growth rate (%)** |
|---|---|---|
| **2012** | 0.49 | -17.49 |
| **2013** | 0.48 | -11.28 |
| **2014** | 0.48 | -17.83 |
| **2015** | 0.48 | -7.13 |
| **2016** | 0.48 | 9.95 |
| **2017** | 0.48 | 24.25 |
| **2018** | 0.48 | 28.20 |
| **2019** | 0.31 | 37.40 |

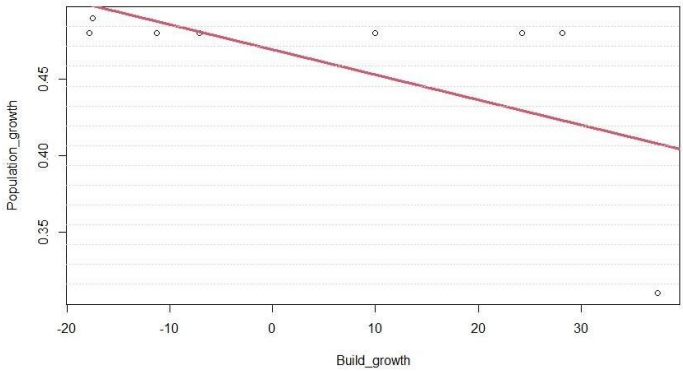


*Figure 2: Simulation results of population growth and housing growth*

Based on the result of the correlation test (t: -1.8256, df=6, p-value: 0.1177, cor=-0.5975933), in Figure 2, we identify a negative linear relationship between population growth and housing growth. However, population growth does not follow the housing growth.

In the next step, we conduct multiple regression tests to analyze the growth of built-up areas, green spaces, and open spaces. Additionally, we are examining the interaction between green space growth and population in existing/newly planned urban environments.

Based on the result of the multiple regression test (Multiple R-squared: 0.975; Adjusted R-squared: 0.9249; F-statistic: 19.48 on 2 and 1 DF, p-value: 0.1582), in Figure 3 and Figure 4, we identify a negative linear relationship between population growth and existing/new development green growth using data collected by the Statistical Office of the Republic of Serbia and Master Plan of Belgrade (Official Gazette of the City of Belgrade, 27/03, 11/2016, 20/16, 110/2019).

*Table 2: Data on urban green space in master plan*

| | **Green index- existing (%)** | **Green index- planned (%)** |
|---|---|---|
| **2001** | 14.65 | 26.30 |
| **2010** | 13.02 | 26.30 |
| **2016** | 12.65 | 17.81 |
| **2019** | 12.38 | 22.74 |

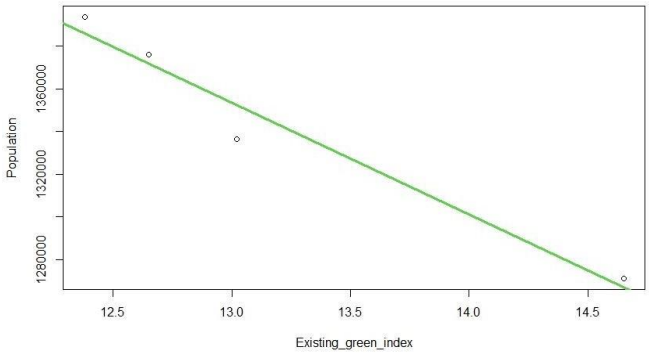


*Figure 3: Simulation results of population growth and existing green space growth*

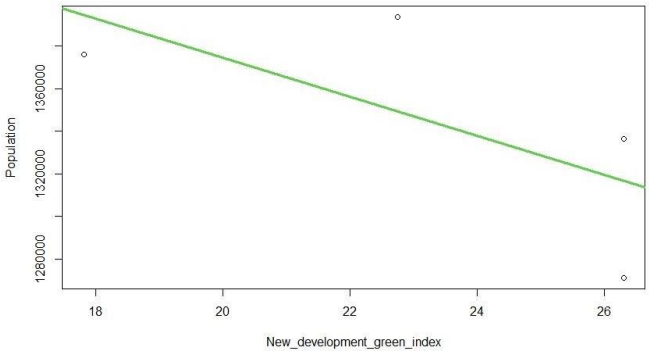


*Figure 4: Simulation results of population growth and new planned green space growth*

## Discussion

As mentioned above, urban green spaces are of fundamental value in new urban planning to find a new balance within the built city. As evidence, the concept of sustainability needs to link and balance the skills of urban planners. Urban planners need a new tool in urban planning, which means the balance between the built and green structures. Due to green-based planning, the green area is integrated into the urban structure using innovative technological solutions, which can be classified and analyzed using various databases.

One of the most evident results noticed during the analysis of build form and green spaces defined in master plans was how the graph changed in typologies of urban green space (Figure 1). According to the urban parameters in the master plan, urban planners define the parameter of green spaces related to the block or plot as not to populations. As a result, population growth does not follow housing growth (Figure 2), and green space growth is incoherent with population growth in the new master plan (Figure 4).

Comparing data from one plan to another was difficult given that there is no continuity in planning, and differences and inconsistencies in defining the typology of urban green spaces are evident between plans. According to statistical data, one of the main problems identified was the low availability of urban green data resources. Data is kept in many places in the city administration, and there is no necessary continuity in monitoring, systematizing, and classifying data.

## Conclusion

The land policy has a significant role in the urban planning. We can see that land-use policy is separate from green policies and built planning from green planning. Urban planners need a new tool to understand city development, an integrated approach to green space planning to balance built cities, and combine techniques and skills to balance built and green planning issues.

Our analysis involves the importance of using the R software environment for statistical computing and graphics in master plans. Data visualization can demonstrate the dynamics of change in the planning area and trends that are likely to influence the success of the proposed development and identify balance competing demands and pressures.

In conclusion, we have proposed an integrated tool for green-based planning using an R software environment for statistical analysis of population, housing, built-up, and green spaces in the master plan. Central themes are interoperability between information modeling environments and data organization in relational databases. With the new tool, urban planners can utilize data visualization to create a sustainable and green city.

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# ENHANCING CUSTOMER JOURNEY THROUGH PROCESS MINING: A LITERATURE REVIEW AND FUTURE RESEARCH DIRECTIONS

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***Abstract***

*Providing an exceptional customer experience has become a primary goal in modern business, with best-practice companies setting strategic objectives for designing and enhancing the customer journey. The customer journey approach has been applied for many years in service design to create a cohesive customer experience across all touchpoints. Advances in technology and the emergence of innovative channels have enabled companies to collect large amounts of data about customer experiences, creating an opportunity to align service design with data science to gain valuable insights. Process mining, a discipline of data science, has shown to be effective in analysing and improving business processes, with the customer journey emerging as a new area for its application. This paper aims to critically review the literature on the application of process mining to enhance the customer journey and highlight future research directions in this field. The literature search was conducted in the Scopus database using the terms "customer journey" and "process mining". Through systematic analysis, studies were selected that developed new methods for applying process mining in the customer journey and applied process mining techniques to real data sets. The research shows that, despite growing academic interest, the literature on applying process mining to the customer journey remains limited, and a unified data-driven method for analysing and mapping the customer journey is lacking. The study highlights the evident convergence between qualitative methods from service design and process mining techniques but also emphasizes the need for further research to develop an integrative approach.*

***Key words:*** *Customer Experience, Customer Journey, Service Design, Data Science, Process Mining*

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## Introduction

Customer experience has become a leading business goal for most companies (Lemon and Verhoef, 2016). According to research by HBR Analytic Services, nearly three-quarters of surveyed business leaders believe that delivering relevant and reliable customer experiences is crucial to their company's overall performance, with nearly everyone considering it important in two years (HBR Analytic Services, 2017). Providing exceptional customer experiences across multiple channels and touchpoints has become critical for gaining a competitive advantage (Becker and Jaakkola, 2020; McColl-Kennedy et al., 2019). Additionally, customer experience has gained significant prominence in research across various academic disciplines, particularly in marketing, service management, and service design. The number of published academic papers on customer experience has significantly increased in recent years (Lipkin, 2016; De Keyser et al., 2020; Becker and Jaakkola, 2020; Gallardo-Garcia, 2023).

In the literature, the concept of customer experience is defined in various ways, meaning there is no single, universally accepted definition. Meyer and Schwager (2007, p. 2) describe customer experience as "the internal and subjective response customers have to any direct or indirect contact with a company". Brakus et al. (2009, p. 53) conceptualize brand experience "as subjective, internal consumer responses (sensations, feelings, and cognitions) and behavioural responses evoked by brand-related stimuli that are part of a brand's design and identity, packaging, communications, and environments". Lemon and Verhoef (2016, p. 71) define customer experience as "a multidimensional construct focusing on a customer's cognitive, emotional, behavioural, sensorial, and social responses to a firm's offerings during the customer's entire purchase journey." Becker and Jaakkola (2020, p. 9) conceptualize customer experience as "nondeliberate, spontaneous responses and reactions to offering-related stimuli along the customer journey."

Based on these definitions, we can conclude that the concept of customer experience encompasses the cognitive, affective, physical, sensory, and social reactions of customers to the offer or company, and is intrinsically linked to the concept of the customer journey. Understanding the customer journey has become a primary focus for organizations aiming to improve customer experience and enhance their business operations (Følstad and Kvale, 2018), with companies practising best-in-class approaches having clearly defined strategic goals for designing and improving the customer journey (Homburg, Jozic and Kuehnl, 2017).

The customer journey perspective has long been acknowledged as essential in the practices of leading service design agencies (Kimbell, 2011) and has also been featured in influential books in this field (Stickdorn and Schneider, 2012; Polaine et al., 2013; Stickdorn et al., 2018). According to Stickdorn et al. (2018, p. 26-27), service design is defined as "a human-centered, collaborative, interdisciplinary, iterative approach which uses research, prototyping, and a set of easily understood activities and visualization tools to create and orchestrate experiences that meet the needs of the business, the user, and other stakeholders." Service design employs

various visual and qualitative methods to explore, analyse, and design the customer journey.

The advancement of information technologies has enabled companies to collect vast amounts of data regarding customer experience through their channels, representing a significant opportunity for improving the customer journey. However, it also presents a challenge in transforming this data into actionable insights that benefit both the company and its customers. At this point, data science and service design intersect, as data science plays a crucial role in uncovering patterns within data through a quantitative approach (Kunneman, Alves da Motta-Filho, van der Waa, 2022). Various data science disciplines can be applied in service design, including process mining, which the literature recognizes as having significant potential in customer journey analysis (Aalst, W. van der, 2016; Bernard and Andritsos, 2017; Terragni and Hassani, 2018; Reinkemeyer, 2022; Halvorsrud et al., 2024). Despite the growing recognition of the importance of applying process mining to customer journey analysis, existing literature bridging these two domains remains limited.

The scientific contribution of this paper is to bridge the disciplines of process mining and service design through a critical literature review on the application of process mining methods in customer journey analysis and to identify future research directions in the application of quantitative methods in this field.

The paper is organized as follows. In the first section, we will explore the concept of the customer journey in the literature, analysing different definitions and approaches in customer journey analysis and design. In the second section, we will explore process mining methods and review existing research on the application of process mining in customer journey analysis. In the final section, we will propose future research directions that could contribute to an enhanced application of process mining in customer journey analysis.

## 2. Methodology

In conducting a comprehensive review of the literature on the application of process mining within customer journey analysis, we utilized the Scopus scientific database. In the database search, we used a combination of the terms “Customer Journey” AND “Process Mining” within the title, abstract, and keywords. Based on the specified criteria, 39 titles were retrieved. In the next step, a detailed analysis was conducted to select papers that focus on the application of process mining in the field of customer journey while eliminating those unrelated to this area. The papers selected for further analysis are those in which a new method for process mining in customer journey analysis was developed, or where a specific method was applied to a real dataset related to customer journeys in a particular industry. The limitation of this method lies in the possibility that there may be papers that similarly address the application of data science methods in processes related to customers. However, this research focuses on the terms “customer journey” and “process mining”, as these terms have been widely used in literature and practice

for a considerable amount of time. The review of the selected papers is presented chronologically to identify the research progress in this field.

# 3. Customer journey

## 3.1 Defining the customer journey

Despite significant scientific interest in customer experience and journey, there is no universally accepted definition of the customer journey in the literature, nor is there consistent terminology. Based on their research, Zomerdijk and Voss (2010, p. 74) outline that "companies often referred to a series of touchpoints as the customer journey. The customer journey involves all activities and events related to the delivery of a service from the customer's perspective". Patrício et al. (2011, p. 182) describe the customer journey as "a series of touchpoints, involving all activities and events related to the delivery of the service from the customer's perspective". Kankainen et al. (2012, p. 221) view the customer journey as "the process of experiencing service through different touch points from the customer's point of view." Halvorsrud, Kvale, and Følstad (2016, p. 6) define the customer journey as "a customer's interactions with one or more service providers to achieve a specific goal".

Fundamental terms related to the customer journey are touchpoint, phase, and steps. A touchpoint is the basic building block of the customer journey and is most commonly defined as the interaction between the company and the customer during the customer journey (Becker and Jaakkola, 2020; Lemon and Verhoef, 2016; Patrício et al., 2011; Halvorsrud, Kvale, and Følstad, 2016). Touchpoints can be categorized depending on who controls them - those directly influenced by the company, partner, or customer, as well as those independent (external or social) (Lemon and Verhoef, 2016). The carriers of touchpoints are the company's channels, such as branches, contact centres, web portals, mobile apps, wearable device apps, self-service devices, social networks, instant messaging apps, SMS, and email. The customer journey unfolds through three main phases: the pre-purchase phase, the purchase phase, and the post-purchase phase (Lemon and Verhoef, 2016). Within each phase, there are specific steps that the customer goes through during the journey (e.g., online research, contacting the call centre, in-store purchase, waiting for installation, reporting an issue, contract termination).

In line with the existing literature and the purpose of this paper, the customer journey can be defined as a dynamic series of touchpoints through which the customer interacts with the offer or the company before, during, and after the purchase to achieve a specific goal.

It is important to note that the customer journey approach differs from the Blueprint method, developed by Shostack (1984) and later enhanced by Bitner, Ostrom, and Morgan (2008). This method is based on flowcharts that visually represent the steps in service delivery processes. These processes are invisible to the customer, meaning they occur without interaction between the company and

the customer. We can say that the Blueprint method adopts a company perspective on service delivery, while the customer journey represents the customer's perspective.

### 3.2 Customer journey analysis

In customer journey analysis, companies focus on customer interactions across multiple touchpoints, encompassing all customer journey phases (Lemon and Verhoef, 2016). The concept of the customer journey is closely related to using visualization methods, specifically customer journey maps (Følstad and Kvale, 2018). Customer journey mapping is one of the fundamental practical approaches in service design and management, representing a visualization of the customer journey process over a timeline of multiple phases and steps, highlighting key events in customer interactions at touchpoints. Customer journey mapping typically includes journey phases, touchpoints, customer reactions, and key customer experience indicators. In addition to visualization, various qualitative and quantitative methods are used in customer journey analysis. Observation studies, interviews, workshops, and complex qualitative and quantitative analyses are among the most commonly employed methods, where data from various sources are integrated to create customer journey maps (Følstad and Kvale, 2018). Customer journey analysis can be applied to improve existing services as well as in the development of new services.

Customer journey mapping has been practically applied in service design for nearly two decades, and the application of this method was explored by Kimbell (2011) in three leading service design agencies. In addition to practical applications, the customer journey mapping method has found its place in leading books on service design (Stickdorn and Schneider, 2012; Polaine et al., 2013; Stickdorn et al., 2018). Stickdorn et al. (2018) emphasize that the role of customer journey maps is not just to visualize the customer experience over a certain period but also to identify problems in the customer experience and find solutions to them. Maps allow the intangible nature of service and experience to be made visible and help the service design team gain a shared understanding of the customer experience. Journey mapping is always done from the customer's perspective and follows a specific representative of a customer group (main actor). The maps have both horizontal and vertical dimensions. The horizontal dimension shows the main journey phases and steps, while the vertical dimension visualizes the customer experience for each step (storyboards), customer satisfaction levels (emotional journeys), customer engagement levels (dramatic arc), the channel with which there is interaction, stakeholders, connections to backend processes, and potential issues in each step. Both qualitative methods, such as user statements, observations, and visual content that illustrates the experience, as well as quantitative methods, like satisfaction surveys, can be used in mapping.

The literature in this field does not provide a standardized methodological approach to customer journey analysis. Halvorsrud, Kvale, and Følstad (2016) were the first to initiate the creation of a standardized approach for customer journey

analysis. In this regard, they proposed an integrated customer journey model that views service delivery from the customer's perspective. In their model, they established precise terminology, conceptualized the distinction between planned and actual journeys, objective and subjective factors, and adopted foundational elements for journey visualization. Customer journey analysis based on this model relies on a comparative analysis of the service delivery process as a) a planned process, which involves how the company designed the service delivery process, and b) the actual process, representing the real customer experience during service delivery.

The customer journey analysis identifies deviations, i.e., unplanned or unnecessary touchpoints in the actual process compared to the planned process. Customer journey analysis is conducted through five phases: defining the scope of the analysis, identifying the planned journey, selecting users and collecting data, analysing the actual journey, and reporting. To achieve a comprehensive analysis of the actual journey, they used both quantitative and qualitative methods. Quantitative methods were used to collect data on the flow and duration of the process from the company's information systems. Qualitative methods included interviews and the diary method, where users recorded the service delivery process.

They applied this model to analyse the customer journeys of mobile broadband customers at Telenor, a telecommunications company. The analysis was conducted on 23 customer journeys, which encompassed 9 to 19 touchpoints each. The results showed that none of the analysed journeys aligned with the planned journey, indicating that the process contained many deviations and unnecessary touchpoints compared to how the company had planned the journey. Their analysis revealed that the customer journey does not correspond to how service providers plan it and that more detailed planning and analysis of the customer journey is necessary.

### 3.3 Customer journey analysis in omnichannel environment

The modern omnichannel environment presents a significant challenge for companies, as they must create a cohesive customer journey across all touchpoints. Due to technological advancements, companies have developed various channels to interact with customers, while customers have simultaneously gained the freedom to choose the channels that best meet their needs and preferences (e.g., they can explore offers online but make a purchase at a retail store, or vice versa). The consequence of numerous channels and touchpoints is the potential for a wide variety of customer journeys, which may deviate from the customer journey planned by the company. Further, advancements in technology and channels have resulted in an unprecedented surge in the volume of data that companies collect regarding customer behaviour and their experiences throughout the entire customer journey. Consequently, there is a strong need for applying quantitative methods in the analysis of customer journeys, as these methods can help generate valuable insights from the vast amounts of data collected during the customer journey.

Kunneman, Alves da Motta-Filho, and van der Waa (2022) explored how quantitative data science methods can contribute to service design projects. They conducted research in the existing literature and, through an iterative process, analysed with service designers which data science disciplines could be applied in their practice. Based on their research, they identified several data science disciplines applicable to service design, including opinion mining, physiological condition mining, process mining, insight mining, generative models, and clustering. The following section will focus on process mining, which represents "an important bridge between data mining and business process modelling and analysis" (Process Mining Manifesto, 2012, p. 172).

# 4. Applying process mining to customer journey analysis

## 4.1 Process Mining

The primary role of process mining is to discover, monitor, and improve business processes by generating insights from event logs available in information systems. This discipline's increasing significance has been influenced by the tremendous growth in the volume of event data across various information systems and the significant need for companies to enhance their business processes (Aalst, W. van der, 2016, 2012).

The starting point of process mining is the event log. Each event log refers to a specific activity that occurred at a particular moment and can be assigned to a unique case. An event log consists of a case ID as a numeric identifier, the activity that occurred, and a timestamp with the precise time of each activity. Additional attributes can be added to these minimal elements of the event log to provide further information about specific activities. In a corporate information environment, event logs are digital traces stored for any business activity in the databases of various information systems (Reinkemeyer, 2022).

There are three primary types of process mining. The first is process discovery, which creates a process model based on event logs without using any prior information. The second type is conformance, in which the process model is compared with event logs from the actual process. Conformance checking can be used to verify whether the actual process matches the model and vice versa. The third type is process enhancement, where the main goal is to expand or improve the existing process model using information about the actual process based on event logs. While conformance checking measures the alignment between the process model and the actual process, this third type aims to improve the process model (Process Mining Manifesto, 2012).

Numerous process mining applications have been developed that enable the application of this technique across various industries. Most of these applications support the visualization of business processes and a specific type of conformance checking with the process model. More advanced solutions provide automated connections with information systems (SAP, Salesforce, Oracle, ServiceNow,

Workday), enabling continuous data collection (van der Aalst & Carmona, 2022). There are over 40 companies in the market that have developed process mining applications, and according to the Gartner report, the leaders in this field are Celonis, UiPath, Software AG, SAP Signavio, Microsoft, Apromore, Appian, ABBYY, Mehrwerk (Magic Quadrant for Process Mining Platforms, 2024). According to research conducted by Deloitte, the majority of surveyed companies (63%) have already implemented some form of process mining solutions (Global Process Mining Survey, 2021).

### 4.2 Literature review on the application of process mining to customer journey analysis

Bernard and Andritsos (2017) were the first authors to investigate the application of process mining in mapping customer journeys (CJM). They highlighted the significant potential of applying this method in customer journeys. Their work demonstrated an excellent correspondence between XES format components and CJM. The XES format (eXtensible Event Stream), developed by the IEEE Task Force, is the most accepted in process mining for importing event logs into process mining applications. The proposed CJM model is based on a hierarchical XML structure and includes the following CJM components: journey, customer, touchpoint, experience, channel, stage, and lens. They mapped the developed CJM model to the XES format, which allows further analysis in process mining applications. Then, they imported the synthesized CJM model into the Disco process mining application. Their basic model consists of a “de jure” model, which is normative and aims to manage or control the actual state of the process, and a “de facto” model, which aims to represent the actual state. In other words, the first model is the planned customer journey, and the second is what happens in customer journeys. Bernard and Andritsos, through this work, successfully bridged customer journey mapping and process mining, opening up opportunities for further research in diverse customer journey scenarios across various industries.

In their later work, Bernard and Andritsos (2018) focused on further integrating process mining and CJM, particularly in discovering CJM process models. The basic idea in discovering process models is to create a process model based on event logs in an information system. They proposed a new model called CJM-ab (CJM abstractor), which allows process mining algorithms to discover processes to abstract the CJM process model. The CJM-ab model uses four steps to represent CJM at different levels of abstraction in order to abstract the process model. In the first step, the goal is to create a process tree based on event logs. They consider the process tree method the most suitable for discovering customer journey process models. In the second step, CJM must be created based on the same event logs. They applied Bayesian Information Criterion (BIC), Calinski-Harabasz index, Markov model, and manual data processing methods in this step. In the third step, the process tree created in the first step needs to be parsed, for which they developed a script in JavaScript. In the fourth step, they transformed the CJM at different levels of abstraction of the process model.

They applied the CJM-ab model to a dataset obtained from a scientific conference where the conference organizer, in the context of the customer journey, was the service provider, and the scientists who submitted their papers to the conference were the customers. The customer journey encompassed the entire path from the call for papers through review management to the final acceptance or rejection of the paper. The dataset included 10,000 customer journeys and 236,360 activities.

Terragni and Hassani (2018) explored the application of process mining in the web environment to investigate customer journeys, predict user activities, and recommend actions to maximise specific key performance indicators (KPIs). They believe the web is ideal for analysing customer journeys as every user activity is recorded in an event. They also think that applying process mining in this area can overcome the limitations of Web Analytics tools. In their work, they created a model for analysing web customer journeys using a real dataset obtained from an internet portal selling various types of products. The dataset contained clickstream data for one month, with 10 million events and 2 million users.

Their model's core elements are data preprocessing, web log data filtering, process discovery, behaviour clustering, making recommendations, and procedure evaluation. 1) In data preprocessing, it was necessary to create a mapping function $f(u_i) = a_j$ that maps each url ($u_i$) to specific actions ($a_j$) from the set of activities $A = (a_1, a_2, .., a_m)$. They used a procedure adopted from Poggi et al. (2013), hand-written rules, and unsupervised clustering. 2) Since such a dataset of event logs contains unnecessary data that can mislead the analysis, they filtered the data and halved the total number of events. 3) For process discovery, they used the Disco application, which employs the Fuzzy Miner algorithm. 4) As customer journeys in the web environment are highly flexible, users can have very different activity flows representing deviations from the planned customer journey. Therefore, the resulting process model is unstructured, requiring manual filtering or unsupervised clustering. 5) The goal of their model is to find ways to optimise KPIs through the analysis of customer journeys. The primary KPI in their work is increasing the number of visits to product pages that match individual users rather than the page with the most popular products, which is the same for everyone. To this end, they applied a recommendation system based on collaborative filtering techniques, replacing recommended product pages based on product similarity with a more advanced technique – a collaborative filtering algorithm adopted by Hu et al. (2008). Since they did not have data on users' favourite products, they used data on time spent on a product page, frequency of visits, and similar data from customer journeys to create appropriate user recommendations. 6) They evaluated the model using the ACU (Area Under the Curve) statistical model. The results showed that their collaborative filtering algorithm had a significantly higher ACU than a simple recommendation for the most popular product page and a slightly higher ACU when considering page visits.

Arias et al. (2020) focused their research on applying process mining in mapping customer journeys in healthcare. Their study demonstrated significant

possibilities for applying process mining in discovering different pathways patients might go through and analysing touchpoints through which patients pass. They conducted their case study using data from the information systems of a hospital and its associated emergency services. They applied their research to two diagnosis groups – pneumonia and acute myocardial infarction. The dataset included 6,715 cases with 523,521 events. For creating customer journey maps, they adopted the components defined by Bernard and Andritsos (2018) but adapted their meanings to the healthcare context (e.g., customer-patient). In the first step of the process mining analysis, they exported data from information systems in CSV format. Then, they split the data into two groups (cases event log and activities event log). Both datasets were uploaded to a data pool, and a new data model was created. For process analysis, they used the Celonis application. They investigated which customer journey models existed and through which touchpoints patients passed based on data from two diagnosis groups. They also examined the impact of gender and age on the path a patient took during the healthcare procedure and the impact of gender and age on the length of hospital stay.

Hassani and Habets (2021) explored the application of process mining in predicting the next touchpoint in a customer journey. The ability for a company to know the next step of the customer can allow for proactive action and timely customer support. They applied the developed model in one of the leading telecommunications operators in the Netherlands. The business goal of this operator was to eliminate all unnecessary touchpoints that repeat in customer journeys and resolve all customer requests at the first touchpoint. To achieve this, it was necessary to know which touchpoint would be next for the customer and, if possible, the type of request the customer would make (which could be just a clarification or a service cancellation).

For this research, they used two eight-week datasets, including over a million data rows and nearly half a million customer journeys. Initially, they defined touchpoints, categorised them, and analysed their frequency. They then analysed customer journeys in the first dataset using the heuristic miner algorithm to determine which touchpoint is typically next. Some sequences are typical, such as a call (conversation with an operator) followed by an order, service ticket, or logistical activity. In the second dataset, they analysed the distribution of customer journeys by the number of touchpoints (one touchpoint had 39% of journeys, two 40%, and three 14%). In addition to this data, they included data on the reasons for calls, which employees enter descriptively or select from options. This type of data is beneficial for prediction but, due to free-text entry, must be cleaned and reduced to useful information. In the model, they used logistic regression, random forest, boosted trees, and LSTM neural network. In evaluating the performance of this model, they found that predictions for some touchpoints were very weak (chat and branch), while others were very good (service technician dispatching to resolve a standard problem). They attributed the weaker results for some touchpoints to their nature, as these touchpoints can sometimes be unpredictable in user behaviour.

### 4.3 Research findings

Although process mining is a relatively new discipline, it has found an excellent application in analysing and improving business processes across various industries, and one of the new fields where it can find successful application is customer journey analysis. The synergy between process mining and customer journey analysis offers significant opportunities for better understanding and enhancing customer experience (Halvorsrud et al., 2024).

Even though the number of studies in this field is still limited, existing research has made significant progress in connecting these two approaches. Bernard and Andritsos (2017, 2018) were the first to develop a methodological framework for applying process mining in analysing and planning customer journeys, laying the groundwork for further research in this area. Terragni and Hassani (2018) demonstrated the importance of applying this method in the web environment, which is somewhat more suitable for implementation, and showed the value of process mining in creating data-driven recommendations based on customer journey data. Arias et al. (2020) illustrated how applying process mining to customer journeys in the healthcare industry can provide crucial information necessary for enhancing patient experience and how patient data (e.g., gender, age) can be used in process mining analysis to obtain valuable insights. Hassani and Habets (2021) showed how process mining can contribute to predicting subsequent touchpoints in the customer journey, thus improving the customer experience, and highlighted the correlation between specific touchpoint characteristics and prediction capabilities.

Based on the review of existing literature, it is evident that despite the significant contributions of current research, there is a lack of a unified process mining method for analysing and mapping customer journeys, and further research in this area is needed to establish a standardized approach.

## 5. Future research direction and discussion

The application of process mining in customer journey analysis can significantly contribute to uncovering valuable insights that cannot be obtained through the analysis of a limited scope of customer journeys. Qualitative methods, applied to a narrower sample of customer journeys, are essential for deeper analysis and understanding of the entire journey, including all touchpoints and the overall customer experience. On the other hand, the value of applying process mining in this area lies in its ability to cover a broader range of customer journeys and additional customer data, which can contribute to a better understanding of the complete customer journey.

Despite the great potential for applying process mining in the analysis and design of customer journeys, there are certain challenges in applying process mining in this area. Halvorsrud et al. (2024) highlight several challenges in the joint application of process mining and customer journey analysis: 1) Capturing the end-

to-end journey: the success of process mining application depends on its ability to cover all touchpoints and events in the customer journey, and not just limit itself to the analysis of internal processes; 2) Organizational borders in the service delivery network: the customer journey spans different organizational units and often different organizations, which poses a challenge for process mining to cover all data from different organizations; 3) Non-detectable touchpoints: Process mining relies on IT system records, but touchpoints like direct in-person conversations with customers often go unrecorded in these systems and thus remain invisible in process mining analysis; 4) Capturing the customer experience: customer experience is a multidimensional concept that accumulates throughout the entire journey, requiring deeper qualitative analysis that cannot be quantified in a way that can be analysed through process mining.

To further enhance the application of process mining in customer journey analysis and design, future research should prioritize the following areas:

- Standardization of process mining models to enable more consistent analysis and mapping of customer journeys
- Creation of an integrated framework that combines qualitative methods with process mining techniques to encompass all touchpoints and the entire customer journey
- Development of a model that merges process mining with quantitative customer experience metrics, offering a more comprehensive understanding of customer experience
- Expansion of process mining methodologies to incorporate additional customer data, yielding deeper insights into the customer journey.

## 6. Conclusion

Providing exceptional customer experience through multiple channels and touchpoints has become crucial for gaining a competitive advantage in modern business. To ensure an outstanding customer experience, companies must set strategic goals in customer journey design. The numerous channels through which companies interact with customers and the large number of touchpoints significantly increase the number of different customer journeys, which may differ from those planned by the company. The complex service environment with multiple channels presents a significant challenge for companies, as it requires creating a cohesive customer journey across all touchpoints. At the same time, companies collect vast amounts of data on customer behaviour and experiences throughout the customer journey. Therefore, in addition to existing qualitative methods, it is essential to incorporate quantitative methods into customer journey analysis to generate new insights from the large amount of available data. Process mining in customer journey analysis can significantly contribute to uncovering essential insights that are not attainable by analysing a limited number of customer journeys. The advantage of process mining lies in its ability to encompass a large volume of customer journeys and additional customer data, allowing for a more

comprehensive understanding of the entire journey. Although existing research in this field highlights the promising potential of process mining, it remains relatively unexplored and offers significant opportunities for further research and development. The convergence between qualitative methods from service design and process mining methods is evident, and future research and practice should foster the development of an integrated approach to customer journey design that addresses the challenges and limitations of existing methods.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CYBER RISKS OF CYBERLOAFING - HRM PERSPECTIVES OF ORGANIZATIONAL SECURITY

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***Abstract***

*Cyberloafing is becoming an increasing challenge for organizations. This practice presents a significant security risk to organizational systems. Security breaches can lead to serious consequences, including financial losses, compromised confidential information, and damage to the organization's reputation. Additionally, cyberloafing can negatively impact communication, disrupting work processes and reducing the effectiveness of team collaboration. The aim of this paper is to explore cyber risks related to cyberloafing and organizational security, focusing on analysing existing studies to identify the main risk factors and propose guidelines for their effective management. Using the systematic literature review (SLR) methodology, the Scopus and Web of Science databases were examined. The search identified relevant literature related to cyberloafing and cybersecurity. This document answers questions about the most common cyber risks associated with cyberloafing in organizations, how it affects the security of organizational data and networks. It explores the effects of cyberloafing on organizational communication and team collaboration effectiveness and provides guidelines and strategies for managing cyberloafing risks within organizations. These findings can contribute to security in organizations to better understand the security threats associated with cyberloafing, which can be valuable for academia and organizations especially in today's digitalized work environments.*

***Key words:*** *cyberloafing, cyber risks, organizational security, organizational communication, systematic literature review.*

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# 1. Introduction

Surfing the Internet by employees during work hours for personal reasons is called Cyberloafing or “non-work related computing” (Khansa et al., 2017, p. 142). Cyberloafing has become increasingly common and creates concern among business owners about organizational security. The rise of virtual work teams, flexible work arrangements, and the widespread use of electronic devices are some of the reasons that allow employees to engage in non-work-related activities during working hours. It may seem harmless, but it represents a significant challenge in the work environment. While cyberloafing can sometimes have a positive effect on employees by providing them with short mental breaks from work tasks, it also represents a significant challenge for organizations, primarily due to reduced productivity and increased security risks (Kirk et al., 2023). Some studies have identified cyberloafing as a deviant behavior in the workplace, specifically classified as "productivity deviance" because of its negative impact on employee productivity and financial losses for companies (Lim, 2002; Lim & Teo, 2005). Additionally, cyberloafing can increase an organization's vulnerability to security threats and cause network traffic disruptions due to excessive network usage (Liberman et al., 2011; Pee et al., 2008). More serious forms of cyberloafing, such as illegally downloading material or viewing inappropriate content, can expose companies to legal and ethical responsibilities (Vitak et al., 2011). So according to Statista data (2023), the manufacturing sector in the United States recorded 259 cases of data compromise and 638 ransomware attacks globally. Such figures point to the need for improved cyber security, considering that the number of attacks on the US supply chain will double between 2022 and 2023. In order to increase the security of the organizations and reduce the risks, the management of the online activities of employees becomes a key factor in strengthening the cyber security of the organizations if we take into account the fact that many companies face high costs of data breaches, on average 4.73 million dollars per incident in industrial organizations. Liberman et al. (2011, pp. 2192–2199) consider that Internet browsing carries risks for network security because employees may inadvertently download viruses that threaten organizational systems. For example, if employees engage in activities such as online gambling or viewing inappropriate content using organizational IT resources, the company could face serious damage to the organization's reputation and may face legal consequences.

## 1.1 Research objectives

The aim of this paper is to investigate the cyber risks associated with cyberloafing and organizational security through the analysis of existing studies, to determine the main risk factors and propose guidelines for their effective management. To achieve the goal of this work, the following research questions are asked:

Q1. What cyber risks are most often associated with cyberloafing in organizations?

Q2. How can cyberloafing compromise the security of organizational data and networks?
Q3. How can cyberloafing affect communication within organizations and the effectiveness of team collaboration?
Q4. What guidelines and strategies are outlined for managing cyberloafing risks in the organization?

### 1.2 Research approach

In this research, a systematic literature review (SLR) methodological approach was used (Snyder, 2019; Kraus et al., 2022). This approach ensures objectivity, systematicity and reliability in the collection of information and research results, contributing to existing knowledge about the risks of cyberloafing for organizational security. Scopus and Web of Science (WoS) databases were searched, with the key terms "cyberloafing", "risks" and " security".

## 2. Results

Using the Scopus database with the search term (TITLE-ABSTRACT-KEY ("cyberloafing" AND "risk" AND "security")), 5 scientific papers were found, while the keywords (TITLE-ABSTRACT-KEY ("cyberloafing" AND " risk")) resulted in a total of 10 scientific papers from 2017 to 2024, with searches conducted across all fields of the database. In the Web of Science (WoS) database, searches with the keywords: "cyberloafing" AND "risk" AND "security" yielded 5 scientific papers. "cyberloafing" AND "risk" resulted in 11 scientific papers from 2017 to 2024 across all fields (Figure 2). The total number of documents in the Scopus and WoS databases with the keywords "cyberloafing," "risk," and "security" amounts to 21 documents from 2017 to 2024 (Figure 1).

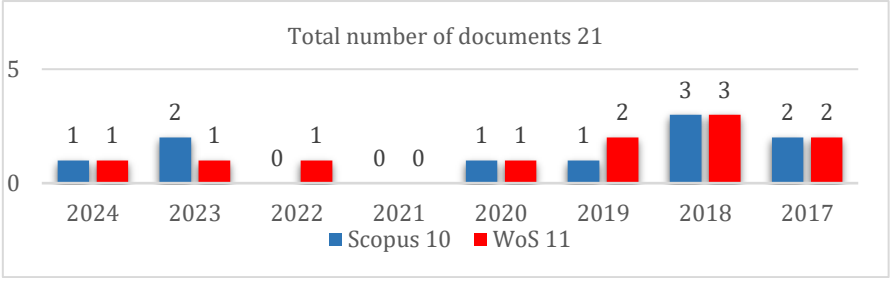


*Figure 1. Documents by year investigating Cyberloafing, Risk, Security in Scopus and Wos database (2017- October 2024). Source: Authors' work: 2024*

The area of the research topic/categories presents the period of 2017 to October 2024 and include various subject area. In both databases, the highest number of documents is found in the field of computer science and related disciplines, as well as in social sciences (Figure 2).

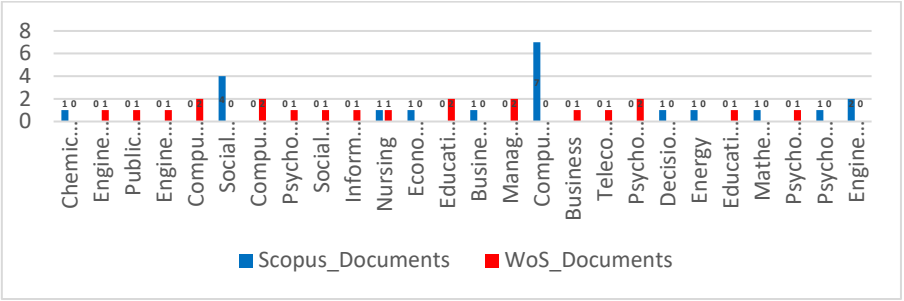


*Figure 2. Documents by subject area investigating Cyberloafing, Risk, Security in Scopus and Wos database (2017- October 2024). Source: Authors' work: 2024*

A systematic literature review found a total of 21 documents, of which 10 are in the Scopus database, and 11 in the WoS database. Overlaps were found in 8 documents and 2 documents found only in Scopus and 3 in WoS. A total of 13 documents. All 13 documents were reviewed, 7 of which are relevant to the research topic. Access is not possible for one document. During the review process, 4 relevant documents (from 2012 to 2023) were found outside the Scopus and Wos databases, bringing the total number of relevant documents to 11, which will be further analyzed in this work. The table shows the titles of scientific papers found by the specified search. It includes the database, the title of the work, the year of publication, the purpose (goal) of the work and the risks of cybelofing for the security of organizations from the perspective of human resource management (HRM) (Table 1).

*Tabel 1. Risks of cybelofing to the security of organizations from a human resource management (HRM) perspective.*

| ID | **Author name, year** | **The purpose(goal) of the work** |
|---|---|---|
| | **The name of the work** | **Risks of cybelofing to the security of organizations from a HRM perspective** |
| **1** | Khansa, L., Kuem, J., Siponen, M., & Kim, S. S. (2017) | Examines how announcing formal controls affects employees' cyberloafing. |
| | To cyberloaf or not to cyberloaf: The impact of the announcement of formal organizational controls | - downloading malicious software or allowing unauthorized access to the organization's network, disrupting operations by overloading network resources, engaging in illegal activities (downloading pirated content, accessing inappropriate websites) exposes the company to legal and ethical responsibilities |
| **2** | Hadlington, L., & Parsons, K. (2017) | Explores (from UK) how cyberloafing and internet addiction endanger organizational information security. |

| ID | Author name, year<br>The name of the work | The purpose(goal) of the work<br>Risks of cybelofing to the security of organizations from a HRM perspective |
|---|---|---|
| | Can cyberloafing and internet addiction affect organisational information security? | -employees with a lower awareness of information security increases vulnerability to cyber threats, visiting unsafe websites (gambling sites, adult content, checking personal e-mail) increases the risk of malware infections and cyber-attacks, leads to network congestion through excessive use of network |
| 3 | Ross, J. (2018) | Highlights the growing trend of cyberloafing among healthcare professionals, who engage in non-work during work hours. |
| | Cyberloafing' in health care: A real risk to patient safety | - jeopardizing patient safety and information security in healthcare institutions, risk of infection with malicious software and data breaches, proposed solution "zone without interruption" |
| 4 | Vernon-Bido, D., Grigoryan, G., Kavak, H., & Padilla, J. (2018) | Explores how employee cyberloafing affects organizational cyber risk by reducing productivity and increasing malware and security breach risks. |
| | Assessing the impact of cyberloafing on cyber risk | -introduction of malicious software through unsafe websites (pornography, gambling), employees with a lower level of information security awareness (online shopping, checking personal e-mail and social media) |
| 5 | Jiang, H., Tsohou, A., Siponen, M., & Li, Y. (2020) | Discusses how Internet monitoring, intended to reduce cyberloafing and improve security, can negatively affect employees. |
| | Examining the side effects of organizational Internet monitoring on employees | -Internet surveillance can reduce employee trust and commitment, which weakens compliance with security policies and reduced awareness of security practices |
| 6 | Kolog, E. A., Mensah, I., & Egala, S. B. (2024). | Examines the impact of cyberloafing on productivity and cybersecurity risks in Ghana's public sector, focusing on factors such as security, surveillance and security risks that deter cyberloafing. |
| | Cyberloafing deterrence in the public sector of Ghana | -strain network resources (slowing down or interrupting critical operations), personal use of organizational systems can reduce system performance, introduction of malicious software (visiting unprotected websites - viruses, trojans), access to unprotected websites (spyware infections), leads to unauthorized access to confidential information, data leakage (use of personal e-mail or other unprotected communication channels), frequent use of the Internet reduces the security vigilance of employees (identity theft, manipulative tactics) |
| 7 | Schroeder, A. N., & Whitaker, J. H. (2018) | Explores technology-enabled employee deviance, like cyberbullying and cyberloafing, through Robinson and Bennett's workplace deviance model. |

| ID | Author name, year<br>The name of the work | The purpose(goal) of the work<br>Risks of cybelofing to the security of organizations from a HRM perspective |
|---|---|---|
| | An examination of workplace cyberdeviance | -visiting unsafe websites (downloading viruses or malware), risk of leaking sensitive information (Using unprotected platforms or unencrypted channels), Downloading unverified applications from unauthorized sources, exposure to phishing attacks (checking personal email and social media), reduced awareness about security protocols, network overload (excessive data usage, reduces bandwidth and system performance) |
| 8 | Kim, K., del Carmen Triana, M., Chung, K. & Oh, N. (2016) | Examines cyberloafing, focusing on how personality traits such as conscientiousness and emotional stability influence its frequency. |
| | When do employees cyberloaf? An interactionist perspective examining personality, justice, and empowerment | -Organizations in areas with high data security requirements should consider conscientiousness and emotional stability when hiring (screening candidates for traits such as conscientiousness), negative emotional states (consider interventions that reduce negative impacts on employee emotions) |
| 9 | Koay, K. Y., Soh, P. C. H., & Chew, K. W. (2017) | Examines the relationship between employees' private demands, job stress, and cyberloafing. |
| | Do employees' private demands lead to cyberloafing? | - high levels of stress reduce employee attention to security protocols (unauthorized access or malware infection), reduced attention to safe use of information systems |
| 10 | Lim, V. K. G., & Teo, T. S. H. (2022) | Reviews existing research on cyberloafing and offers guidelines for future studies. |
| | Cyberloafing: A review and research agenda | - exposing the system to unsafe websites (downloading malicious software and compromising network security), excessive personal use of the Internet (overloading network resources, slowing down business applications) |
| 11 | Fei, Z (2023) | Examines various aspects of cyberloafing, including its predictors and consequences, and how it affects the work environment. |
| | The impact of cyberloafing: A literature review and future prospects | -depletes the working resources of employees (reduced work efficiency), browsing the Internet and downloading programs (introduce viruses), exposure of the organization to significant legal and reputational problems (online gambling or watching inappropriate content) |

The reviewed papers represent theoretical frameworks or empirical research on the topic. Findings from the literature review indicate that cyberloafing represents a significant security risk for organizations. The findings reveal that cyberloafing can cause a slowdown or interruption of critical operations. Employees who are often involved in cyberloafing generally have a lower level of awareness of security threats, thereby increasing the organization's vulnerability to cyber-attacks such as identity theft and manipulative tactics. Cyberloafing can reduce productivity

and strain network resources, increasing the risk of malware infection from visiting unsafe websites, such as gambling sites or adult content. Such activities can result in data leakage as employees use unsecured channels to communicate or view personal e-mail. From the example in the health sector, there are possible serious implications for patient safety, given that the use of personal devices and access to insecure websites can compromise information security, which can lead to disruptions in key health services. Cyberloafing can result in reduced employee awareness of security protocols, which increases the possibility of overlooking threats such as phishing attacks. Monitoring the online behavior of employees can have certain psychological consequences because it reduces trust, which can weaken compliance with security policies, which further increases the vulnerability of the organization. Organizations in sectors with high data security requirements should consider traits such as conscientiousness and emotional stability when hiring. High levels of stress at work can also result in an increased frequency of cyberloafing, further compromising information security within an organization.

## 3. Discussion

The systematic review of the literature carried out in this paper presents an overview of cyber risks related to cyberloafing from the perspective of human resource management in the context of organizational security. In the Scopus and Web of Science databases, many works related to cyberloafing can be found, but the results show an insufficient number of works that deal with the researched topic.

### 3.1 The most often cyber risks associated with cyberloafing in organizations

The most common risks cited are the reduction of information security due to unknowingly downloading a malicious file or visiting unsafe sites, which can lead to malware infections and unauthorized network access. Excessive use of network resources for personal needs can overload the network, slow down the system and reduce the efficiency of business applications. Activities such as illegally downloading content or visiting inappropriate sites can cause legal and ethical consequences and threaten the reputation of the organization. Frequent cyberloafing reduces employee awareness of security protocols and increases the risk of security threats such as phishing attacks. The use of personal e-mail or insecure communication channels can compromise data confidentiality and lead to information leakage.

### 3.2 Cyberloafing can compromise the security of organizational data and networks

Cyberloafing can significantly compromise the security of organizational data and networks because employees often visit insecure websites or use unsecured communication channels, increasing the risk of downloading malware, such as viruses and spyware. Security aspects of the network can be compromised due to

excessive use of network resources leading to congestion, network slowdowns and business disruptions. Visiting unsafe sites increases the possibility of infections and cyberattacks. Access to confidential information is provided due to personal use of e-mail or unsecured communication channels. Reduced awareness of security threats due to employees' reduced attention to security protocols, making it easier for attackers to exploit system weaknesses, such as phishing attacks and identity theft.

### 3.3 The impact of cyberloafing on organizational communication and team collaboration efficiency

Cyberloafing can positively and negatively affect organizational communication and team collaboration. By distracting employees and disrupting work processes, which reduces their attention and responsibility towards colleagues, which affects the efficiency of communication and can lead to delays in completing tasks. For example, if they are burdened with personal problems and their concentration is divided, they may inadvertently compromise organizational security by clicking on the Internet or communicating without sufficient attention to sensitive information, which can prevent the flow of essential information and reduce the effectiveness of teamwork. Reduced engagement in collaborative activities weakens team cohesion, making it difficult to achieve goals that rely on effective team collaboration. Occasional cyberloafing allows employees to take a mental break from work tasks, and in this way can help reduce stress and increase productivity through short breaks to increase efficiency after returning to work tasks.

### 3.4 The guidelines and strategies for managing cyberloafing risks in organization

To reduce the cyber risks caused by cyberloafing to increase the security of organizations, a combination of formal rules on internet use, strategic supervision and employee education is recommended. Through clear guidelines on acceptable behavior on the Internet during working hours, with sanctions for violations if necessary, and through employee training on security protocols and raising awareness of security threats, the likelihood of risky behavior can be reduced. Establishing "no-disturbance zones" for key tasks and limiting the use of personal devices, when necessary, is recommended. Organizations can use monitoring systems that notify administrators when employees are visiting unsafe websites or spending too much time on non-work activities. A balanced approach is recommended to avoid negative effects on employee motivation and confidence. Encourage responsible use of the Internet and actively involve employees in the development of security policies. Setting a proportionate share of time for personal Internet use and limiting access to non-business websites. Regular training on cyber security further increases employees' awareness of potential threats, creating a secure work environment.

## 4. Conclusions

Cyberloafing represents a security risk, potentially endangering data, communication and security within organizations. By identifying key risks and vulnerable security aspects and proposing strategies for managing these risks, an important scientific contribution is made to understanding and mitigating cyber risks associated with cyberloafing in organizations. The necessary digitization of work environments highlights the need for constant research into the role of human resources in managing this problem to maintain the security of organizations. These findings and guidelines are valuable for the academic community, the public sector, private organizations and companies because they can contribute to the development of new approaches to reducing security threats and be a starting point for new research in digitized work environments.

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# ENGENEERING AND CONSTRUCTION

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE FINANCIAL AND ECONOMIC RISKS IN THE RISK ASSESSMENT MODEL MADE FOR WASTEWATER TREATMENT PLANT

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***Abstract***

*This paper analyses the financial and economic risks in the risk assessment model made for wastewater treatment plants. This group of risks was identified during the doctoral research conducted with the Delphi method. In the risk assessment model, six groups of risks are identified and evaluated within a team of the Delphi method: legal, financial and economic, logistics, environmental protection, management, and design risks. The financial and economic risk group has five identified risks. These risks are specified after the literature review and previous project experiences. The importance of identification of these risks is making the adequate risk response.*

***Key words:*** *risk, financial, economic, Delphi method*

## 1. Introduction

The risk assessment model for the construction process of wastewater treatment plants was developed as a part of a doctoral thesis. It is a unique model made after detailed literature research, which included a review of journals, legal acts, and books and collected information about operational plants (Topalić Marković et al., 2020). The risks in the model are organized into categories, and each of them individually can lead to delays in work and issues in exploitation, thus directly affecting economic and financial losses. There are 37 risks in the model divided into six risk groups.

The research involved the expert's group using the Delphi method. One of the risk groups that is important for the planning and design phase of construction is the legal group of risks, and the other groups include financial and economic risks,

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logistics risks, ecological risks, management risks, and design risks (Topalić Marković, 2022).

The model itself is a part of project risk management. Risk management identifies, approaches, and prioritizes risk, followed by coordinated actions that reduce, monitor, and control the possibility and impact of adverse events. Risk management aims to reduce the possibility of uncertainties preventing the achievement of the project objectives (Bowers, 2016).

The importance of risk management in the construction process of wastewater treatment facilities is increasing. This is because the population has increased, and the need for an engineered system for wastewater management in large cities has become more evident (Riffat, 2012). The construction of a wastewater treatment plant is a complex and extensive project, sometimes taking several years. Plants represent multi-million investments due to their complexity, equipment, and many people involved in all parts of the project. Risk analysis and risk management are important parts of the decision-making process in the construction industry. After analyzing different articles, guidelines, and projects of wastewater treatment plants, it can be concluded that the construction industry does not focus enough on project risk analysis and assessment in this area (Walewski et al., 2006; Renault & Agumba, 2016; Ogunsanmi, 2011).

Over the years, the management of wastewater treatment systems has been characterized by a stepwise progression from solving sanitation problems (this was the main focus in the early phases of the 20th Century) to avoiding eutrophication in receiving water bodies and nutrient recovery/recycling (has been emphasized over the past 10 years) (Bowers, 2016).

Uncertainties and risks in the field of wastewater treatment are considered according to the design guidelines. Historically, the design itself is based on the requirements of the institutions, design standards accepted by the industry or legal regulations (industry standards tailored to specific requirements with individual amendments) (Jaroslav Černi Institute for the Development of Water Resources, 2015).

The risk model, which was developed as a part of the doctoral thesis is different from the standard guidelines because it includes 37 risks strictly connected to the civil engineering aspects of projects. This model is essential in the initial phases and design phases, when poor decisions can subsequently lead to poor efficiency and financial losses. For Serbia, it is crucial to know how to manage the risks, because there will be many future projects for wastewater treatment plants required for Serbia's EU accession (Topalić Marković & Mučenski, 2022).

This topic is important for Serbia and has the potential for implementation in practice, especially because Serbia is awaiting a big step ahead, and this is the process of entering the European Union. There is a norm for wastewater treatment plants that every settlement with more than 2000 inhabitants must oblige (Jaroslav Černi Institute for the Development of Water Resources, 2015). The capital of Serbia, Belgrade, and some larger cities do not have wastewater treatment plants (WWTP).

So, this model can be important and implemented in earlier stages of the project to reduce economic and financial losses.

## 2. Results

The identification of risks in the planning phase of a project and the arrangement of impact values has become a fundamental basis of today's various construction projects (Yucelgazi & Yitmen, 2019).

The commonly used terms of economic and financial risk are usually vaguely defined. Narrowing down the economic risk to only lending transactions or equity investments, which is often done, is considerably narrowing down the term (Turlajs & Jurenoks, 2006). In this research financial risk describes any risk that could impact project finances. Economic risks are financial risks that affect the overall economy.

For the first time, risks identified in this model are combined in this way, and it is important to note that they are used for the Delphi method. These risks are connected to the risks in the initial and design phases of the project. All risks presented are rated by the experts who participated in the Delphi method. After two rounds, the respondents reached a consensus, confirmed by descriptive statistics.

The economic and financial risks are defined after a detailed literature analysis, laws and bylaws, and projects. This group of risks comprises five risks. Evidence for every risk can be found in the literature. These risks are the following [10]:

1. Inadequate budget (lack of funds) for building modern plants (CEDEF, 2015)
2. Uncontrolled cash flow in some phases of the project (Kishan et al., 2014; Wideman, 1992)
3. Inflation and unexpected price change (Kishan et al., 2014; Wideman, 1992)
4. Unfinished and incorrect estimation of financial benefits (Walewski et al., 2006)
5. Unfinished and incorrect estimation of economic benefits (Walewski et al., 2006)

These risks are explained and defined for the risk assessment model (Topalić Marković, 2022):

1. Inadequate budget (lack of funds) for building modern plants
   This risk is identified in (CEDEF, 2015)
   Risk explanation: The big problem is caused by insufficient funds for modern plant construction. There may not be money to buy quality equipment for the wastewater treatment facilities, which can endanger the treatment process and the water quality. Also, an unrealistic budget refuses a serious bidder.
2. Uncontrolled cash flow in some phases of the project
   This risk is identified in (Kishan et al., 2014; Wideman, 1992)

Risk explanation: If the investor does not provide high-quality supervision on the project over the expenditure of funds approved for the project contractor, it may happen that do not use the money for the intended purposes.

3. Inflation and unexpected price change
   This risk is identified (Kishan et al., 2014; Wideman, 1992)
   Risk explanation: Inflation, that is, price disturbances that can potentially occur increase the price of works during building construction, which are not foreseen in the design phase when the designer forms construction costs, can cause serious consequences for the project.
4. Unfinished and incorrect estimation of financial benefits
   This risk is identified in (Walewski et al., 2006)
   Risk explanation: If financial assessments remain incomplete or have incorrect benefits, there is a possibility that the project will have a deficit of money. Financial benefits refer to the owner of the infrastructure. For example, when planning return income loans, the main problem is the incorrect assessment of the income of the facilities based on estimates of the amount of purified water. If the loan installment burdens the price of water, there can be a significant drop in water consumption (water consumption is reduced), and by itself, therefore, the inflow of money for loan installments decreases.
5. Unfinished and incorrect estimation of economic benefits
   This risk is identified in (Walewski et al., 2006)
   Risk explanation: If economic assessments remain incomplete or have incorrect benefits, the project may contain omissions regarding its importance for the region and the entire society. This may lead to a reconsideration of the project or optional significant changes.

This research was conducted to fully meet the needs of the project managers when planning risk management. Therefore, it is important that everything is available with information on whether and how project managers create management plan risks. If they create plans, this model will help them go through the definition more easily and create an adequate risk response.

The main significance of the created model is a better understanding of risk factors, which can lead to reduced financial losses and better project sustainability. The limitations of the research are a small number of experts with managerial experience in the Delphi team and that experts participating in this research were from only two countries, Serbia and Bosnia and Herzegovina.

## 3. Conclusions

This paper presents the financial and economic risks in the risk assessment model for wastewater treatment plants. This group of risks was identified during doctoral research conducted with the Delphi method. Risks in the risk assessment model are identified and evaluated within a team of the Delphi method: legal, financial and economic, logistics, environmental protection, management, and design risks. The financial and economic risk group has five identified risks. The importance of identification of these risks is making the adequate risk response. For Serbia, it is crucial to know how to manage the risks, because there will be many future projects for wastewater treatment plants required for Serbia's EU accession.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# USING MACHINE LEARNING PRACTICES TO DETECT FRAUD AND RISK MANAGEMENT

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***Abstract***

*This paper presents a machine learning (ML) approach to detect credit card fraud and manage related risks in transactions. Traditional fraud detection systems struggle to adapt to evolving fraudulent patterns, leading to financial losses. ML techniques offer improved accuracy and efficiency in fraud detection. The proposed framework includes data preprocessing, feature engineering, model training, and evaluation. Key features such as transaction amount and location are extracted for analysis. ML models, including neural networks, decision trees, and logistic regression, are trained and evaluated using precision, recall, F1 score, and AUC-ROC. Cross-validation is employed for hyperparameter tuning, and a hybrid approach integrates supervised learning with anomaly detection to reduce false positives. Experiments use synthetic data to ensure privacy. This study contributes to safer and more transparent credit card transactions through advanced ML practices, enhancing fraud detection accuracy.*

***Key words:*** *Credit Card Fraud Detection, Machine Learning, Anomaly Detection, Risk Management.*

## 1. Introduction

Credit cards, widely used for transactions such as groceries, travel, and shopping, have become indispensable due to their convenience and perks like reward points (Tiwari et al., 2021). However, the rapid expansion of electronic commerce has also led to a rise in credit card fraud, involving identity theft and unauthorized transactions (Patil and Lilhore, 2018; Sharma et al., 2021). Fraudsters increasingly exploit digital tools such as VPNs and Tor networks, making it difficult

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to trace their activities. As society moves toward cashless payments, the need for robust fraud detection has intensified. This study explores the application of machine learning techniques—Artificial Neural Networks, Decision Trees, and Logistic Regression—to detect fraudulent activities using synthetic data. The findings demonstrate that synthetic datasets, when processed through machine learning classifiers, can effectively predict fraudulent transactions, safeguarding personal data and preserving privacy. This work builds on a rich body of literature that compares various fraud detection algorithms, with Random Forest, Decision Trees, and Neural Networks consistently demonstrating high accuracy (Afriyie et al., 2023; RB & KR, 2021; Kumar et al., 2022). The paper highlights the use of synthetic data to ensure privacy, offering insights into optimizing machine learning models for future studies in credit card fraud detection.

The paper is structured as follows: Section 1 reviews prior research on credit card fraud detection using machine learning. Section 2 details the data and variables used, while Section 3 outlines the methodology. Section 4 presents and discusses the results with graphical summaries. The paper concludes by summarizing findings, addressing limitations, and offering recommendations for future research.

## 3. Data

The study uses the "Credit Card Transactions Synthetic Data Generation" dataset by Rodrigues (2023), published on January 2, 2023. This synthetic dataset includes 5,000 customer profiles, 100 terminal records, and 1,785,308 transactions, containing no real credit card numbers, customer data, or personally identifiable information (PII). Key independent variables include daily transactions, transaction amount, terminals used, transaction time, and entry method. The dependent variable is fraud detection, while control variables such as customer profiles, spending behavior, bank identifiers, and location data provide additional context for analyzing fraudulent activities.

## 4. Methodology

The machine learning models were developed in Python using JupyterLab for efficient execution and result visualization. The process began by merging the datasets and removing irrelevant non-numeric columns. The imbalanced dataset was then balanced using the RandomOverSampler() function. Afterward, the dataset was trained on various machine learning models, with hyperparameter tuning applied to improve performance. Key performance metrics, including the Confusion Matrix, Classification Report, and AUC score, were gathered to evaluate and compare the models.

### 4.1 Measurement Metrics

The Confusion Matrix provides a detailed assessment of the model's classification performance by delineating four key outcomes: true positives (accurately identified fraudulent transactions), true negatives (correctly identified legitimate transactions), false positives (legitimate transactions incorrectly classified as fraudulent), and false negatives (fraudulent transactions not detected). The Classification Report offers a comprehensive summary of the model's efficacy through metrics such as accuracy (the proportion of correct classifications overall), precision (the proportion of accurately predicted fraud cases), recall (the model's capacity to detect actual fraud), and the F1 score (the harmonic mean of precision and recall, providing a balanced measure of performance). Additionally, the AUC score evaluates the model's discriminatory ability between fraudulent and legitimate transactions, with higher values signifying superior performance. The ROC curve, which plots the true positive rate against the false positive rate, serves as a visual representation of this capacity, with curves closer to the upper left corner indicating higher predictive accuracy.

### 4.2 Machine Learning Models

Three widely used machine learning models—Artificial Neural Networks (ANN), Decision Trees (DT), and Logistic Regression (LR)—were selected for analyzing fraudulent credit card transactions. ANNs, inspired by neural structures, were implemented using Keras and optimized through hyperparameter tuning to enhance accuracy, with performance measured by AUC, accuracy, confusion matrix, and classification report. Decision Trees, known for handling outliers and feature scaling, used the Gini Index for classification and were evaluated on similar metrics. Logistic Regression, effective for binary classification, provided interpretability by highlighting the influence of each variable on fraud detection, and its performance was also assessed using standard metrics.

## 5. Results and Discussion

The initial dataset comprised a total of 1,785,308 transactional records, out of which 3% were identified as fraudulent, while the remaining 97% consisted of legitimate transactions. Given this significant imbalance, it was necessary to balance the dataset before proceeding with model training. Figure 5.1 illustrates the frequency distribution of fraudulent and non-fraudulent transactions, providing both numerical and percentage representations. To further understand the relationships between fraudulent activities and other variables, a correlation analysis was performed using a correlation matrix. As depicted in **Figure 5.2**, no strong correlations were observed between the fraud variable and any other numerical variables in the dataset.

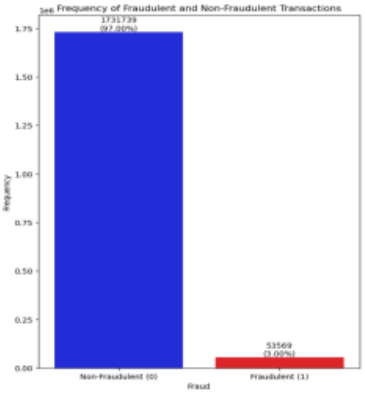


*Figure 5.1: Frequency of Transactions*

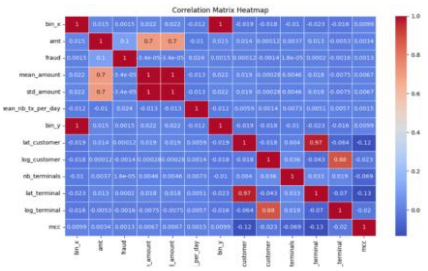


*Figure 5.2: Correlation Matrix*

The strongest correlation was observed between the fraud variable and the "amt" (transaction amount) variable, which demonstrated a weak positive correlation of 0.1. **Figures 5.3** display the distribution of transaction amounts for both fraudulent and non-fraudulent transactions. It is notable that fewer than one thousand transactions in either category exceeded an amount of 200 per purchase.

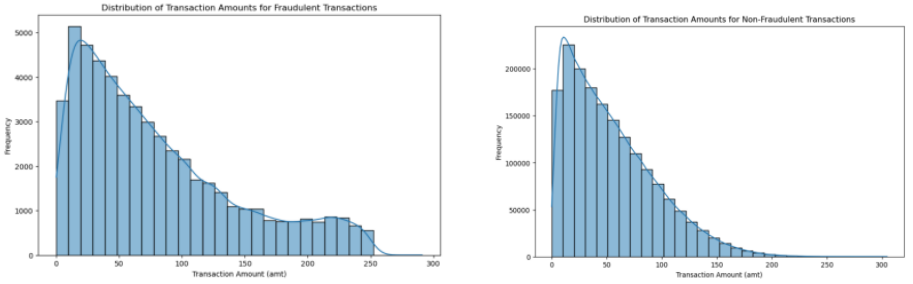


*Figure 5.3: Distribution of Amount in Fraudulent and Non-Fraudulent Transactions*

Based on the correlation analysis, no other significant relationships between fraudulent and non-fraudulent transactions were observed. Consequently, the next step involved training the machine learning models. For this purpose, a sample consisting of 20% of the overall dataset, amounting to 692,696 transactions, was used for analysis.

### 5.1 Results of the ANN Model

The confusion matrices for Artificial Neural Networks (ANN), Decision Trees (DT), and Logistic Regression (LR) reveal distinct performance levels in detecting fraud. ANN accurately classified 343,121 non-fraudulent transactions but struggled with fraud detection, achieving a low recall of 0.34%. In contrast, the DT model showed strong performance across all classifications, with an overall accuracy of

98%. The LR model performed the weakest, misclassifying 264,396 transactions and achieving only 61.8% accuracy. This comparison underscores the superior performance of the DT model, outperforming both ANN and LR in recall, precision, and accuracy.

*Table 5.1: Comparison of Confusion Matrices for ANN, Decision Tree, and Logistic Regression Models*

| Model | Predicted Class | Actual Class: Not Fraud (0) | Actual Class: Fraud (1) |
|---|---|---|---|
| **ANN** | Not Fraud (0) | 343,121 | 2,879 |
| | Fraud (1) | 228,900 | 117,796 |
| **DT** | Not Fraud (0) | 332,905 | 2879 |
| | Fraud (1) | 228,900 | 117,796 |
| **LR** | Not Fraud (0) | 235,928 | 110,072 |
| | Fraud (1) | 154,324 | 192,372 |

The classification reports for the ANN, Decision Tree (DT), and Logistic Regression (LR) models reveal notable differences in performance. The DT model excelled, with high precision, recall, and F1-scores of 0.98, indicating strong accuracy in identifying both fraud and non-fraud cases. In contrast, the ANN model, despite good performance on non-fraudulent transactions (0.99 recall), had poor fraud detection (0.34 recall), leading to lower weighted average recall and F1-score. The LR model showed the weakest performance, with precision, recall, and F1-scores around 0.62, highlighting its challenges in distinguishing between fraudulent and non-fraudulent transactions. Overall, the DT model outperforms both ANN and LR, particularly in handling unbalanced datasets.

*Table 5.2: Comparison of Classification Report of Each Model*

| *Class* | *Metric* | *ANN* | *DT* | *LR* |
|---|---|---|---|---|
| ***Not Fraud (0)*** | Precision | 0.60 | 1.00 | 0.60 |
| | Recall | 0.99 | 0.96 | 0.68 |
| | F1-Score | 0.75 | 0.98 | 0.64 |
| | Support | 346,000 | 346,000 | 346,000 |
| ***Fraud (1)*** | Precision | 0.98 | 0.96 | 0.64 |
| | Recall | 0.34 | 1.00 | 0.55 |
| | F1-Score | 0.50 | 0.98 | 0.59 |
| | Support | 346,696 | 346,696 | 346,696 |
| ***Weighted Avg*** | Precision | 0.79 | 0.98 | 0.62 |
| | Recall | 0.67 | 0.98 | 0.62 |
| | F1-Score | 0.63 | 0.98 | 0.62 |
| | Support | 692,696 | 692,696 | 692,696 |

The ROC curve analysis further differentiates the performance of the three models in detecting fraudulent transactions. The Decision Tree model demonstrated exceptional capability, achieving an AUC score of approximately 0.99. This result aligns closely with the findings of Afriyie et al. (2023) and RB & KR (2021), reflecting the model's high sensitivity and specificity in distinguishing between fraudulent and

non-fraudulent transactions. The ROC curve for the Decision Tree model is nearly identical to the ideal curve, indicating superior performance. In contrast, the Artificial Neural Network (ANN) model yielded an AUC score around 0.67, revealing a more modest performance with less effective separation between the classes. Similarly, the Logistic Regression (LR) model achieved an AUC score close to 0.66, demonstrating limited effectiveness in accurately classifying fraudulent transactions. These results corroborate the classification report findings, where the Decision Tree consistently outperforms both the ANN and LR models. This performance is in line with the conclusions of RB & KR (2021) and Afriyie et al. (2023), which highlight the Decision Tree's superior accuracy and reliability in detecting fraudulent transactions compared to the ANN and LR models.

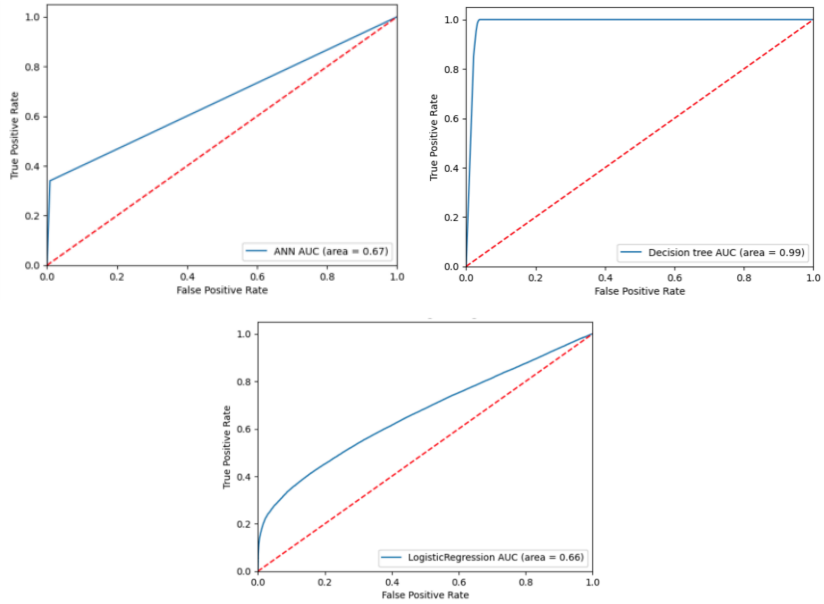


*Figure 5.4: ROC Curve for the ANN, DT and LR Models*

## 6. Conclusion

This study evaluated the effectiveness of synthetic credit card data for fraud detection using three machine learning models: Artificial Neural Networks (ANN), Decision Trees (DT), and Logistic Regression (LR). After balancing the dataset, the DT model achieved strong results, with accuracy, precision, recall, and F1-scores around 98% and an AUC of 99%. In contrast, ANN and LR showed lower accuracy at 66% and 61.8%, likely due to suboptimal hyperparameter tuning or difficulties with the imbalanced dataset. Future research should refine these models and explore additional algorithms, while companies could benefit from using Decision Trees with synthetic data to enhance privacy and security.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# STRATEGIES FOR INDUSTRY: ENGINEERING SOLUTIONS IN NOISE CONTROL AND RISK MANAGEMENT

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***Abstract***

*Implementing comprehensive noise management plans in every organisation is not just a task; it is also a responsibility to maintain a productive and healthy atmosphere in the work environment. By upholding minimal noise exposure levels, we directly contribute to safeguarding workers' health and well-being, a mission that should drive our every action. Many studies have confirmed that, nowadays, exposure to noise at the workplace is, in most cases, above the proposed level. On the other hand, employees are also exposed to other physical stressors whose minimal variations affect productive capacity, social relations and employee health. In the context of Industry 5.0, it is crucial to adopt strategies that prioritise the well-being and comfort of employees. This human-centred approach enhances potency and fosters a sense of added value for workers, making them an integral part of an organization which improves resilience and a broader focus on sustainability. The paper analyses noise across 13 different industries, particularly emphasising the excessive sound pressure levels experienced by workers. It also delves into the critical values of 1/3 octave frequency that might harm different aspects of workers' health. In addition to this, worker satisfaction in standard and open-plan offices will also be considered. Particular emphasis will be placed on exploring diverse engineering solutions to minimise noise exposure, alongside conducting risk assessments in scenarios where preventive protection measures are not implemented for specific reasons.*

***Key words****: noise, industry, frequency analysis, engineering, well-being, risk.*

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# 1. Introduction

Throughout the years, an evolving framework has been aimed at protecting workers from hazardous workplace noise while emphasising employer responsibility towards ensuring a safe acoustic environment.

The first significant publication on noise exposure at work was in 1963, followed by the Code of Practice for Reducing Noise in 1972. The Noise at Work Regulations were implemented in 1989, setting out employer duties and action levels for daily personal noise exposure. In 2005, the Control of Noise at Work Regulations introduced updated guidance to prevent and reduce hearing loss due to workplace noise. These regulations outlined specific action levels requiring interventions from employers to minimise potential harm from excessive noise exposure(Courtislow, 2024).

Noise is a pervasive challenge in industrial settings, posing potential risks to workers and operations. The clamour of machinery, equipment, and processes can reach high decibel levels, detrimentally affecting employees' hearing and overall well-being (Metidieri et al., 2013). Prolonged exposure to excessive noise can result in permanent hearing loss, stress, reduced productivity, and communication difficulties.

On the other hand, the service sector is experiencing an expansion in its workforce, particularly within office environments. This is coupled with a trend of technological systems assuming an increasing number of low-skilled tasks (Roelofsen, 2008). Therefore, organizations must prioritize establishing conducive, comfortable work environments to facilitate uninterrupted employee productivity and the achievement of organizational objectives, both short-term and long-term.

Industry 5 focuses on technological innovations that improve production and work processes through intelligent technologies such as automation, artificial intelligence, and the Internet of Things. This approach also considers the impact of noise on working conditions, which is essential to improving productivity and preserving the employee's health.

It is well known that high noise levels can cause stress, fatigue, decreased concentration and increased nervousness among employees. Different countries have varying criteria for determining the risk of noise damage, typically within the range of 85-90 dB(A). However, any sound level that is bothersome or exceeds 75 dB(A) may be classified as noise.

A crucial first step in improving working conditions is reducing noise levels, such as by using insulating materials, implementing technological solutions to reduce machine noise, or providing personal noise protection. Also, using sound-absorbing materials, creating designated quiet zones, and implementing noise control policies can result in significant benefits. Evaluating noise hazards in the workplace typically entails gauging noise levels to ascertain employees' exposure to excessive noise. This can be accomplished through specialized measuring instruments and routine monitoring. After the measurements, the findings and risk assessment should be carefully examined to gather information about the potential

impacts of noise levels on employees' well-being. Human resource management in industrial settings presents a complex challenge, necessitating deploying engineering solutions to achieve optimal outcomes for employees and employers.

### 1.1 Materials and Methods

The study was conducted across thirteen distinct processing sectors: printing, chemical, automotive, metal, meat, plastic, rubber, wood, shoe, flooring, textile, furniture, and energy. Notably, three of these industrial facilities are under foreign ownership, specifically in the automotive industry's textile, flooring, and plastic and rubber parts production. Each industry's noise levels were measured, focusing on the machine type or the specific workstation. As per the Serbian guidelines on workplace protection measures and standards (Official Gazette, 2019), the equivalent $L_{eq}$ values with filter A should be assessed over the effective daily duration of a worker's exposure to noise to determine the daily noise exposure level, Lex,8h (Directive 2003/10/EC, 2003). Sound pressure level was measured within the range of frequencies between 25 Hz and 10 kHz using a TES 1358A Sound Level Meter (SLM) with the RS-232 connection, which complies with the IEC 651 Type 1 standard.

The second part of the research involves conducting questionnaire surveys (NAWOP23) with fifty employees who work in 4 banks with open-plan offices. Noise measurements were also taken. The banks were chosen based on the type of open-plan workspace they have. For data analysis, the statistical software IBM SPSS Statistics 20 was used. Frequency analyses were applied to display the structure of the sample, and questionnaire item reliability was investigated using Cronbach's alpha.

## 2. Results

The noise levels were assessed in thirteen manufacturing facilities for all types of machinery and work positions within the production areas of the factories. Figure 1. illustrates that the recorded $L_{eq}$ values in industrial processes typically range from 70 to 100 dB(A) (Luburic et al., 2020), aligning with findings by other researchers (Al-Dosky, 2014; Yang et al., 2016). The average value is calculated to be 83.28 (8.22) dB(A), and the highest mean value of 118.56 (1.30) dB(A) is observed during metalworking procedures involving the use of a hammer in the metal industry. The highest recorded noise levels were in the sawmill and furniture industries, surpassing the 85 dB (A) threshold value (Figure 1). These specialised workshops employ around twenty workers, aiming to expand their production. The average noise level in the sawmill is $L_{eq}$ = 92.05 (1.37) dB (A), and in the furniture factory, $L_{eq}$ = 92.82 (6.19) dB (A). There are several issues of concern here. All the machinery produces high noise levels, further worsened by their proximity. This means the workers are constantly exposed to unpleasant noise during work hours. It is also well-established that more noise sources lead to higher noise levels.

Consequently, increased noise levels pose a significant risk of negatively impacting the health and well-being of employees in this type of work environment.

Based on the presented results, it can be concluded that close to 40% of the industry generates noise above the sufficient value for 8 hours of work, while 70% generates noise above 80 dBA.

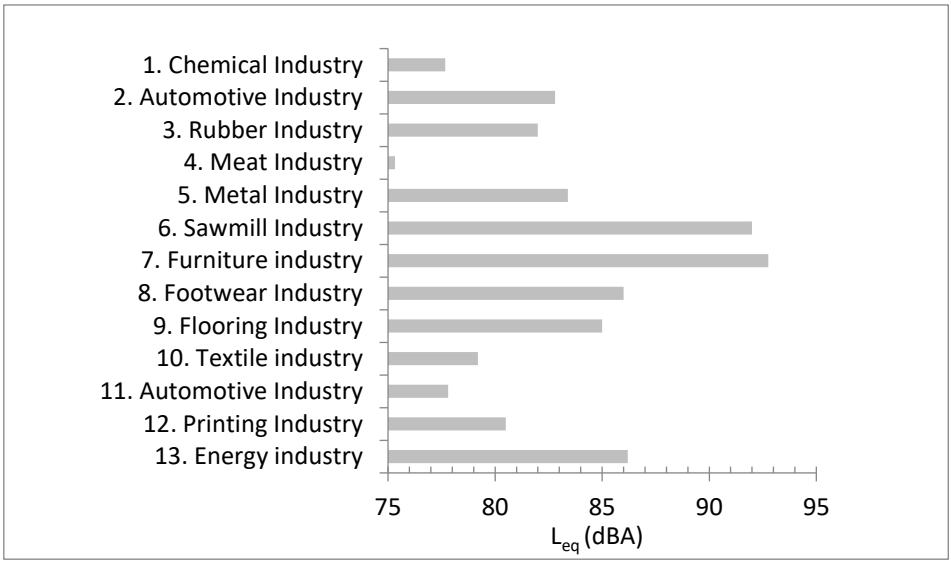


*Figure 1. Representation of mean noise levels $L_{eq}$ in investigated industries*

Noise was also measured in open-plan offices. According to Serbian guidelines, the permissible noise level for tasks involving mental focus and regular verbal or telephone communication is 50 dBA, while for office work, the level is 45 dBA. The recorded average noise $L_{eq}$ levels measured in four banks with open-plan offices ranged from 58 dBA to 61 dBA, surpassing the recommended thresholds, as seen in Table 1.

*Table 1. Average values for $L_{eq}$, $L_{max}$ and $L_{min}$*

| No. | $L_{Aeq}$ [dB] | $L_{Amax}$[dB] | $L_{Amin}$[dB] |
|---|---|---|---|
| 1 | 58.38(1.20) | 66.40 (0.99) | 47.5 (0.91) |
| 2 | 59.26(0.58) | 66.44(2.42) | 50.2(0.42) |
| 3 | 60.72(1.88) | 79.92(2.04) | 49.5(1,63) |
| 4 | 58.42(1.14) | 68.18(2.43) | 48.7(1.45) |

## 2.1 Questionnaire survey and statistical analysis

Conversely, Table 2. summarizes subscale scores (15-item questionnaire) for 66 employees who work in investigated open-plan offices. Subjects had the highest mean scores for the psychophysical changes and ability to perform the work

subscales, which indicates that noise can generally affect psychophysical health and negatively affect productivity.

*Table 2. Descriptive statistics for noise effects on employees using a 5-point Likert scale*

| | N | AS | SD |
|---|---|---|---|
| Stress | 66 | 2.95 | 1.531 |
| Psychophysical changes | 66 | 3.71 | 2.252 |
| Ability to perform work | 66 | 3.75 | 2.493 |

## 3. Discussion

Based on the research findings, noise is a significant contributor to workplace pollution. It significantly affects people's well-being and substantially impacts work productivity and overall job satisfaction. Therefore, management and governing bodies are responsible for ensuring a healthy work environment. One potential solution to this issue is integrating engineering solutions into the design of workspaces.

To improve the acoustic quality, several authors suggest installing divider panels between workstations and using sound-absorbing materials for the roof (Esfandiari et al., 2021). According to Chetoni et al. (2016), different frequencies affect room elements differently. For example, windows significantly transmit noise at low frequencies, while the ceiling is a significant source at higher frequencies. To reduce noise levels in noisy rooms, high-impedance floor coverings like acoustic metamaterials with excellent sound absorption coefficients in the 602-1287 Hz range can be used (Yang et al., 2022). Additionally, Čudina et al. (2016) recommend using art paintings with specific color combinations (predominantly pastel colors with green, blue, and grey) to mitigate the effects of background noise in an open-plan office.

The noise level generated in industrial processes is affected by various factors, such as the nature of the process, operating speed, and the materials used. Studies suggest that the age of the machinery has a minimal impact on the noise produced. Machines such as pneumatic power tools, compressors, pumps, metal and wood forming machines, and turbo generators produce high noise levels. A global acoustic quality index has been proposed to help evaluate machinery noise (Pleban, 2010). In foreign-invested factories, noisy machines are either enclosed with modular acoustic panels or located in separate rooms, and this practice is recommended for general implementation. Furthermore, these factories have established protocols for workers and visitors to adhere to protective measures to minimize excessive noise exposure. It is essential to prioritize noise control and practical strategies, as some research questions the effectiveness of hearing protection as a long-term substitute for noise control (Groenewold et al., 2014). Standard protective equipment includes user-friendly earplugs and earmuffs, but workers often do not use them. Some authors (Reddy et al., 2012) note that workers believe noise is an acceptable and unavoidable part of the job.

## 4. Conclusions

Noise control is an essential aspect of risk management in the workplace, as excessive noise can lead to a range of health issues and impact productivity. Employers must implement measures to reduce noise levels, such as using sound-absorbing materials, installing barriers or enclosures around noisy equipment, and providing employees with hearing protection. Additionally, regular monitoring and assessment of noise levels in the workplace are crucial to identify areas where interventions may be needed. By effectively managing noise-related risks, organizations can ensure their employees' well-being while improving overall work environment quality and performance.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EFFECT OF HEMP FIBER PRE-TREATMENT ON REPAIR CEMENT MORTAR MECHANICAL PROPERTIES

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***Abstract***

*In recent years, the construction industry has seen a significant rise in the usage of natural fibers such as hemp fiber (Cannabis sativa L.) for composite materials reinforcement. The objective of the research presented in this paper was to examine the impact of the hemp fiber pre-treatment (saturated with $Ca(OH)_2$ solution or 1.6 M NaOH solution) and condition (untreated or saturated with deionized water) on the mechanical properties of the fiber-reinforced repair cement mortar. The total of five mortar mixtures, reference one and four mixtures containing 1% hemp fibers (cut to length of the 10 mm) by mass of the cement were prepared, and their 7-day and 28-day compressive and flexural strengths were determined. The effectiveness of the applied hemp fiber pre-treatment or condition was evaluated primarily from the aspect of the mechanical properties of the examined mortars. Furthermore, based on the 28-day compressive strength results, the examined mortars were classified into one of the four classes of repair cement mortars in accordance with the standard SRPS EN 1504-3.*

***Key words****: natural fiber, chemical pre-treatment, repair cement mortar, compressive strength, flexural strength.*

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# 1. Introduction

In recent years, the usage of natural fibers as reinforcement in cement-based composites has increased significantly. Natural fibers are preferred compared to artificial fibers, as they are renewable, low-cost, easy to access and less harmful to the environment (Çomak et al., 2018, pp. 794–799), (Rocha et al., 2022, 2043). Natural fibers can be obtained from natural resources such as plant bast (from i.e. hemp, jute, ramie, flax, kenaf, mesta and roselle) (Samanth & Bhat, 2023, 100034). Industrial hemp (i.e. *Cannabis sativa L.)* consists of around 23% of the fibers and 75% of the shive and reaches a height of 2 to 6 meters during the growth period lasting 100 to 120 days (Nováková, 2018, 03011). Furthermore, it can grow on new or old soil, withstand extreme temperatures while requiring only modest amounts of water (Malabadi et al., 2023, pp. 67-78). Çomak et al. (2018, pp. 794–799) examined density, water absorption, compressive strength, flexural strength, compressive strength after flexural tensile and splitting tensile strength of the cement mortars reinforced with previously untreated hemp fibers. The fibers were added in the different ratios (0%, 1%, 2% and 3%) and different lengths (6 mm, 12 mm and 18 mm). The obtained results showed that cement mortars reinforced with 2–3% amount and 12 mm length of natural hemp fiber give the optimum results. According to Merta (2016, pp. 291–303), the optimal balance between the increased energy dissipation capacity and the resulting loss in compression strength of the cement-based composite was obtained with hemp fibers of 10 mm in length. The different fiber surface pre-treatments, such as chemical one, can also determine the bond between the fiber and the cement-based matrix and affect the final characteristics of the cement-based composites. Zhou et al. (2017, pp. 1-10) examined enhancing the mechanical properties of hemp fiber-reinforced concrete through the $Ca(OH)_2$ solution pre-treatment of 15-mm length fibers, at a volume fraction of 1%. Besides saturated lime water treatment, a variety of recent studies (Shah et al., 2021, pp.1-19) showed that sodium hydroxide (NaOH) treatment also plays a significant role in the adhesion of fiber concrete composites.

The research presented in this paper deals with the effect of the different hemp fiber conditions (e.g. untreated, or saturated with deionized water), and chemical pre-treatments (e.g. saturated $Ca(OH)_2$ solution, or 1.6M NaOH solution) on the 7-day and 28-day flexural and compressive strengths of the fiber-reinforced repair cement mortars that contain 1% hemp fibers (cut to the length of the 10 mm) and added by mass of the cement.

# 2. Materials, mixtures and methods

## 2.1 Component materials

In order to examine the effect of the different fiber pre-treatments (e.g. untreated, or saturated with: (i) deionized water, (ii) saturated $Ca(OH)_2$ solution, and (iii) 1.6M NaOH solution) on the hemp fiber-reinforced repair cement mortar 7-

day and 28-day flexural and compressive strengths, the following component materials were used for the preparation of repair mortars:

- Ordinary Portland cement (PC) CEM I 42.5R (Lafarge-BFC Serbia) with specific gravity of 3.1 g/cm$^3$ and Blaine fineness of 4000 cm$^2$/g,
- Hemp fibers (*Cannabis sativa L.)* cut to the length of 10 mm,
- CEN standard sand, in accordance with SRPS EN 196-1 (2008),
- Deionized water.

Poletanović et al. (2021, 125072) reported the characterization results of the same hemp fibers that were applied in this research: (i) tensile strength up to 900 MPa, (ii) density of 1500 kg/m$^3$, and (iii) water absorption 100% after 120 min.

### 2.2 Pre-treatment of the hemp fibers and mortar mixtures

The experimental study was performed on five different repair mortar mixtures made with water-to-cement ratio of 0.5: the reference cement mortar (RM1), and four cement mortar mixtures (RM2-5) containing 1% hemp fibers (length: 10 mm) added by mass of the cement:

- RM2 – repair cement mortar containing 1% untreated hemp fibers,
- RM3 – repair cement mortar containing 1% untreated hemp fibers saturated with deionized water,
- RM4 – repair cement mortar containing 1% dried hemp fibers treated with saturated limewater solution, and
- RM5 – repair cement mortar containing 1% dried hemp fibers treated with 1.6 M NaOH solution.

The labels and quantities of component materials for each mortar mixture are listed in Table 1.

*Table 1: Repair mortar mixtures*

| Component material | RM1 | RM2 | RM3 | RM4 | RM5 |
|---|---|---|---|---|---|
| CEM I 42.5 R (g) | 450 | 450 | 450 | 450 | 450 |
| Hemp fibers (g) | - | 4.5 | 4.5 | 4.5 | 4.5 |
| Standard sand (g) | 1350 | 1350 | 1350 | 1350 | 1350 |
| Deionized water (g) | 225 | 225 | 225 | 225 | 225 |

The hemp fiber surface pre-treatments (with saturated limewater solution as well as with 1.6 M NaOH solution) were provided according to the procedure described in (Troedec et al., 2008, pp. 514-522), i.e. fibers were pre-drying at 40°C for 24 h, and then were placed for 48 h in a saturated lime solution (pH 12.7) or 1.6 M NaOH solution (pH 14.2). After that, fibers saturated with calcium ions were washed with deionized water, while fibers soaked in 1.6 M NaOH solution were, at first, neutralized with 1% vol. acetic acid and then also washed with deionized water. Furthermore, chemically treated fibers were dried at 40°C for 24 h. Untreated

hemp fibers as well as chemically treated are presented in Figure 1, and there are noticeable differences in the color shade.

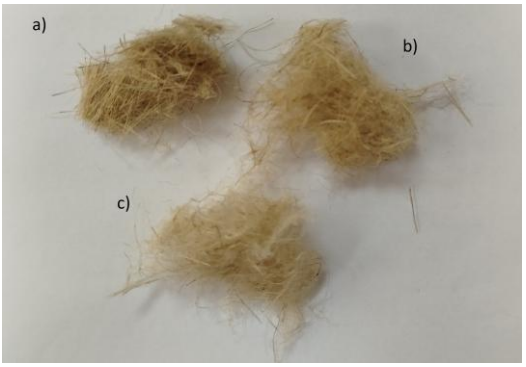


*Figure 1: Hemp fibers: a) untreated, b) treated with saturated limewater solution, and c) treated with 1.6 M NaOH solution*

### 2.3 Methods

The 7-day and 28-day flexural strengths of the mortars were determined according to the standard SRPS EN 196-1 (2008) using prism-shaped specimens with dimension of 40 mm × 40 mm × 160 mm, after recommended curing resume (covered in film for 24 h, demoulded after 24 h and cured under water at (21 ± 2)°C until testing). The mean strength values were obtained by testing the three prisms per mortar mixture. The load at failure was determined using the Michaelis scales.

The 7-day and 28-day compressive strengths of the mortars were determined according to the standard SRPS EN 12190 (1999) on the halves of the prisms remained from flexural strength testing. The mean strength values were obtained by testing the six prism halves per mortar mixture. The load at failure was determined using a hydraulic press with a capacity of 150 kN.

## 3. Results and discussion

### 3.1 Flexural strength

The 7-day and 28-day flexural strength results of the tested mortars, prepared with a water-to-binder ratio of 0.5, are shown in Figure 2. The ranges of flexural strengths after 7 and 28 days of curing were 7.86-9.09 MPa and 9.13-9.60 MPa, respectively.

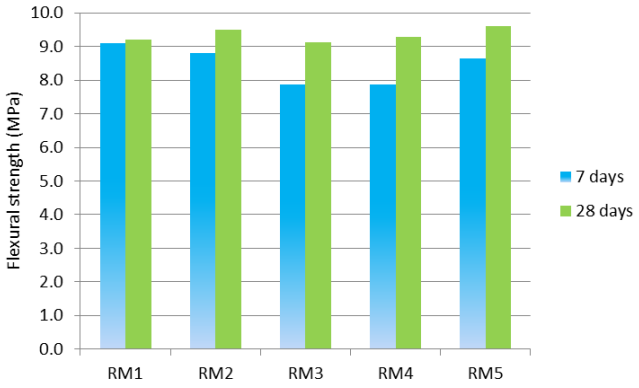


*Figure 2: 7-day and 28-day flexural strengths of examined mortars*

At the age of 7 days, the reference cement mortar (RM1) had the highest flexural strength, while mortar RM2 and RM5 had slightly lower, by 3.2% and 4.9%, respectively. Mortar RM4 and RM3 had lower flexural strengths by 13.5% and 13.6% in comparison to the reference mortar, respectively. At the age of 28 days, the RM5 mortar had the highest flexural strength that was slightly higher in relation to reference cement mortar (by 4.4%), followed by mortars RM2 and RM4, by 3.2% and 0.9%, respectively. Mortar RM3 had a slightly lower flexural strengths by 0.7% compared to the reference mortar.

Based on the obtained results at the age of 28 days, it can be concluded that all tested mortars had flexural strength in the range of the reference one (i.e. the differences were less than 10%).

Due to the presence of hemp fibers, the specimens did not completely physically break into two parts after testing the flexural strength, as illustrated in Figure 3a. Later, they were manually broken in half, Figure 3b.

*Figure 3: RM5 mortar specimens: a) after 7-day flexural strengths examination, and b) before compressive strength examination*

### 3.2 Compressive strength

The 7-day and 28-day compressive strength results of the tested mortars, prepared with a water-to-binder ratio of 0.5, are shown in Figure 4.

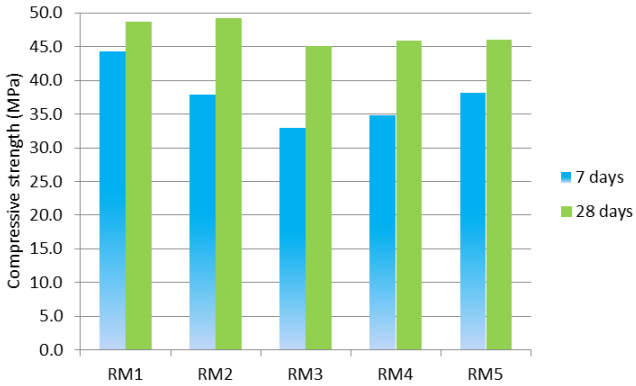


*Figure 4: 7-day and 28-day compressive strengths of examined mortars*

The ranges of compressive strengths after 7 and 28 days of curing were 32.92-44.22 MPa and 45.05-49.22 MPa, respectively. As in the case of the flexural strength, reference cement mortar had the highest compressive strength value at the age of 7 days, while mortar RM5, RM2, RM4 and RM3 had lower by 13.8%, 14.5%, 21.3% and 25.6%, respectively. At the age of 28 days, mortar RM2 had the highest strength, by 1.1% higher than the reference one, while mortars RM5, RM4 and RM3 had slightly lower strength, by 5.5%, 5.7% and 7.5%, respectively.

Based on the obtained results at the age of 28 days, the highest compressive strength had the mortar with 1% untreated hemp fibers, while all tested mortars fulfilled the requirement for class R4 of structural repair mortars according to the standard SRPS EN 1504-3 (2005) in terms of compressive strength (BS EN 12190:1999), i.e. their mean compressive strength values were higher than 45 MPa.

## 4. Conclusions

Based on the obtained experimental results, in terms of the effect of the different fiber conditions (e.g. untreated, or saturated with deionized water), and chemical pre-treatments (e.g. saturated $Ca(OH)_2$ solution, or 1.6M NaOH solution) on the 7-day and 28-day flexural and compressive strengths of the hemp fiber-reinforced repair cement mortars, the following can be concluded:

- All tested mortars fulfilled the requirement for class R4 of structural repair mortar according to the standard SRPS EN 1504-3 (2005) in terms of compressive strength;
- The highest 28-day compressive strength had the repair cement mortar with 1% untreated hemp fibers, while all tested mortars had compressive

strengths in the range of reference one, i.e. the differences were less than 10%;

- At the age of 28 days, the repair cement mortar containing 1% dried hemp fibers treated with 1.6 M NaOH solution had the highest flexural strength (higher by 4.4% in comparison to reference cement mortar), followed by the repair cement mortar containing 1% untreated hemp fibers (higher by 3.2%), while all tested mortars had flexural strength in the range of the reference one, i.e. the differences were less than 10%.

Considering the obtained results as well as environmental aspects of hemp fiber conditions/pre-treatments, it can be concluded that the optimal results were obtained in the case of untreated hemp fibers added in an amount of 1% by cement mass to the repair cement mortar.

## Acknowledgments

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-114 Review paper

# INNOVATIVE APPROACHES TO NATURAL DISASTER MANAGEMENT: THE ROLE OF AI AND IoT

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***Abstract***

*The aim of this paper is to represent the innovative approaches to the natural disaster management, emphasizing the role of Artificial Intelligence (AI) and the Internet of Things (IoT) in transformation of natural disaster management based on predictive solutions. The paper highlights the improvements in real-time monitoring, early warning systems, and predictive accuracy for natural disasters. The integration of AI and the IoT has revolutionized natural disaster management and prediction. AI algorithms analyze datasets from IoT sensors deployed in vulnerable areas, enabling real-time monitoring and early warning systems. These technologies enhance predictive accuracy for disasters. Machine learning models process historical and real-time data to identify patterns and forecast events with unprecedented precision. This synergy improves emergency response, minimizes casualties, and mitigates economic losses. Possible challenges in implementation of innovative approaches to Natural Disaster Management based on AI and IoT include ensuring data security, managing the high volume of data, and integrating AI-IoT systems into existing infrastructure. The innovative approaches to Natural Disaster Management leads to optimized resource allocation, minimized economic losses, and support of efficient recovery efforts. By integrating these advanced technologies, businesses and economic systems can achieve a competitive advantage, ensuring stability and sustainability in the face of increasing global challenges.*

***Key words:*** *Artificial Intelligence (AI), Internet of Things (IoT), Natural Disaster Management, Predictive Accuracy, Real-Time Monitoring.*

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# 1. Introduction

In the last ten years, a remarkable push for digitalization has been observed in many sectors and industries. This particular transition, which is attributed to the emergence of advanced technological capabilities, has facilitated the emergence of processes that are more responsive, intelligent, convergent, and effective. All these improvements in technology are consolidated under the banner of what is referred to as Industry 4.0, or the Fourth Industrial Revolution. More precisely, Industry 4.0 is a newly created strategy that integrates four fundamental factors through the intersection of physical and cyber systems which enhances interconnectivity and machine-to-machine exchanges of various operations.

The most important factor in understanding Industry 4.0 is that this new phenomenon incorporates several previously unavailable technologies such as AI, Digital Twins, Blockchain, and Cloud Computing. For the first time, AI has introduced possibilities of learning machines and data analytical skills that permit machine predictive maintenance, performing intelligent functions, and analysis of machine behavior, hence minimizing manual intervention in the operation system.

Natural disasters have been one of the threats to human societal and socioeconomic activities. Over the last several years, the development of advanced technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) have assisted in improving how natural disasters can be handled and managed.

The data has been directly or indirectly gathered through the available IoT devices even from regions with complex topographies and very high temporal and spatial resolutions, enabling the aiding of the emergency service providers with valuable information. However, they can also help management of disasters using proper solutions that help in predicting, detecting, managing, and responding to any risks (Aboualola et al., 2023). The popular use of portable communication devices by citizens and their mass social interaction tends to abide by information social media strategies and allow decision-making and substantial awareness (Yu et al., 2018).

There are high expectations in terms of the capabilities of artificial intelligence and the IoT in the management of natural disasters. However, successfully implementing the above-stated benefits requires collaborative measures on internal disputes and management issues that are encumbered.

The focus on issues like data quality, data integration, and building reliable AI models will be important for ensuring that these new technologies are utilized effectively.

Given the relentless threat of natural disasters, it is reasonable to expect a possible incorporation of AI and IoT in the strategies of disaster management.

## 2. Disaster management

Disaster management is one of the disciplines that have witnessed a great deal of progress in recent years. This can be accounted for by the increasing occurrence of disasters and the greater-than-ever magnitude of the disasters attributed to reasons such as climate change.

Recently however one paper demonstrated an economic analysis of natural disasters, in particular a focus on the need to develop specific economic policies in response to disasters (Botzen et al., 2019). The authors conducted a systematic review of models and empirical studies dealing with the estimation of direct and indirect losses from natural disasters, integrating processes, theory, and evidence concerning most key standard, computational, and empirical approaches. The research adds to the literature on disaster risk perception and management specifically in understanding the processes and strategies that can be employed to curb the effects of disasters when they happen on the economy of the country and its various operations.

Another study attempted to assess the importance of big data in natural disaster management. The presence of information technology, they indicated, has altered the strategies that human societies use to manage natural disasters with a view of minimizing human pain, economic pain, and losses. They systematically reviewed the previous studies on big data in natural disasters and their management and focused on the current state of the art of the technology of meaningful intervention (Arslan et al., 2017)

The results from these studies point to the fact that management of natural disasters cannot be effective if implemented in isolation, but that several approaches inclusive of data and policy measures as well as community resilience are adopted.

To deal with the prevailing gaps that exist because of the institutional capacity and economic challenges there are management principles that constitute business continuity about the disaster recovery pole. It is also very important to mitigate the impact of disasters, especially in terms of protecting human lives, displacement of people, and damage to key services. Disaster management, includes disaster preparedness, mitigation, response, and recovery (UNDRR, 2019).

Considering the prevention, preparedness, mitigation, response, and recovery, the function of the disaster management system is very important, especially in an economic view. Their impact goes beyond the loss of lives and can engage the destruction of industries, disruption of supply chains, and even exhausting government attention and resources on reconstruction activities after the disaster. It is established in the studies that spending on disaster preparedness and mitigation solutions would cut the amount of recovery expenditures and save the economy from deleterious needs and losses (Hallegatte & Vogt-Schilb, 2016). This is more so applicable to developing nations where disasters affect the vulnerable most and achieving the sustainable development goals is a challenge (UNDRR, 2019).

Disaster management can be further sophisticated with the help of advanced technology such as Big data, AI, and satellite surveillance, as has been observed by Arslan et al. (2017). Water-related disasters have overwhelmed the emergency response professionals developing natural disaster management industries and resulted in the loss of lives, stability of economies, and sustainability of societies to future occurrences and impacts.

## 3. Artificial Intelligence

The traditional disaster management strategy comprises of four steps: mitigation, preparedness, response, and recovery. These steps include activities that take place before and after a calamity in order to help limit suffering, avert loss of lives and boost efforts toward saving and aiding the affected. This covers arranging rescues and the restoration of the area after disasters occur, in order to shield the people and the facilities from such risks in the future (Cutter et al., 2014; UNDRR, 2019). The Sendai framework has been clear about the importance of advancement on technology to curb the difficulties brought by natural disasters (United Nations, 2015). As disaster management entails action, the aim of disaster management is, to develop methods that help to prepare for a disaster, help to respond to a disaster in the shortest time, and help to utilize all the necessary means of repair, restoration of the activity and prevention of further consequences (Hallegatte et al., 2013).

Artificial Intelligence (AI) keeps gaining application in disaster risk management (DRM) in domains like hazard identification, vulnerability assessment, consequence prediction and devising strategies to mitigate risk. For instance, regression models with data from past occurrences can be employed by AI to indicate the future crisis scenarios that the networks would be facing due to the impacts of disasters (Arslan et al., 2017). Additionally, spatial regression models can assess vulnerability and help design resilient infrastructure (Ahmadi et al., 2024). AI's applications extend into preparedness by offering efficient early warning systems and optimizing evacuation plans (United Nations, 2015).

In the response stage, AI-based communication tools have proven useful for improving decision-making and enhancing situational awareness, which is critical for effective rescue efforts. These tools ensure seamless communication among those involved in relief operations (Hallegatte & Vogt-Schilb, 2016). Post-disaster recovery also benefits from AI, as it can assess damage to structures and support recovery planning by tracking progress in rebuilding efforts (Ahmadi et al., 2024). Furthermore, AI techniques are being applied to enhance infrastructure resilience, such as using fuzzy set theory and expert judgment to evaluate critical infrastructure resilience (Dick et al., 2019). Deep learning and machine vision have also been used to detect threats to power systems and prevent failures through predictive maintenance (Dick et al., 2019).

## 4. Internet of Things

The Internet of Things (IoT) is gaining popularity among businesses and the scientific community alike as it is a novel and developing concept (Dijkman et al., 2015). Out of the various perspectives offered by various authors, IoT concerns the integration of different devices, systems, and processes over the system consisting of the Internet with the help of data transferring (Gubbi et al., 2013). Their visions of IoT include boundless, ubiquitous, and persistent wireless links between people and machines, services, and devices. This approach not only eliminates the need for individuals to be present in the environment and physically interact with devices and systems, but it also improves the capabilities to observe, interact, and control systems from a distance (Ashton, 2009). When presenting the IoT in the context of disaster management several arguments on the advantages of the use of IoT are provided including monitoring, control, quality evaluation, cost, and time optimization (Al-Turjman, 2017). A cognitive data delivery framework satisfies the data transmission challenges that appear in a large network during disasters as proposed by Al-Turjman (2017), thus improving the network's performance. Also, IoT is very helpful in the early warning and monitoring systems of geohazards such as landslides, rockfalls, and earthquakes (Mei et al., 2020). Implementing IoT systems into DRM procedures has the potential to provide twining speed and analytical accuracy in hazard forecasting, and decision-making efficiency which would cut costs in any response or recovery process.

In addition, these pieces of data from IoT such as sensors, detectors, and embedded computers can also be manipulated by artificial intelligence (AI), therefore helping to prevent hazards out of the prompt.

The Sendai Framework for Disaster Risk Reduction stresses the need for institutional strengthening of disaster risk management and IoT can assist in moving towards this need by bringing an adaptive decision-making context (UN, 2015). Also, less uncertain technologies have been demonstrated using IoT to support critical infrastructure protection. For example, a novel approach by Schultz et al. (2020) suggested the application of signal-processing technologies for critical infrastructure resilience enhancement. Yet, notwithstanding its potential benefits, there are some concerns regarding the effective utilization of IoT, including technical uncertainties and risks of the use of IoT. These concerns are important to address particularly with regard to boosting the trust and adoption of IoT technologies in disaster management (Sundmaeker et al., 2010).

## 5. Conclusion

In conclusion, the use of modern technology such as AI and IoT is changing the way natural disasters are being managed. People are able to integrate advanced technologies into all stages of disaster management: prevention, preparedness, response and recovery, assisting in faster, smarter and better use of predictions, policies and resources. Predictive Analytics tools of AI enhance hazard detection and

the assessment of risk by sifting through voluminous data and envisaging the possible disaster events. While IoT provides comprehensible communicative applications and surveillance for ecological hazard through its connected devices to assign hazardous disasters manageable levels. Such changes and improvements lead in decreasing not only the duration but also the accuracy of the actions in disaster management and risk surroundings and thus less human operations are exposed for with the help of these strategies. With the help of appropriate laws, these technologies and systems in the disaster response methods may increase situational awareness, improve evacuation strategies, as well as enhance recovery strategies aimed at evaluation of property damage and mapping of rebuilding activities. In addition to this their involvement in the enhancement of critical asset protection and disaster risk management is very important in the effort of reducing the risk. Nonetheless, barriers exist that require resolving relative to the implementation of technology, data safety, and investment in infrastructure. Collaboration with stakeholders in this manner will ensure that optimal utilization of AI and IoT in address the problem of natural catastrophes is assured. In general, it can be highlighted, that the use of these techniques increases the likelihood of development of more efficient and flexible disaster management systems recovering lives and belongings of people and communities.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EFFECTIVE NOISE MANAGEMENT – THE ROLE OF REGULAR CRANE MAINTENANCE

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***Abstract***

*Noise is defined as any sound that has the potential to disturb humans. As one of the significant occupational health hazards on construction sites, different levels of noise are produced by different construction equipment. The noise level among crane operators varies between 74 – 97 dB (A), and at some points, it reaches the maximum level of 101 dB (A). Different research indicated that the crane operator's noise exposure depends on the task, crane model, and quality of the crane cab insulation. This research highlights the importance of conducting regular crane maintenance, as it can positively affect the decrease of noise exposure of crane operators. The aim of this study is to represent key elements of cranes that produce high noise and how they should be maintained by defining methods, time frames, and instruments that will be incorporated into the management of workplace noise. Reduction in noise level is accomplished with regular lubrication of moving parts, replacing wear and tear components, and ensuring proper alignment and balance. Through effective noise management that includes consistent inspection and monitoring, noise damping measures, and a set of preventive measures, the noise levels are kept within safe limits, lowering health risks to workers, such as hearing loss and other health issues. Implementing different preventive measures, such as predictive maintenance, scheduled servicing, and training for crane operators and maintenance staff, results in a quieter and safer operational environment.*

***Key words****: noise, cranes, maintenance, inspection*

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# 1. Introduction

Noise represents one of the significant occupational health hazard in the construction industry, which among other construction machinery, is also produced by cranes. Crane operators are exposed to average daily noise between 74 and 97 dB (A), at some points, it even reaches the maximum level of 101 dB (A) and the exposure to noise of crane operator depends on the task and crane model (Legris & Poulin, 1998). Proper operation and maintenance of cranes represents one of the least expensive and most rewarding noise control practices. Through regularly lubrication of elements, replacing worn bearings and other parts as needed, but also keeping the doors and windows closed, it can be accomplished the reduce of noise when working with cranes (Suter, 2002). The aim of this study is to represent key elements of cranes that produce high noise and how they should be maintained by defining methods, time frames, and instruments that will be incorporated into the management of workplace noise.

# 2. Identifying key noise – producing elements in cranes

There are different sources (Finochenko et al., 2019) of noise that are separated into several groups:

- Noise produced by crane moving along the track – because there is an interaction between the rough surfaces of the wheel and rail, impacts within automatic coupling devices between the crane and flatcars;
- Noise generated by main equipment (diesel generator, traction motor, speed transformer) – tear and wear of cogged wheels causes a significant increase of vibration in the speed transformer and traction motor frame;
- Noise generated by auxiliary equipment (electrical machines and rectifying installation cooler fans, air conditioning system of the cabin).

Noise from cranes can also come from lack of lubrication oil of reducer of the crane, or due to adjustment of the tilting of the braking mechanism on both sides of the running mechanism of the cart, during the braking process, the braking torque on both sides is deviated, causing the side torsion to cause vibration. Crane noise can also be from operator violating the rules or incorrectly operating the crane. The quality of crane and its own characteristics is important to control and improve, because it can largely maintain a state that is not excessively loud.

As they are producing different forms of sounds, it is recommended to better understand the causes of these noises, in order to enhance better performance of machine which will improve the operator's safety on work. A first step in understanding the causes of these noises is to identify key noise-producing elements in cranes (Table 1)

*Table 1: Key noise-producing elements in cranes*

| Element of crane | | Element of crane | |
|---|---|---|---|
| **Supporting structure** | Turntable | **Crane drive mechanism** | Gearbox, shaft, belt pulleys, bearings, gears, reducer, electric motor, couplings |
| **Gripping devices** | Sheaves, hoist drums and sprockets | **Braking mechanism** | Brakes, brake pads, brake discs, brake drums, pistons, wedges, springs, welded parts, electromagnetic brake device, clutches |
| **Movement mechanism** | Wheel, rails, limit switch, couplings, rolling surfaces | **Electrical components** | Electric motor |
| **Hydraulics components** | Pumps, valves, hoses, pipelines, cylinders, hydraulic motor | **Cabin of operator** | Radio-devices, heating, ventilation and air conditioning (HVAC) system |

## 3. Effective noise management – inspections and maintenance

### 3.1 Crane inspections: Types of inspections and essential instruments

Crane inspections represent second step in resolving the problem of noise produced by cranes. Regular inspections of cranes are important in detecting potential risks that can lead to accident during the work and it can represent the potential deficiency of elements that increase noise levels and indicate the possibility of serious accidents during the work with cranes.

Since the elements of cranes must go through detailed inspections, according to Labour Department UK (2001) and Goodwin & McClave (1993) there are different types of crane inspections and essential instruments used to achieve those inspections, such as:

- **Visual inspection (VI)** – includes checking and examining the condition of individual parts of lifting equipment to identify any problems that could impact on integrity of crane with use of adequacy lightning, hammer, loupe, binoculars, endoscopes, borescopes or 3D video – systems, with additional hammer testing;
- **Dimensional inspection (DI)** – includes check of dimensional tolerances of deformations of certain key components and configurations that matter affect the stability, performance and function of the lifting equipment with use of rulers, protractors and callipers;
- **Functional testing (FT)** – consists of the unloaded test and the load performance test in order to check the functionality of various operational and safety systems of the crane, and it includes using the load testing such as concrete or metal blocks/panels;
- **Equipment opening (EO)** – includes check of any covered, closed, hidden or wrapped components to verify whether they are within the limits

recommended by the manufacturer's specification, and it includes using the tools specified by manufacturer;

- **Electrical testing (ET)** – consist electrical tests by authorized electricity operators;
- **Non – destructive testing (NDT)** – includes different methods such as liquid penetrant testing (use of penetrant solution and developer, visible or UV light), magnetic particle testing (use of alternating current (AC) magnetic yoke or a permanent magnet set), electrical testing methods (use of ACPD or ACFM catheter) , ultrasonic testing (use of ultrasonic kit), X-ray testing (via X-ray device), acoustic emission (AE) technique (via AE instrument), microscopic level testing, thermography (using thermal cameras), optical laser – based techniques or monitoring vibrations and creating their footprint using a vibrometer.

### 3.2 Crane inspections: Systematization of recommended inspection methods for key noise – producing elements of cranes

After defining types of inspections and essential instruments used to achieve those inspections, for the every key noise-producing element of the crane, systematization of recommended inspection methods is done and showed in Table 2 based on Labour Department UK (2001), ACT (2022) and Dickie, D. E. D. (1975).

*Table 2: Systematization of recommended inspection methods for key noise – producing elements of cranes*

| Element of crane | | TYPES OF CRANE INSPECTIONS | | | | | |
|---|---|---|---|---|---|---|---|
| | | VI | DI | FT | EO | ET | NDT |
| **Supporting structure** | Turntable | • | / | • | / | / | liquid penetrant testing, magnetic particle testing, X-ray testing, AE technique, thermography, NDT test for cracks |
| **Gripping devices** | Sheaves, Hoist drums, Sprockets | • | • | • | / | / | magnetic particle testing, NDT test for cracks |
| **Movement mechanism** | Wheel | • | / | unloaded test | / | / | / |
| | Rails | • | / | unloaded test, ground voltage measuremen t | / | / | magnetic particle testing, ultrasonic testing, X-ray testing, optical laser –based techniques |
| | Limit switch | • | / | • | / | / | / |
| | Couplings | • | • | unloaded test | / | / | / |
| | Rolling surfaces | • | / | unloaded test | / | / | / |
| **Crane drive mechanism** | Gearbox | • | / | / | • | / | / |
| | Shaft | • | / | / | • | / | |
| | Belt pulleys | • | / | / | • | / | / |

*Continuation of the Table*

| Element of crane | | TYPES OF CRANE INSPECTIONS | | | | | |
|---|---|---|---|---|---|---|---|
| | | VI | DI | FT | EO | ET | NDT |
| | Bearings | • | / | / | • | / | / |
| | Gears | • | • | / | • | / | magnetic particle testing |
| | Reducer | • | / | • | • | / | / |
| | Electric motor | • | / | • | • | • | / |
| | Couplings | • | • | / | • | / | / |
| **Braking mechanism** | Brakes | • | • | unloaded test | • | / | / |
| | Brake pads | • | • | unloaded test | • | / | / |
| | Brake discs | • | / | unloaded test | • | / | / |
| | Brake drums | • | / | unloaded test | • | / | / |
| | Pistons | • | / | unloaded test | • | / | / |
| | Wedges | • | / | unloaded test | • | / | / |
| | Springs | • | / | unloaded test | • | / | / |
| | Welded parts | • | / | unloaded test | / | / | magnetic particle testing, AE technique |
| | Electromagnetic brake device | • | / | unloaded test | • | / | / |
| | Clutches | • | / | unloaded test | • | / | / |
| **Electrical components** | Electric motor | • | / | / | • | • | / |
| **Hydraulics components** | Pumps | • | / | • | / | / | / |
| | Valves | • | / | • | / | / | / |
| | Hoses | • | / | • | / | / | electrical testing methods |
| | Pipelines | • | / | • | / | / | electrical testing methods |
| | Cylinders | • | / | • | / | / | NDT test for cracks, magnetic particle testing, AE technique |
| | Hydraulic motor | • | / | • | • | / | / |
| **Cabin of operator** | Radio-devices | • | / | / | / | / | / |
| | HVAC system | • | / | • | • | / | / |

### 3.3 Crane inspections: Timeframe for Execution of Inspection and Testing of Cranes

Inspection and appropriate testing of cranes must be implemented in sufficiently frequent intervals to ensure crane parts that are subject to deterioration due to corrosion, damage, wear, abrasion, be replaced before become unusable with production of strange sound and noise. Table 3 outlines the timeframes for inspecting key noise-producing elements of cranes, based on various authors and their proposed inspection intervals.

*Table 2: Timeframes for inspecting key noise-producing elements of cranes*

| **ACT (2022)** | | | | |
|---|---|---|---|---|
| **Inspection and testing before installation** | **Inspection and testing during commissioning** | **Routine inspection and maintenance** | **Annual inspection (12 months or longer)** | **Major inspection** |
| All the elements | | | | |
| Operator inspection (before working-shift) | Turntable, Sheaves, Hoist drums, Sprockets, Wheel, Rails, Limit switch, Couplings, Rolling surfaces, Brakes, Brake pads, Brake discs, Brake drums, Pistons, Wedges, Springs, Welded parts, Electromagnetic brake device, Clutches, Electric motor | | | |
| **Labour Department of United Kingdom (2001)** | | | | |
| **Daily** | | **Weekly** | | **Monthly/ Quarterly** |
| All the elements – visual inspection | | Sheaves, hoist drums, sprockets, braking mechanism, movement mechanism, electric motor, hydraulic components | | Depends on manufacturer's manual conditions |
| **Dickie, D. E. D. (1975)** | | | | |
| **Frequent (1-5 days)** | | **Monthly** | | **Annual** |
| Supporting structure (VI,FT)<br>Gripping devices (VI, FT)<br>Crane drive mechanism (VI)<br>Movement mechanism (VI, FT)<br>Braking mechanism (VI, FT)<br>Hydraulics components (VI, FT) | | Gripping devices (check for cracks, DI)<br>Crane drive mechanism (DI,EO)<br>Movement mechanism (DI)<br>Braking mechanism (DI, EO)<br>Electrical components (VI, EO)<br>Hydraulics components (EO)<br>Cabin of operator (FT, VI, EO) | | NDT for all elements<br>Electrical components (EI, every 6 months) |

Additionally, apart from the mentioned inspections, it is necessary for every crane that spends a year or more at the same construction site to undergo a detailed visual inspection of each welded part. NDT testing must be performed before the crane is moved to another location or construction site (Dickie, D. E. D., 1975).

Within the framework of the time definition of tests by NDT methods, a significant difference can be observed in inconsistencies in inspection intervals – according to ACT (2022) NDT tests are carried out earlier installation and during the exploitation of the equipment every 5 or 10 years, depending on the component being used subject to examination. On the other hand, the Dickie, D. E. D. (1975) suggest that NDT tests are carried out as part of annual inspections in order to maintain the means and equipment for lifting loads in the best and safest condition. Significant problem represents the non-uniform system of inspection and verification where there the time intervals of inspection are inadequately determined.

When comparing Rulebook on the procedure of inspection and checking of work equipment and testing of working environment conditions (2023) with ACT (2022) it is observed a significance difference in time interval for preventive inspections, since Rulebook proposes that inspection and testing must occur as specified by technical regulations or manufacturer's instructions, within three years

of the last inspection, with exception for electrical installations (inspection every six months).

### 3.4 Crane management: Regular maintenance

Maintenance represents the combination of technical, administrative and management measures which are undertaken around the entire life of the equipment with the aim of re-use establishing the condition of the equipment so that it can perform its intended functions. During equipment maintenance, a variety of activities are carried out, such as monitoring, inspection, testing, repair, replacement, cleaning, lubrication, tidying up, but also implementation of preventive activities (KTF standard 2015). Maintenance should be carried out in accordance with the manufacturer's instructions, aimed at preventing possible malfunctions lead to dangerous situations and documented.

Important step when maintaining the cranes is that the control book must be filled out regularly and contain basic information about the crane (ex. location, crane operators, data on periodic inspections and tests etc.). To conduct the maintenance, the crane is located on the place of the easiest access in the least disruptive location. The space under the crane must be fenced off and secured from access of unemployed persons. All drives must be switched off, and in special cases when maintenance work is being carried out must be performed during the operation of one of the crane drives (and there is no risk of injury) is ensured continuous audio or visual communication between the crane operator and the maintenance person.

According to KTF Standard (2015) maintenance of crane can be organized like three lines of maintenance:

- First line of maintenance – dialy, periodic and preventive maintenance performed by the crane operator in accordance with the descriptions in the user manual;
- Second line of maintenance – minor repairs and services that do not require approval or execution by the manufacturer;
- Third line of maintenance – major maintenance, significant services, and repairs/reconstructions that require approval or execution by the manufacturer.

On the other hand, CCOHS (2024) simplifies the maintenance of crane, by dividing the activities of maintenance in two groups, first group is breakdown maintenance, which is conducted after a reported failure, including the reparation of crane as soon as possible, and second group is preventive maintenance which is conducted twice a year, includes inspection of all the elements and theirs purity.

In order to better organize the maintenance process, it is necessary to form maintenance lists which will include the key noise – producing elements in cranes of importance for the safe operation of the crane which are specified by the manufacturer, engineer or company requirements.

## 4. Conclusion

The steps in this research (identification of key noise-producing elements of cranes, systematization of recommended inspection methods for key noise–producing elements of cranes, and defining time-frames for their inspection and testing) show that they contribute to reducing the noise level. By conducting regular maintenance of key elements of the crane, sources of noise can be detected and eliminated before major damage or downtime occurs. Through effective noise management that includes consistent inspection and monitoring, noise damping measures, and a set of preventive measures, the noise levels are kept within safe limits, lowering health risks to workers, such as hearing loss and other health issues.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# EXPLORING THE POTENTIAL OF SEDIMENT BENEFICIAL USE: ECONOMIC VIABILITY AND ENVIRONMENTAL SUSTAINABILITY

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***Abstract***

*Over the past few decades, sediment has gained recognition as a challenging resource, attributed to its potentially harmful effects and the substantial volumes found within aquatic environments. Although, traditionally viewed as a waste product of dredging operations, sediment holds immense potential for beneficial use across multiple sectors, offering economic benefits while addressing environmental concerns. The utilization of sediment as a construction material constituent offers a sustainable alternative to virgin resources, reducing extraction pressures and lowering production costs. However, the economic feasibility of sediment beneficial use hinges on several critical factors. The quality of sediment, including its contamination levels and necessitates appropriate treatment measures. Process of solidification and stabilisation uses binders to physically strengthen the sediment for structural engineering use while also reducing the mobility and solubility of the contaminant. Different waste materials can be used as additional binders, in the remediation process. Their effectiveness is evaluated based on the microstructural properties and chemical integrity of produced aggregates. Transportation costs and regulatory frameworks further shape the economic landscape, impacting project viability and scalability. Market demand for recycled materials and technological advancements in sediment processing play pivotal roles in unlocking its economic potential. This research underscore the importance of a comprehensive understanding of sediment management strategies, balancing economic considerations with environmental sustainability goals. Through innovative approaches and collaborative efforts, sediment beneficial use can emerge as a cornerstone of circular economy principles, driving economic growth while preserving and enhancing natural ecosystems.*

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***Key words:*** *sediment beneficial use, economic assessment, environmental sustainability.*

## 1. Introduction

Dredging is essential for maintaining and developing waterways, ports, and navigation channels, as well as for land reclamation, flood management, and environmental restoration. Dredged material, composed of natural sediments such as clay, silt, sand, gravel, rock, and organic matter, is increasingly recognized as a valuable resource rather than a waste product [CEDA,2019a and 2019b]. Sustainable management of dredged sediments, with an emphasis on their beneficial reuse, offers both environmental and economic advantages [Yung et al,2024]. Beneficial reuse refers to the application of dredged or naturally occurring sediments in a way that aligns with human development goals while being compatible with environmental and ecosystem needs. In this context, dredged material should be considered a resource that can contribute positively to society, rather than waste requiring disposal. Its reuse can provide significant societal, environmental, and financial benefits, particularly given the large volumes of dredged material that are typically involved in such projects. Effective management of these materials represents a significant opportunity for sustainability [Suedel et al, 2021].

For construction projects such as the development of cycling paths, one potential application of dredged material is as a substitute for conventional materials like natural sand. The economic feasibility of using dredged sediment in such applications, however, depends on several factors, including the quality, quantity, and availability of the material, as well as its suitability for the intended purpose [Almokdad and Zentar, 2023]. Dredged material may require minimal or no treatment if it meets the appropriate specifications for use, but its suitability for construction purposes—such as compaction, drainage, and durability—needs to be carefully assessed [Almokdad and Zentar, 2023; Yung et al,2024]. The availability of dredged material is another critical factor, as it involves logistical considerations such as sourcing, transportation, and storage. Proximity to the construction site, the timing of material availability, and coordination with ongoing dredging activities can significantly influence the economic costs associated with using dredged sediments [Garbarino et al, 2016].

Although the initial costs of dredging, processing, and transporting sediments may exceed those of using natural sand, the long-term economic and environmental benefits of using dredged material should also be considered. These benefits may include reduced disposal costs, the potential for environmental impact mitigation, and contributions to sustainability through the circular economy [Wijdeveld, 2024]. Furthermore, the social acceptability of using dredged material is an important factor, as local communities and stakeholders may have concerns regarding

environmental impacts or other issues. Engaging with stakeholders and conducting environmental impact assessments are essential for ensuring the broader social and environmental acceptability of dredged sediment reuse [Wijdeveld, 2024].

This study aims to assess these variables in order to provide a rough estimate of the relative economic costs of using dredged sediments versus natural sand in the construction of cycling paths.

### 1.1 Methodology

The economic section of the study pertains to the cost estimation for the construction of road infrastructure (cycling paths, access roads, etc.) on a selected watercourse, which needs to be dredged due to sediment accumulation. This study would be aimed at supporting tourism development and includes components with a social-societal aspect. The project budget is defined by differential costs, which include the transportation of the dredged material, considering that other costs (such as dredging costs, costs for testing the composition of the material, and others) are shared costs that exist in both options (Option 1 – disposal of dredged material, versus Option 2 – construction of a cycling path using the dredged material).

For the comparison of different sediment management options, the costs associated with constructing the landfill body were considered for the disposal option, while the total costs of constructing the cycling path were considered for the alternative option. All calculations were based on the same volume of sediment—1000 $m^3$.

When calculating the construction of a 2.5-meter wide cycling path, which can be built within the previously defined budget, the following construction activities were considered:

- The preparation works include marking the site. The contractor is required to protect all markers of the state trigonometrical network from damage during the execution of works and must replace any damaged or destroyed markers at their own expense. Before starting the main works, the contractor must, in the presence of the relevant organization, mark all underground utilities that intersect with the cycling path.
- Land clearing is performed on the areas where the cycling path will be constructed, or as instructed by the supervisor if modifications or adjustments to the original plan are required due to actual field conditions. Land clearing includes cutting shrubs, bushes, and vegetation using a bulldozer, followed by loading and transporting the cleared material to the landfill.
- Earthworks include the machine excavation of the humus layer, which is removed using a grader to level and smooth the ground. Additionally, material is spread and levelled for the embankment, using suitable material for constructing the embankment.
- The pavement structure is constructed by stabilizing the soil with hydraulic binders to create a bearing road structure.

## 2. Results

The Figure 1. compares the costs associated with two management options for 1000 $m^3$ of dredged sediment: disposal and the construction of a cycling path using the dredged material.

For the disposal option, the total cost is estimated at 4,665,506 RSD, which includes expenses related to the transportation and placement of the sediment in a landfill or designated disposal area. In contrast, the cycling path option, which involves using the dredged material for infrastructure development, is projected to cost 3,611,351 RSD. This lower cost reflects the potential reuse of the sediment as a construction material for the path. The cost for building the cycling path includes the preparation of the site, the earthworks required to integrate the dredged material into the path construction, and other associated infrastructure costs.

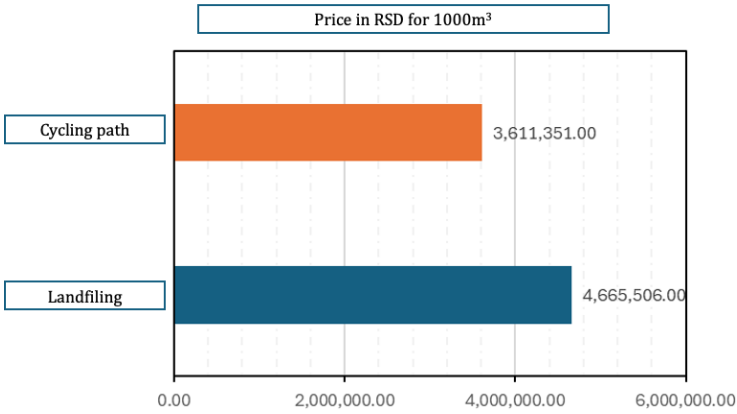


*Figure 1: Cost Calculation of Different Sediment Management Options: landfilling vs. Cycling Path Construction*

The significant difference in costs between the two options highlights the potential economic benefits of repurposing dredged sediment for construction projects. While the disposal option involves a higher expenditure, using dredged material for beneficial purposes, such as building a cycling path, not only reduces the financial burden of disposal but also contributes to sustainable infrastructure development. Additionally, the reuse of dredged sediment can mitigate the environmental impact of transporting and disposing of the material, supporting broader sustainability goals.

The Figure 2 presents a comparison of the costs for constructing a cycling path with a width of 2.5 meters using two different materials: natural material and dredged sediment. For preparation works, the cost per meter is the same for both materials, at 2,875 RSD. This includes tasks such as site marking and clearing, which do not vary depending on the type of material being used. In the earthworks

category, which involves activities such as excavation and material leveling, the cost for using natural material is significantly higher at 26,829 RSD per meter compared to 8,073 RSD per meter when using dredged sediment. The lower cost for dredged sediment is attributed to the fact that it is being reused, thereby reducing the need to transport and source additional materials. For the pavement structure—which refers to the construction of the actual cycling path surface—the cost is lower when using natural material (7,520 RSD per meter) compared to dredged sediment (14,945 RSD per meter). This difference arises due to the additional processing and stabilization required to use dredged sediment as a construction material, making it more expensive in this stage of the process.

Total construction costs per meter, using dredged sediment results in a lower overall cost of 25,893 RSD per meter, compared to the 37,224 RSD per meter for natural material. This cost-saving is due to the reduced earthworks and material transport expenses associated with dredged sediment, which offset the higher costs of stabilizing the material for use in the cycling path.

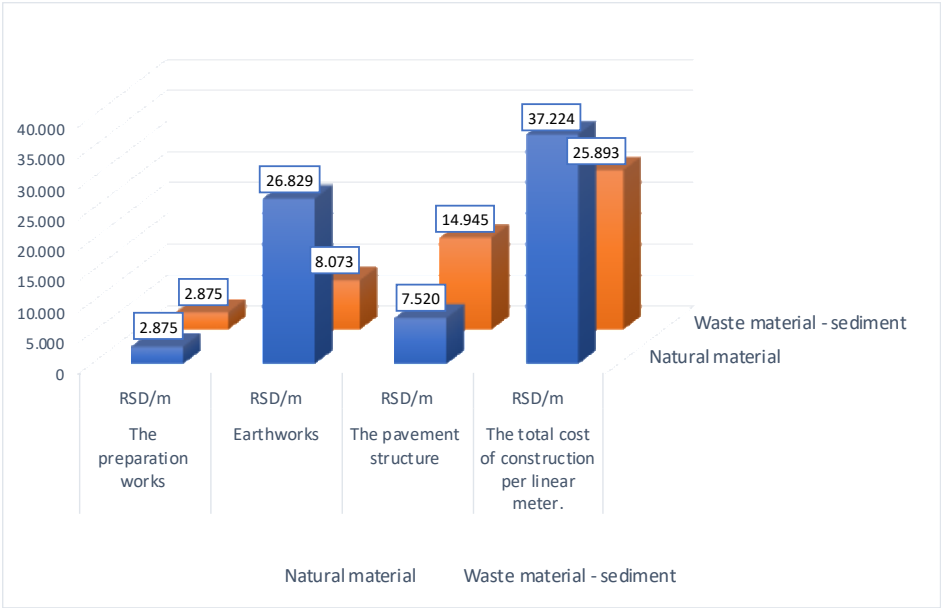


*Figure 2. Economic Cost Comparison: Dredged Sediment vs. Natural Material (Sand) for Cycling Path Construction*

## 2.1 Environmental Benefits

From an environmental protection perspective, the project contributes to reducing the amount of sediment present at the bottom of the river. The implementation of the project activities increases the depth of the riverbed, which in turn increases the flow. By increasing the flow, sediment transport is enhanced, sedimentation is reduced, and the possibility of re-sedimentation of the riverbed is

minimized. The increased flow positively impacts the active part of the channel, increasing the diversity of the riverbed, which in turn improves habitat variety, benefiting both plant and animal species.

Regarding global emissions, it is estimated that the construction industry accounts for about 10% of total $CO_2$ emissions. The construction and maintenance of transportation infrastructure not only entail significant administrative costs but also require large amounts of energy and water, deplete natural resources, and increase greenhouse gas (GHG) emissions [United Nations Environment Programme, 2024].

In 2016, the European Commission adopted a document titled "*Criteria for Green Public Procurement for the Design, Construction, and Maintenance of Roads*" aiming to promote the use of products, services, and works with a reduced environmental impact. Additionally, in December 2019, the *European Green Deal* was adopted, which aims to achieve net-zero greenhouse gas emissions by 2050.

In the context of these goals, the focus has shifted towards developing methodologies for assessing sustainability in the construction of transportation infrastructure. One of the key aspects is the beneficial reuse of materials, such as river sediment, which can have a wide range of applications in various construction projects. This approach not only reduces the need for transporting sediment over long distances but also promotes greater sustainability by lowering greenhouse gas emissions from transport.

## 4. Conclusions

This study has demonstrated the potential economic and environmental benefits of using dredged sediments for the construction of cycling paths, as compared to the conventional use of natural materials like sand. The analysis of construction costs reveals that, while the initial stages of dredging and processing may involve higher costs for dredged sediment, the overall cost of using dredged material for infrastructure projects can be significantly lower than the costs associated with disposal. This is particularly evident in the case of constructing a 2.5-meter wide cycling path, where the use of dredged sediment results in reduced earthwork and transportation expenses, ultimately leading to lower total construction costs.

From an environmental perspective, the project offers multiple advantages. The use of dredged sediment reduces the need for disposal, mitigating the environmental impact of transporting and landfilling large quantities of material. Moreover, the increased riverbed depth resulting from dredging enhances sediment transport and minimizes re-sedimentation, contributing to the overall health of the waterway ecosystem. The reuse of dredged sediment also supports sustainability goals by reducing the consumption of natural resources and minimizing carbon emissions, especially when considered in the context of broader transportation infrastructure development.

The findings underscore the importance of considering dredged material not as waste, but as a valuable resource that can support both economic development and environmental protection. The financial savings from repurposing dredged sediment, combined with the potential to reduce environmental impacts and enhance sustainability, highlight the importance of incorporating beneficial reuse practices into infrastructure projects.

In conclusion, this study contributes to the growing body of knowledge on the sustainable management of dredged sediments, offering a practical framework for decision-makers to consider the economic viability and environmental benefits of reusing dredged material in infrastructure projects. The results suggest that, with careful planning and regulatory support, the use of dredged sediment in projects such as cycling path construction can be a highly beneficial approach, providing long-term economic, environmental, and societal benefits.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# POSSIBILITIES FOR FOSTERING URBAN DEVELOPMENT IN CITIES AND REGIONS THROUGH THE IMPLEMENTATION OF INTERDISCIPLINARY RESEARCH OUTCOMES WITHIN THE FRAMEWORK OF INTERNATIONAL PROJECTS

*Milena Krklješ,*[1] *[0000-0003-4252-258X], Dejana Nedučin*[2] *[0000-0002-9828-072X]*

***Abstract***

*Urban development is a critical factor in the overall advancement of society. The discourse on sustainable development of both local environments and entire regions is increasingly framed within a transdisciplinary context. In this framework, diverse heritage plays a crucial role in promoting local values, enhancing cultural dimensions, stimulating tourism, and thereby driving the economic development of communities. The implementation of interdisciplinary findings and conclusions from various thematic frameworks of international projects can significantly contribute to this process. This paper aims to identify and elucidate the potential of various urban design methodologies in urban planning, particularly in areas of significant tangible and intangible heritage. It is considered that local values of distinct locations can be substantially enhanced through urban design that acknowledges and preserves heritage as a generative element. This approach facilitates the connection of disparate places, enhances the visibility of diverse communities, and yields benefits not only at the local level but also across the broader region.*

***Key words:*** *urban development, cities, cultural heritage; international projects*

## 1. Introduction

Urban development in contemporary cities and regions presents a complex challenge that demands innovative, interdisciplinary approaches. As cities confront pressures such as population growth, environmental change, and socio-economic disparities, there is a growing need for sustainable and inclusive development. In this context, interdisciplinary research plays a critical role in identifying and

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implementing solutions that address these multifaceted challenges. Cultural heritage, both tangible and intangible, holds exceptional potential to foster not only local development but also international and intercultural connections. Recognizing and harnessing the value of cultural heritage can create powerful synergies in urban development.

This paper explores the possibilities for fostering urban development through the implementation of interdisciplinary research outcomes, with a particular focus on the role of cultural heritage. It examines how the integration of cultural heritage into urban planning and international collaborations can foster sustainability, resilience, and inclusivity in city growth. Drawing on successful case studies and ongoing initiatives, the research demonstrates how leveraging cultural heritage as a key component in urban development projects can promote long-term economic and social benefits for both local communities and broader regions.

## 2. Cultural heritage as a tool for urban development

In modern cities, the growing demand for industrial and residential space has led to uncontrolled urban sprawl. Historic cities face significant challenges due to suburban expansion and the difficulties of revitalizing their urban cores. These challenges are often exacerbated by modern aesthetics and short-sighted administrative decisions that prioritize superficial heritage renewal while neglecting the need for sustainable solutions. Such solutions should incorporate progressive urban design that respects tradition, enhances heritage, and fosters urban solidarity. Urban regeneration, including the selective expansion of historic areas and the introduction of pedestrian zones, is crucial for sustainable development. It must prioritize long-term sustainability and be aligned with sound economic principles (González González & Torres, 2011). Integrated urban development policies merge architecture, urban planning, and infrastructure to create environments that prioritize high quality of life and sustainability. This approach regenerates cities through sustainable models focused on innovation, urban area rehabilitation, and resilient infrastructure (Sofeska, 2016).

Cultural heritage is a key element in urban development, encompassing both tangible and intangible aspects of the built environment that shape the identity of a region. When integrated into the daily life of communities, it significantly enhances their overall development. Recognizing the potential of cultural heritage, many local communities and administrations now prioritize its role in sustainable urban planning. Beyond the technical responsibility to protect heritage from degradation, there is a growing need to make it accessible to a wider audience and integrate it into sustainable development strategies (ICOMOS, 2011; UNESCO, 2011). The social dimension of sustainable development emphasizes improving citizens' quality of life by promoting social equity and ensuring equal access to education, livelihoods, and resources. This dimension is particularly relevant to cultural heritage, as it is an integral component of sustainable development strategies (Tweed & Sutherland, 2007). The implementation of cultural heritage within urban development goes

beyond tourism. It involves carefully balancing preservation with modernization, ensuring that heritage sites are protected while being adapted for contemporary uses (Figure 1). This process includes enhancing the visibility of heritage sites, developing new, culturally significant events, and improving supporting infrastructure.

Local communities play a vital role, with their cultural practices enriching the region's narrative and fostering social cohesion. To ensure heritage management aligns with urban development, five principles are essential: raising public awareness, encouraging participation, fostering cultural diversity, promoting social and economic viability, and managing change. These principles, when applied in managing historic public spaces, significantly contribute to improving urban environments and preserving cultural values in urban development process (Pourbahador & Brinkhuijsen, 2023).

*Figure 1: Two-century-old silk dyeing factory renovated as the Svilara Cultural Station.*

Public participatio|n is widely recognized as an effective approach to addressing urban challenges and enhancing functional urban spaces (Shuib et al., 2015; Syukron, 2022). Community awareness and appreciation of their own heritage can stimulate greater visitation, thereby improving both individual sites and the broader region. International organizations responsible for cultural heritage protection, such as UNESCO and ICOMOS, emphasize the need for holistic and integrated heritage impact assessments that consider both technical and social dimensions. These assessments support decision-making processes across various levels of urban heritage management (Ornelas et al., 2023).

Appropriate planning of public spaces is critical in improving the quality of life, especially in developing countries where socio-economic disparities affect social and territorial cohesion. Public participation in these decision-making processes is vital for fostering local engagement and ensuring that urban planning addresses the needs of the population (Jiménez-Caldera et al., 2024). By fostering dialogue and collaboration among stakeholders, public participation minimizes potential conflicts and enables the sustainable development of heritage tourism,

benefiting both local communities and the broader urban environment (Aas et al., 2005).

## 3. International projects as framework for the fostering of urban development

Research focused on issues of urban development is undoubtedly significant, as its findings can be implemented in current urban planning projects and recommendations. Through an interdisciplinary approach, it is possible to influence decision-making and initiate activities at various institutional levels, aiming to improve the condition of cultural heritage, which in turn would have a positive impact on the urban development of the area.

Different options of integration of heritage and urban development along the Danube River have been implemented through 3 different EU-funded international projects: Interreg Danube Transnational Programme DTP 1-1-249-2.2 DANUrB - Danube Urban Brand - a regional network building through tourism and education to strengthen the Danube cultural identity and solidarity, Interreg Danube Transnational Programme DTP3-1- 359-2.2 LIVING DANUBE LIMES - Valorising cultural heritage and fostering sustainable tourism by LIVING the common heritage on the DANUBE LIMES as basis for a Cultural Route and ERASMUS + PROGRAMME: Innovative Teaching for Inclusive Development in Small and Medium Sized Danubian Cities – DANUBIAN SMCs, 2019-1-RO01-KA203-063878.

Within the mentioned projects in cities along the Danube River (Figure 2), various aspects of cultural heritage, which can serve as a catalyst for urban development, were examined. Workshops for students and educators, the results of which were published and made accessible to a wide range of interested parties, along with numerous stakeholders involved in the projects, contributed to the activation and increased visibility of the region's urban heritage within urban areas.

*Figure 2: Novi Sad, Serbia (on left) and Budapest, Hungary (on right).*

Although the spatial framework for the implementation of the projects was extremely broad and comprehensive, which has resulted in numerous differences between settlements across the various Danube regions, especially in terms of socio-economic inequality, all regions participated equally in the activities and implementation of the results to improve the level of development both locally and

regionally. However, each project emphasized a different aspect of integrating cultural heritage into urban development.

In the DANUrB project, the focus was on enhancing tourism potential to foster cross-border cultural connections between settlements along the Danube by exploring underutilized cultural and social resources for better economic and cultural development, aiming to highlight and strengthen the regional identity of cultural heritage along the Danube.

By concentrating on the heritage of the Roman Limes and striving to present the traces that exist along the Danube from the Roman Empire, the thematic framework of the Living Danube Limes project encompassed ancient sites along the river, combining tangible and intangible heritage. It emphasized a shared history while supporting cultural and natural differences along the former borders of the Roman Empire, which was a transnational cultural and economic waterway. The main goal of the project was to design activities that would bring history to life, offering a wide range of different tourism and educational products, thereby boosting the region's tourism development.

Like the two previously mentioned projects, DANUrB+ is a project with a thematic framework that covers settlements along the Danube, aiming to promote the rational use of cultural heritage and resources in peripheral and border cities and areas along the river. It seeks to create new opportunities for enhancing the attractiveness of selected settlements and reactivating underutilized cultural heritage to strengthen the Danube's identity (Krklješ et al., 2023). By analyzing the settlements along the river, possibilities emerge for creating a comprehensive urban development, one that involves cultural heritage and connects communities under a distinctive tourist brand. This approach could significantly increase the number of visitors and stimulate economic growth within these regions (Krklješ & Nedučin, 2023).

## 4. Conclusions

Urban development involves the integration of architecture, urban planning, design, and infrastructure within a framework that prioritizes sustainability and a high quality of life. This concept encompasses the transformation of cities, guiding urban planning models toward sustainable capital formation, innovation, the rehabilitation of specific urban areas, and the establishment of resilient urban infrastructure. It promotes a forward-thinking model of urban growth, emphasizing the need to reorient traditional urbanization approaches. Rather than relying on conventional planning methods, it calls for the creation of an adaptive urban structure.

A key aspect of this urban development model is its consideration of cultural heritage within a broader urban context, which includes social, cultural, economic, and environmental dimensions. By integrating these layers, this approach provides a mechanism to balance urban growth with quality of life through strategic planning and resource management. This balance is crucial for ensuring that urban expansion

does not compromise the cultural, environmental, and social integrity of a city, while fostering innovation and sustainability in the process.

The UNESCO (2021) guidelines articulate the significance of fostering economic opportunities for local communities through strategic public and private investments, as well as promoting innovative local entrepreneurship that supports sustainable development. This approach encourages the utilization of local resources and the advancement of creative industries, which simultaneously safeguard associated intangible heritage. Furthermore, the guidelines emphasize the essential function of national and local regulatory frameworks, coupled with rigorous monitoring and impact assessments of economic, social, and environmental changes.

Such measures are crucial to ensuring that these transformations do not undermine the authenticity and integrity of world heritage sites. Ultimately, these strategies are vital for the long-term conservation of the area's outstanding universal values, reinforcing the interconnectedness of cultural heritage and sustainable development.

The aforementioned projects exemplify how cultural heritage can be effectively integrated with international expertise to foster a dynamic and economically advantageous urban environment. By leveraging cultural heritage alongside other urban resources, this approach can serve as a foundational element for sustainable urban development. Such a synergy not only enhances the economic viability of urban areas but also enriches the cultural fabric, contributing to a holistic approach to urban development.

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# IMPACT OF INDOOR AIR QUALITY ON WORKERS HEALTH AND PRODUCTIVITY

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***Abstract***

*Harmful health outcomes from exposure to air pollution have been documented for decades. Air pollution outdoors and indoor air pollution have detrimental effects on workers' health and productivity in different working environments. Indoor air pollution seriously affects occupants' health as individuals spend most of their time indoors completing other activities of daily living, working, and sleeping. A large number of epidemiological research have demonstrated that the influence of indoor air pollution results in damaging health effects. Various kinds of indoor air contamination have different impacts on occupants. Environmental conditions and individual human characteristics are associated with illness distribution, and people experience results differently. Some factors may enlarge the risk of adverse health outcomes, while others can promote health and well-being. This paper aims to summarize the different aspects of exposure to indoor air pollution and the adverse effects of indoor air pollution on workers' health and productivity in various working environments.*

***Key words:*** *indoor air pollution, working environment, occupational safety and health*

## 1. Introduction

Indoor air pollution (IAP) has become a considerable public health concern as people spend about 90% of their time indoors (Chijioke et al., 2023). This includes homes, offices, and other workplaces where inadequate air quality can cause health issues and decreased productivity. Several studies have shown the unhealthy effects of indoor air pollutants such as volatile organic compounds (VOCs), particulate matter, mold, and carbon dioxide ($CO_2$) (Seguel et al., 2017).

This paper aims to summarize the various types of indoor air contaminants, their health impacts, and the connection between indoor air quality and worker

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productivity. It will also examine individual characteristics that affect susceptibility to IAP and the environmental circumstances that worsen these effects.

## 2. Types of Indoor Air Pollution

### 1.1 Volatile organic compounds

Volatile organic compounds (VOCs) are a group of organic substances that quickly evaporate at room temperature. They are usually found in numerous everyday products in offices, factories, and other working environments. Sources of VOCs include paints, solvents, adhesives, cleaning agents, office equipment like printers and copiers, and even furnishings. Exposure to VOCs can lead to a spectrum of short-term health effects, such as headaches, dizziness, eye and respiratory irritation, and nausea. Long-term exposure may result in more intense health issues, including damage to the liver, kidneys, or central nervous system. Certain VOCs are also classified as carcinogenic, meaning they could potentially contribute to cancer (Goodman et al., 2017).

### 1.2 Particulate Matter

Particulate matter (PM), particularly $PM_{2.5}$, is a significant indoor pollutant often found in environments with poor ventilation and combustion processes (e.g., from cooking or heating). Studies have linked exposure to PM with cardiovascular diseases, respiratory conditions, and even premature mortality.

Particulate matter (PM) refers to small particles or droplets in the air that can be inhaled. These particles vary in size, composition, and origin. They are typically categorized by size:

- $PM_{10}$: Particles with a diameter of 10 micrometers or smaller.
- $PM_{2.5}$: Fine particles with a diameter of 2.5 micrometers or smaller.

Industrial processes, combustion, cleaning activities, and natural and biological sources of particulate matter in the workplace are among the causes.

Elevated concentration levels of particulate matter in the working environment cause numerous harmful effects on health, including respiratory and cardiovascular problems, neurological effects, irritations, and allergic reactions (Felgueiras et al., 2022).

### 1.3 Mold and Biological Contaminants

Mold and other biological contaminants thrive in damp indoor environments and can cause allergic reactions, respiratory illnesses, and other health problems.

Mold is a type of fungus that thrives in damp environments, while biological contaminants include various microorganisms such as bacteria, viruses, and allergens (like pollen and pet dander). These can pose health risks in workplace settings.

### 1.3 $CO_2$ in working environment

$CO_2$ has been identified as a workplace hazard at high concentrations for over a century. However, it's crucial to recognize that $CO_2$ is naturally present in the air at a concentration of about 0.037% and is not dangerous to health at low concentrations. At room temperature and atmospheric pressure, $CO_2$ is a colorless and odorless gas, and because of this, people can't see it or smell it at higher concentrations. $CO_2$ is not combustible and will not support combustion. However, it's in caught spaces that the need for precautions is most crucial. As the concentration of $CO_2$ in the air rises, it can cause different health problems: headaches, dizziness, haze, and loss of attention. Since $CO_2$ is heavier than air, mortality from asphyxiation occur when, at high concentrations, it enters enclosed spaces such as tanks, sumps, or cellars and displaces oxygen. It's also possible for $CO_2$ to accumulate in channels or depressions outside following leaks, and this is more likely to occur following a pressurized release where the released $CO_2$ is colder than the surrounding air. These potential dangers highlight the need for strict protection in confined spaces to ensure the safety and protection of all employees (Zarco-Periñán et al., 2022).

## 2. Productivity Effects of Poor Indoor Air Quality

Inadequate indoor air quality (IAQ) directly affects health and productivity in the workplace (Saidin et al., 2020). Although it may not be visible, the symptoms of IAQ include decreased cognitive function, insufficient concentration, and lower productivity. Employers need to understand the threat of poor IAQ and the steps they can take to improve it.

### 2.1 Reduced Efficiency

Poor IAQ can significantly reduce overall work efficiency. Workers may struggle with fatigue, decreased motivation, and an inability to concentrate, leading to longer task completion times. A numerous studies found that improved IAQ correlated with increased employee performance and productivity.

### 2.2 Increased Sick Leave

Health issues stemming from poor IAQ often lead to increased absenteeism. Employees who experience respiratory problems or other health concerns are more likely to take sick leave, disrupting workflow and affecting team performance. According to the American Thoracic Society can incur substantial costs due to increased sick leave resulting from poor IAQ (Onwusereaka et al., 2022).

### 2.3 Employee Morale

Good IAQ contributes to a positive workplace atmosphere. Employees are more likely to feel valued and engaged in a clean, well-ventilated environment. High

morale can lead to better job satisfaction and lower turnover rates, further enhancing productivity and reducing hiring and training costs.

### 2.4 Enhanced Focus

A workplace with good IAQ enables employees to maintain focus and alertness. Enhanced concentration contributes to improved performance, creativity, and innovation, all of which are crucial in competitive business environments. Environments with optimal air quality foster a culture of productivity and engagement.

## 3. Strategies for Improving Indoor Air Quality

### 3.1 Regular Monitoring

Implementing air quality monitoring systems is essential for maintaining optimal IAQ. Regular assessments can help identify potential pollutants and areas for improvement, ensuring a healthier work environment.

### 3.2 Ventilation Improvements

Enhancing ventilation systems to ensure a continuous supply of fresh air is vital. Proper ventilation reduces the concentration of indoor pollutants and helps regulate temperature and humidity levels.

### 3.3 Use of Air Purifiers

Installing air purifiers can significantly reduce harmful particles and allergens in the air. HEPA filters, in particular, can effectively capture small particles that may contribute to poor air quality.

### 3.4 Maintenance of HVAC Systems

Regular maintenance of heating, ventilation, and air conditioning (HVAC) systems is crucial to ensure they function optimally. Neglected systems can become a source of pollutants, circulating dust, mold, and other contaminants throughout the workspace (Al-Awadi et al., 2019).

## 4. Conclusion

The impact of indoor air quality on workers' health and productivity cannot be overstated. Organizations that prioritize IAQ can enhance employee well-being, reduce health-related costs, and improve overall productivity. By implementing effective strategies to monitor and improve air quality, businesses can create a healthier, more engaging work environment that fosters employee satisfaction and success.

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# CYBERSECURITY RISKS WHILE DRIVING CAR

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***Abstract***

*In recent years, the automotive industry has experienced a significant transformation through the application of new technologies that enable the car to communicate with the outside world. This technological revolution has brought numerous advantages in terms of the safety of road users, comfort, and efficiency. Still, at the same time it has opened the door to new challenges in the field of cyber security. Also, newer vehicles increasingly rely on the use of a number of sophisticated technologies that include sensors, cameras, GPS, radar, LiDAR, and advanced computer systems. All the mentioned systems can be susceptible to cyber-attacks, which must not be allowed in order to avoid unwanted consequences. This paper explores current threats and vulnerabilities affecting vehicle cyber security, including attacks on network systems, unauthorized access to control modules, data security as well as software manipulation.*

***Key words****: autonomous vehicles, driving, cyber-attacks, network, unauthorized access*

## 1. Introduction

Autonomous vehicles are a set of advanced technologies that aim to revolutionize and improve road safety. These vehicles use multiple sensors and artificial intelligence to sense the environment and make independent decisions. AVs represent a significant advance in transportation, as they promise to reduce human error on the road, bring greater road safety, and provide mobility for people who are unable to drive traditional vehicles. However, AVs still face a number of challenges, including resistance to different weather conditions, foolproof cybersecurity and public acceptance of the use of such vehicles in everyday life.

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## 2. Autonomous Vehicles Levels and Vulnerabilities

The process of automation in vehicles involves several different levels, with each level of automation representing a different degree of autonomy. The National Highway Traffic Safety Administration (NHTSA) has proposed the following six-level categorisation of autonomous vehicles (NHTSA, 2024):

- No automation (level 0): The vehicle is fully controlled by the driver, who controls all functions such as steering, acceleration, and braking.
- Driver assistance (level 1): The vehicle is still under the control of the driver but has built-in driving aids such as automatic braking or lane departure warning.
- Partial automation (level 2): At this level, the vehicle is equipped with more advanced systems that can control the acceleration, deceleration, and steering of the vehicle, but the driver must be present and actively controlling the vehicle to be able to take control if necessary. .
- Conditional automation (level 3): The vehicle is capable of controlling all key driving elements under some controlled conditions. However, the driver must be present and ready to take control of the vehicle if requested by the system.
- High level of automation (level 4): A vehicle at this level can independently perform all necessary driving tasks in all conditions. The driver still has the option to take control of the vehicle, but this is not mandatory.
- Full automation (level 5): The highest level of automation. Such vehicles are capable of performing all necessary driving functions throughout the journey without human intervention.

As more advanced technologies are incorporated into autonomous vehicles, these vehicles become increasingly vulnerable to cyber threats (Harris, 2024). Potential hackers can exploit these cyber vulnerabilities, posing a threat to both road safety and user data security, whether motivated by simple curiosity or malicious intent. The following are examples of prominent attack vectors for autonomous vehicles that can compromise security:

- Key hacking: The key fob technology used in almost all vehicles today can be a target for attack. By using a device to amplify the signal, hackers can gain unauthorised access to the vehicle and even the ability to remotely start the vehicle (Algarni & Thayananthan, 2022).
- CAN bus attacks: Because the CAN bus lacks encryption and protection mechanisms in its basic design and is used as the current standard vehicle networking protocol, it can be a target for hackers. By exploiting vulnerabilities in the CAN bus, hackers can take over some of the vehicle's basic functions.
- Hacking the in-car entertainment system: As the in-car entertainment system uses technologies such as Bluetooth, OBD-II, Wi-Fi, and other

similar technologies, it can easily become a target for hackers and allow hackers to gain access to all other parts of the autonomous vehicle system.

- Theft of user information: Given the large amount of user data stored in autonomous vehicles, these vehicles are becoming prime targets for cybercriminals. By hacking into a vehicle's system, hackers could steal private information about both the vehicle and its owner and driver.
- Attacks from the sensor layer: Autonomous vehicles rely heavily on systems that use a range of advanced sensors, such as lidar, millimetre radar, cameras, and GPS. While these systems improve the safety and efficiency of vehicles, they also introduce new vulnerabilities that can have serious implications for road safety.

The wide range of potential attack vectors shows that one of the imperatives in the development of autonomous vehicles is to improve cybersecurity measures. A compromised vehicle poses a significant threat to all road users, which is why this part of the research related to autonomous vehicles is very important. This chapter presents the vulnerabilities of autonomous vehicles related to the On-Board Diagnostic (OBD) port, then to the Global Positioning System (GPS), as well as the vulnerabilities of sensor systems such as LIDAR and cameras.

### 2.1 Onboard Diagnostic Port (OBD) Vulnerability

The OBD port in both traditional and autonomous vehicles is a key component that provides access to gather diagnostic information. By connecting an external device to an OBD port, it is possible to send and receive data from the vehicle's ECU. Such an open connection can be used for malicious attacks on the vehicle system. One of the potential problems is unauthorised access to the vehicle; if an attacker had physical access to the OBD port, they would be able to connect external devices to extract data or even reprogram the vehicle's systems, which could lead to unauthorised control of the vehicle. As some vehicles have OBD ports that support wireless communications (Wi-Fi or Bluetooth), attackers can access the vehicle remotely without the need for physical access. One of the main problems is the lack of encryption, which means that data can be intercepted and manipulated. This can be a major problem if the intercepted data includes commands to critical systems such as steering, braking, or acceleration. In addition, the OBD port could give attackers access to a wide range of in-car information, such as the vehicle's location, speed, and even the personal details of the driver and passengers. Finally, the OBD port could be used to introduce malicious software that could alter the behaviour of the autonomous vehicle, posing a significant risk to road safety.

### 2.2 Global Positioning System (GPS) Vulnerability

The Global Positioning System (GPS) enables autonomous vehicles to accurately track their location and navigate routes, which is very important for their functioning. However, this dependence creates a potential vulnerability that can be

exploited by malicious individuals. If the security of the GPS system were compromised, hackers could potentially manipulate the signals, provide inaccurate information about the exact location of the vehicle, and even cause vehicle collisions, posing a serious threat to road safety (Kumar et al., 2018).

Attacks on the GPS system of autonomous vehicles take two forms: jamming and spoofing. A jamming attack is the emission of a stronger signal on the same frequency as GPS, causing temporary interference (Hu & Wei, 2009). A spoofing attack is a more subtle form of attack where the attacker emits fake GPS signals designed to mimic authentic ones. This type of attack causes the receiver to inadvertently accept false data as genuine. A spoofing attack would typically involve first jamming GPS signals to block the real ones, and then broadcasting spoofed signals to fool the system (Ahmad et al., 2019).

A well-executed attack on an autonomous vehicle's GPS system can seamlessly change the vehicle's location by transmitting a strong, false signal. Various defences, such as tracking identification codes, satellite signals and time intervals, can be used to counter such attacks. As the signal strength is around 163 decibel watts, blocking all higher frequency signals could also be one of the solutions to attack the GPS system (Yang et al., 2019). In their research, the authors developed an antenna-based method that combines anti-jamming and antispoofing techniques for GPS receivers. Currently, there is no fully reliable and practical solution to these attacks on the GPS system of autonomous vehicles. The only solution that can fully guarantee the security of the GPS system is the use of military-grade cryptography.

### 2.3 LiDAR System Vulnerability

One of the key components of any autonomous vehicle is the LiDAR system, which measures distance. By emitting pulses of light and measuring the time it takes for these pulses to reflect off distant surfaces, they create a three-dimensional map of the vehicle's surroundings. The LiDAR system's laser pulses, which are generated hundreds of times per second, are typically reflected off a rotating mirror to create a scan. If the vehicle can produce additional pulses, also known as echo signals, it can detect objects in different weather conditions.

As the LiDAR system is responsible for creating a three-dimensional image of the vehicle's surroundings, i.e. detecting obstacles around the vehicle, the safety of this system is crucial to maintaining road safety. One of the possible threats to this system is real signal attacks, which are a version of replay attacks that aim to change the actual positions of existing obstacles by broadcasting a new original signal from a changed location. To carry out such an attack, only two transmitters and one receiver are needed, as shown in (Petit et al., 2015).

Another possible threat is the spoofing signal attack, which is an extension of the real signal attack. The aim of such an attack is to create phantom objects by transmitting a signal at the same frequency as the scanner. A LiDAR system typically waits for incoming reflections for at least 1.33 microseconds, meaning that if an attacker could inject a signal into this time window, they would be able to

successfully inject false signals into the LiDAR and create false objects in the space around vehicles.

Attacks on the LiDAR system of autonomous vehicles can be very dangerous, with some attacks potentially leading to fatal accidents, especially on highways. For these reasons, the security of this system is one of the most important things to work on. One possible solution could be the use of unpredictable LiDAR. Such a LiDAR would skip pulses but continue to listen for incoming pulses. Another solution would be to reduce the duration of the LiDAR pulse, thus reducing the attack window in the sensor, although reducing the time would result in a reduction in the working range of the sensor (Petit et al., 2015). Another possible solution would be to encode the LiDAR pulses to mitigate these attacks.

### 2.4 Vulnerability of Camera in Autonomous Vehicle

Cameras in autonomous vehicles are used as optical eyes, providing digital video of the external environment. They are used in various autonomous vehicle functions such as lane tracking, traffic sign recognition, and headlight detection (Bahlmann et.al, 2005; Cheng et.al 2006).

One of the major vulnerabilities of camera systems is the possibility of being temporarily or permanently blinded by targeted light jamming. Such an attack could pose a significant risk to occupant safety, particularly in situations where the vehicle's ability to detect key traffic signs is compromised (Petit et al., 2015).

A similar form of attack exploits the recovery time required by cameras after exposure to high intensity light. During this time, autonomous vehicles may be more vulnerable to undetected obstacles. This type of attack could be carried out from any direction, front, rear, or even from an old vehicle, by switching a strong light source on and off (Petit et al., 2015).

One of the solutions to the problems described above would be to use a configuration consisting of a large number of cameras, with each camera recording the same field of view. In this situation, the attacker would have to confuse all the cameras at the same time, which would certainly make his job more difficult. Also, the use of a removable near-infrared filter could allow selective filtering of near-infrared light, increasing the camera's resistance to light-based attacks. And another way to protect would be to use photochromic lenses, which have the unique ability to change colour and block certain wavelengths of light (Petit et al., 2015).

### 2.5 Vulnerability of Ad Hoc Network in Autonomous Vehicle

The Ad Hoc network of autonomous vehicles consists of two main communication channels, namely vehicle-to-vehicle (V2V) communication and vehicle-to-infrastructure (V2I) communication. V2V communication is based on the use of peer-to-peer networking principles, allowing vehicles to establish connections with each other. The V2V communication system is based on the IEEE 802.11p protocol and is built on the principle that vehicles within a certain radio range can automatically form an ad hoc network. Vehicles are network nodes that

can exchange key information such as coordinate positions, directions, metric speeds, and many other data. V2I communication allows vehicles to connect to embedded electronic devices in the wider transport infrastructure system, such as traffic lights, information boards, and other similar devices. The information exchanged between vehicles and infrastructure can be used for a variety of applications, including improving traffic management, optimising traffic flow, promoting fuel efficiency, and reducing environmental impact.

V2V and V2I communication systems have significantly advanced the development and efficiency of autonomous vehicles, but these vehicle-to-vehicle communications are also vulnerable to various cyber threats. Ensuring system availability is a key aspect of the security framework for autonomous vehicles. One of the potential threats is denial of service (DoS) attacks, which can drain network resources and disrupt vehicle operations. Effective countermeasures include authentication measures, anomaly detection systems, and cryptographic solutions. It is also possible to infiltrate the vehicle system through V2V and V2I communications and install malicious software, such as a computer virus, to compromise the software infrastructure of autonomous vehicles. The use of firewall technology and anti-malware systems is recommended to protect against such threats (Pathre, 2013).

## 3. Discussion

Considering that AV vulnerabilities are numerous, and they are not limited to those already mentioned since they are only limitations related to cybersecurity, quantifying the exact percentage of each vulnerability is analysed. This is challenging due to the dynamic nature of the technology and varying degrees of exposure depending on the vehicle's architecture, the manufacturer's cybersecurity measures, and evolving threat landscapes. However, based on general industry assessments and the prominence of certain risks, here's a breakdown with approximate estimations:

1. OBD vulnerability 5-10%, since requires physical access to the vehicle, which reduces its exposure compared to remote vulnerabilities. However, in cases where an attacker gains physical access, they could use the OBD to exploit the vehicle's systems.
2. GPS vulnerability 10-15%, significant, but the use of multiple navigation systems in AVs can somewhat mitigate the risks. Therefore, it is placed in the 10-15% range, reflecting the importance of GPS while acknowledging the presence of complementary systems that reduce sole dependency on it.
3. LiDAR System vulnerability 20-25%, reflects the importance of LiDAR to overall system function and the potential dangers posed by spoofing, jamming, and environmental factors.
4. Camera vulnerability 15-20%, due to their importance and susceptibility to adversarial and environmental interference. This reflects the medium-

to-high risk posed by compromised camera systems, tempered by the use of redundant sensors like LiDAR and radar.

5. Ad Hoc network vulnerability 15-20%, is significant due to its decentralized nature, lack of strong control mechanisms, and susceptibility to attacks where an attacker floods the network with unnecessary data, overwhelming the system and preventing legitimate communications between vehicles and infrastructure. This could disrupt real-time decision-making and safety-critical information exchanges.

These percentages are estimations and can vary depending on the specific architecture of the AV system, the cybersecurity measures in place, and the evolving landscape of both AV technology and cyber threats.

## 4. Conclusions

Autonomous vehicles are complex systems that rely on a variety of technologies, including sensors, machine learning algorithms, communication systems, and control mechanisms. Despite their promise to improve road safety and reduce human error, AVs have several vulnerabilities that could be exploited by malicious actors or could lead to failures in operation. In this paper, several vulnerabilities were analysed, and estimations of vulnerability percentages are given. After thorough analysis, mitigation strategies should be proposed. Possible mitigation strategies can be end-to-end encryption, ensuring that communications between AVs, infrastructure, and cloud servers are encrypted can reduce the risk of man-in-the-middle attacks; regular auditing and patching since continuous monitoring for vulnerabilities in both hardware and software, coupled with timely patching, is crucial for minimizing risk, and implementation of fail-safe mechanisms, where a robust fail-safe system will be built that ensures that even when attacks or failures occur, AVs can safely bring themselves to a halt.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CYBERSECURITY ISSUES OF COMPUTING SYSTEMS

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***Abstract***

*In an era where digital transformation is integral to societal infrastructure, the imperative of robust cybersecurity measures in computing systems has never been more critical. This paper addresses the multifaceted cybersecurity issues confronting contemporary computing systems, encompassing hardware, software, and network vulnerabilities. We explore the evolving threat landscape characterized by sophisticated cyber-attacks, including advanced persistent threats, ransomware, and zero-day exploits. A comprehensive analysis is provided on the latest cybersecurity frameworks and protocols designed to mitigate these risks, with a particular focus on machine learning and artificial intelligence (AI) applications in threat detection and response. Additionally, we examine the role of emerging technologies, such as blockchain and quantum computing, in enhancing cybersecurity defenses. Case studies of recent high-profile cyber incidents are presented to underscore the practical implications of theoretical vulnerabilities and the effectiveness of contemporary security solutions. Furthermore, this paper discusses the regulatory and ethical considerations in cybersecurity, emphasizing the need for a balanced approach that safeguards privacy while ensuring robust protection against cyber threats. By synthesizing current research findings and industry practices, we propose a set of best practices and strategic recommendations for fortifying the cybersecurity posture of computing systems. We aim to provide a comprehensive understanding of the current challenges and future directions in cybersecurity, ultimately contributing to the development of more resilient and secure computing environments.*

***Key words:*** *cyber-attacks, ransomware, Blockchain.*

## 1. Introduction

In the 21st century, digital transformation has become an integral component of infrastructure, reshaping industries, economies, education, and daily life. From micro to macro environment, personal communications to national infrastructure,

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computing systems are embedded in nearly every aspect of modern existence. They enable the seamless operation of production systems, financial markets, healthcare systems, transportation networks, and government services. This integration has significantly enhanced efficiency, connectivity, and accessibility, driving innovation and economic growth. However, the pervasive adoption of digital technologies also introduces significant cybersecurity challenges that must be addressed to safeguard these advancements (Verma, 2024).

Cybersecurity, the practice of protecting systems, networks, and data from digital attacks, has emerged as a critical priority for individuals, businesses, and governments. The consequences of cyber-attacks can be severe, including financial loss, operational disruptions, data breaches, and reputational damage. As cyber threats become more sophisticated and widespread, the need for robust cybersecurity measures has never been more pressing (Olson, et al., 2011). This paper aims to provide a comprehensive analysis of the multifaceted cybersecurity issues confronting modern computing systems, exploring the threat landscape, inherent vulnerabilities, and the latest defense mechanisms.

## 2. Cybersecurity Threats

Different kinds of cybersecurity threats can occur in computing system networks, but three types can often be singled out as the most frequently occurring forms of threats: advanced persistent threats (APT), ransomware and zero-day exploits.

APT are among the most significant and insidious cyber threats. These attacks are characterized by their prolonged and targeted nature, often orchestrated by highly skilled and well-resourced adversaries, such as nation-states or organized cybercrime groups. APTs aim to establish a long-term presence within a target network to steal sensitive information or disrupt operations. Unlike typical cyber-attacks, which may be quick and opportunistic, APTs involve extensive reconnaissance, sophisticated infiltration techniques, and stealthy persistence, making them particularly challenging to detect and mitigate. A diagram of the APT lifecycle with crucial steps and actions is represented in Figure 1 (Buckbee, 2023).

Ransomware has emerged as a prominent threat, affecting individuals, businesses, and critical infrastructure. This type of malware encrypts victims' data, rendering it inaccessible until a ransom is paid to the attackers, typically in cryptocurrency. The impact of ransomware can be devastating, leading to significant financial losses, operational disruptions, and, in some cases, permanent data loss. High-profile incidents, such as the WannaCry and NotPetya outbreaks, have underscored the potential scale and severity of ransomware attacks.

Zero-day exploits leverage previously unknown vulnerabilities in software or hardware, allowing attackers to bypass traditional security defenses. These exploits are particularly dangerous because they can be used to launch attacks before developers have a chance to create and distribute patches. The discovery and exploitation of zero-day vulnerabilities often occur within a highly competitive black

market, where such vulnerabilities can be sold for substantial sums. The challenge of defending against zero-day exploits underscores the importance of proactive security measures and advanced threat detection capabilities.

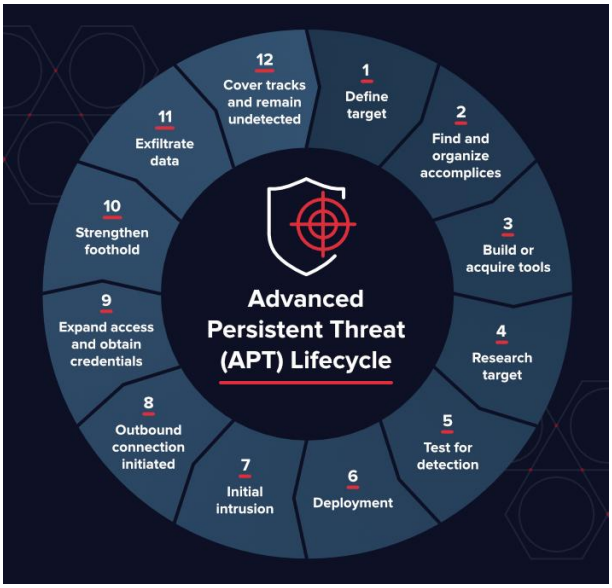


*Figure 1: APT Lifecycle (Buckbee, 2023)*

## 3. Cybersecurity Frameworks and Protocols

Cybersecurity issues have led to the definition of cybersecurity frameworks and protocols designed to mitigate risks, with the implementation of machine learning and artificial intelligence (AI) applications in threat detection and response.

The National Institute of Standards and Technology (NIST) Cybersecurity Framework provides a comprehensive approach to managing and reducing cybersecurity risk. It consists of five core functions: Identify, Protect, Detect, Respond, and Recover (Liu, et al., 2024). These functions guide organizations in understanding and managing their cybersecurity risks in a structured and systematic manner. The framework also emphasizes the importance of risk assessment, continuous monitoring, and incident response planning.

The ISO/IEC 27001 standard is an internationally recognized framework for information security management. It provides a systematic approach to managing sensitive company information, ensuring its confidentiality, integrity, and availability. The standard outlines requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS). Adopting ISO/IEC 27001 helps organizations demonstrate their commitment to security and compliance with regulatory requirements (Podrecca, et al., 2024).

Machine learning (ML) has revolutionized threat detection by enabling the analysis of vast amounts of data to identify patterns and anomalies indicative of cyber threats. Traditional security systems often rely on signature-based detection, which can be ineffective against new and unknown threats. ML algorithms, on the other hand, can detect previously unseen threats by learning from historical data and identifying deviations from normal behavior. Techniques such as anomaly detection, clustering, and classification are commonly used in ML-based security systems to enhance threat detection capabilities.

Artificial intelligence (AI) enhances incident response by automating the detection and mitigation of cyber threats. AI-powered systems can analyze and correlate data from multiple sources in real-time, enabling faster and more accurate identification of incidents (Zhang, et al., 2022). Automated response actions, such as isolating compromised systems, blocking malicious traffic, and deploying patches, help mitigate the impact of cyber-attacks and reduce the response time. AI also plays a critical role in threat hunting, allowing security teams to proactively search for signs of compromise within their networks.

Blockchain technology offers a decentralized and tamper-evident ledger system that can enhance data integrity and transparency. Each block in a blockchain contains a cryptographic hash of the previous block, a timestamp, and transaction data, making it nearly impossible to alter the information without detection. Blockchain's applications in cybersecurity include securing transactions, ensuring the authenticity of digital records, and providing transparent and immutable audit trails (Saleh, 2024). By leveraging blockchain, organizations can enhance trust and accountability in their digital interactions.

Quantum computing represents a paradigm shift in computational power, with the potential to solve complex problems that are currently infeasible for classical computers. While quantum computing poses a threat to existing cryptographic methods, it also offers opportunities for developing new, more secure cryptographic techniques (Chawla & Mehra, 2023). Quantum-resistant algorithms are being researched to withstand the capabilities of quantum computers. Understanding the implications of quantum computing is crucial for future-proofing cybersecurity strategies and ensuring long-term protection of sensitive information.

## 4. Case Studies and Practical Implications

Many large firms all over the world, have been hit by a breach that may have disclosed highly sensitive information about its customers. Besides that, ransomware attacks happen every day not only to legal entities but also to individual users. Governments and regulatory bodies worldwide are establishing standards and regulations to enhance cybersecurity and protect privacy. Notable examples include the General Data Protection Regulation (GDPR) in Europe and the Cybersecurity Information Sharing Act (CISA) in the United States. Ethical considerations play a crucial role in cybersecurity, as organizations must balance the need for robust security with the protection of individual privacy rights, so their

cybersecurity practices adhere to ethical principles, such as transparency, accountability, and respect for privacy.

In Deloitte case, hackers gained access to Deloitte's email system via an inadequately secured administrative account. This email system was hosted on Microsoft's Azure cloud service and was first successfully attacked in October or November 2016. This meant the attackers had access to emails, potentially containing highly sensitive communications between Deloitte and its clients, as well as between Deloitte employees, for nearly a year. The admin account used just a simple password for authentication (Data breaches, 2017).

The Equifax data breach, which occurred in 2017, exposed the personal information of approximately 147 million people. The breach resulted from a vulnerability in the Apache Struts web application framework, which Equifax failed to patch in a timely manner. Attackers exploited this vulnerability to gain access to sensitive data, including names, Social Security numbers, birth dates, addresses, and driver's license numbers. The incident highlighted the importance of timely patch management, robust vulnerability scanning, and proactive threat monitoring (Data breaches, 2017).

The WannaCry ransomware attack, which spread globally in 2017, affected hundreds of thousands of computers across various industries, including healthcare, finance, and government. WannaCry exploited a vulnerability in the Windows operating system, leveraging the EternalBlue exploit to propagate rapidly. The attack encrypted data on infected systems, demanding ransom payments in Bitcoin for decryption. The widespread impact of WannaCry underscored the necessity of regular software updates, robust backup solutions, and effective incident response planning (Akbanov, et al., 2019).

## 5. Best Practices and Strategic Recommendations

There are different methods that can be used to minimize cybersecurity issues but several can be distinguished: risk assessment and management, secure software development lifecycle (SDLC), multi-factor authentication (MFA) and continuous monitoring and incident response.

Cybersecurity actions begin with a thorough risk assessment with the purpose of identifying potential threats and vulnerabilities. Organizations should periodically conduct risk assessments to evaluate the probability and impact of different threats. This process involves identifying critical assets, assessing the effectiveness of existing security measures, and ranking risks based on their potential impact. In this way, organizations can allocate resources effectively and implement adequate security measures.

Implementing an SDLC is essential for minimizing vulnerabilities in software products. The SDLC integrates security practices throughout the software development process, from design to deployment. Key practices include threat modeling, secure coding standards, code reviews, and vulnerability testing. By

incorporating security early and continuously, organizations can reduce the risk of introducing vulnerabilities and ensure the development of secure software.

MFA enhances security by requiring multiple forms of verification for user authentication. MFA typically combines something the user knows (e.g., a password), something the user has (e.g., a mobile device), and something the user is (e.g., a fingerprint) (Almadani, et al., 2023). Implementing MFA significantly reduces the risk of unauthorized access, even if one factor is compromised. Organizations should adopt MFA for all critical systems and encourage its use across their user base.

Continuous monitoring involves the ongoing collection and analysis of security data to detect and respond to threats in real-time. Security Information and Event Management (SIEM) systems play a crucial role in continuous monitoring by aggregating and analyzing logs from various sources. Incident response planning is also critical for minimizing the impact of security incidents. Organizations should develop and regularly update their incident response plans, conduct simulated exercises, and ensure that their security teams are well-trained and prepared to respond to incidents.

## 6. Conclusion

The trend of industry digital transformation besides benefits like: higher levels of efficiency and productivity, enhanced data collection, quality improvements to products and services, etc. has brought system weaknesses in the form of sophisticated cyber-attacks such as APTs, ransomware, and zero-day exploits, which implicates the need for robust cybersecurity measures. Inherent vulnerabilities in computing architectures, including insecure coding practices, inadequate encryption standards, and flawed authentication mechanisms, further aggravate these challenges.

Advancements in artificial intelligence can be implemented for threat detection and incident response, enabling more proactive and adaptive security measures. Emerging technologies, like blockchain and quantum computing, offer both opportunities and challenges for cybersecurity. By synthesizing current research findings and industry practices, this paper proposes best practices and strategic recommendations for fortifying the cybersecurity posture of computing systems.

By analyzing challenges and future directions in cybersecurity, we aim to contribute to the development of more resilient and secure computing environments. This paper provides a comprehensive guide for enhancing cybersecurity in the digital world.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# AUTOMATIC IDENTIFICATION SYSTEMS IN INDUSTRY APPLICATIONS

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***Abstract***

*Automatic Identification Systems have become a cornerstone in enhancing operational efficiency and security across various industrial sectors. This paper provides a comprehensive exploration of these technologies, including Radio Frequency Identification (RFID), barcode systems, Optical Character Recognition (OCR), and Internet of Things (IoT)-based solutions. We investigate their applications in diverse industries such as manufacturing, logistics, healthcare, and retail, highlighting the transformative impact on supply chain management, asset tracking, inventory control, and personnel authentication. The paper delves into the technological underpinnings of automatic identification systems, examining the advancements in sensor technology, data processing, and communication protocols that enable seamless integration and real-time data acquisition. We discuss the implementation challenges and solutions associated with these systems, such as interoperability issues, data privacy concerns, and the need for standardized protocols. Through case studies and empirical data, we illustrate the practical benefits of automatic identification systems deployment, including improved accuracy, reduced operational costs, enhanced security, and increased productivity. Additionally, we explore the role of AI and machine learning in augmenting automatic identification systems capabilities, particularly in predictive maintenance, anomaly detection, and automated decision-making.*

***Key words****: supply chain management, asset tracking, authentication.*

## 1. Introduction

The advent of digital transformation has fundamentally reshaped the landscape of modern industry, driving a shift towards smarter, more efficient, and interconnected production environments. At the heart of this transformation lies

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the integration of automatic identification technologies, which serve as key enablers for optimizing processes, enhancing operational efficiency, and ensuring real-time data accuracy across the entire supply chain.

Automatic identification technologies, including RFID (Radio Frequency Identification), barcodes, QR (Quick Response) codes, and biometric systems, provide industries with the ability to track and trace products, materials, and assets with unprecedented precision. By seamlessly integrating these technologies into industrial processes, organizations can achieve greater visibility, reduce human error, and improve decision-making through data-driven insights.

In this context, digital transformation is not merely about automating existing processes but about reimagining and redesigning them to leverage the full potential of these technologies. As industries continue to adopt and refine these systems, they unlock new opportunities for innovation, cost reduction, and competitive advantage, ultimately creating more agile and responsive production ecosystems.

This paper explores the critical role of automatic identification in driving digital transformation within the industry, examining its impact on operational and business performance.

## 2. Automatic Identification Systems

Automatic identification refers to a range of technologies that enable the automatic recognition, collection, and processing of data about objects, people, or events without direct human intervention. These technologies are fundamental to modern systems that require speed, accuracy, and efficiency in data handling. They can be implemented in control and management systems (Stankovski & Ostojić, 2010; Baranovski et. al 2022), different industrial applications like traceability systems (Stankovski et. al 2009; Tarjan et. al, 2014; Ostojić el. al 2023), production systems (Stankovski et. al 2009; Vukelić el. al 2011) and in agricultural applications (Stankovski el. al 2012; Acharya et. al 2024).

Technologies that are mostly used as automatic identification technologies are: barcode, RFID, NFC (Near Field Communication), and OCR (Optical character recognition).

A barcode is a machine-readable representation of data, typically used to identify products or items. Barcodes are composed of a series of parallel lines or other geometric patterns that vary in width and spacing, encoding information that can be scanned and interpreted by barcode readers. There are different types of barcodes like linear, 2 dimensional, and 3 dimensional whereas linear is mainly used in retail for product identification and pricing, in inventory management and logistics to track stock levels and movement, and in healthcare for patient identification and tracking medical supplies. Two and three-dimensional barcodes are mostly used in industry applications (Direct Part Marking of manufactured parts commonly made of materials such as metal or ceramics, Figure 1.).

*Figure 1: Direct Part Marking (HPRT, 2024)*

RFID and NFC similar technologies are both wireless communication technologies that use radio waves to exchange data. However, they serve different purposes and operate in different ranges and contexts (Ostojić & Stankovski, 2012). Some types of RFID can operate over several meters, while every NFC works within a few centimeters. RFID is generally used for tracking and identifying objects, while NFC is designed for secure, short-range communication, often between two devices. RFID typically involves one-way communication, whereas NFC allows for two-way communication between devices. Both technologies are widely used in various applications like access control, enhancing efficiency, and security, whereby RFID is more often used in industrial applications (Figure 2.).

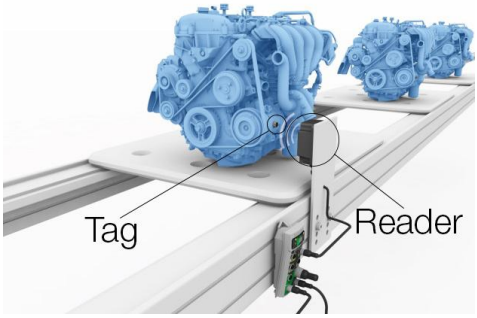


*Figure 2: RFID product tracking (Balluff, 2022)*

OCR is a technology used to convert different types of documents or images captured by a digital camera into editable and searchable data. OCR enables the recognition of printed text characters allowing their conversion into machine-readable text, so it is in most cases used in manufacturing for quality control since it can read and verify product labels, serial numbers, and other printed information during the manufacturing process (Figure 3.) and inventory management for automating the extraction of data from packaging and labels to improve inventory tracking and management. Also, OCR is used in logistics and transportation for package tracking and license plate recognition.

*Figure 3: OCR in the automobile industry (OCR solutions, 2019)*

The basic part of the Internet of Things (IoT), which enables connecting devices, systems, and processes to the Internet, allowing real-time monitoring, data collection, and automation, is the automatic identification of all connected entities. IoT is widely used in industry so a special branch of IoT is called IIoT (Industrial Internet of Things) and it differs from IoT in way that it requires higher levels of reliability, security, and real-time data processing to optimize industrial processes and operations. The processes of asset tracking within the factory, improving supply chain efficiency, and reducing waste are supported by IIoT. Often IIoT sensors monitor machinery, for signs of wear and tear, predicting when maintenance is needed to prevent costly downtime, and also can monitor and control equipment like pipelines, meters, and transformers remotely, improving reliability and reducing operational costs.

A new paradigm is Automatic Identification Systems (AIS), and they have a crucial role in navigation and safety, providing real-time information about vessels, including their position, course, speed, and other relevant data. Integrating Artificial Intelligence (AI) and Machine Learning (ML) into AIS can significantly enhance these systems' capabilities, offering benefits in several areas like trajectory prediction, where AI models can predict an asset's future trajectory based on its current and historical movement data. This can help in anticipating potential collisions or deviations from expected routes, enabling preventive actions. Also, machine learning algorithms can detect unusual asset behavior that might indicate an emergency, unauthorized activity, or other risks. By learning from patterns of normal operations, AI can flag deviations that require attention.

AIS data can sometimes be inaccurate or incomplete. AI can help identify and correct these errors by cross-referencing with other data sources or by recognizing patterns that suggest an error. AI can be used to analyze asset behavior over time, identifying potential security threats such as unauthorized entry into restricted areas or suspicious loitering.

By analyzing AIS data along with other operational data, AI can predict when a vessel might require maintenance, helping to prevent breakdowns and improve operational efficiency. Besides that, fuel consumption optimization by suggesting speed adjustments or alternative routes, leading to cost savings and reduced environmental impact, can be accomplished with AI implementation.

## 3. Benefits and Challenges of Automatic Identification

Implementation of automatic identification in industrial applications brings numerous benefits to industrial systems. To only name a few there is awareness of the real-time state of the system, efficiency, accuracy, security, and real-time inventory status. These technologies enable real-time tracking and monitoring, providing businesses with up-to-date information that is crucial for agile decision-making.

Automated data collection, manufacturing, and business processes can significantly reduce the time and labor required to record information, leading to faster operations and improved productivity. Besides that, automated data collection reduces the risk of human error, ensuring that data is captured accurately and consistently. In some processes, there is sensitive information about the users, like access control and identity verification which needs to be acquired, so manual activities are unsuitable. Automatic identification systems have security protocols that protect from data corruption or manipulation. The typical application of automatic identification in the industry is in inventory management. Automatic identification allows accurate tracking of inventory levels, reducing the chances of stockouts or overstocking and optimizing supply chain operations.

Automatic identification system implementors must also be aware of challenges to ensure successful system implementation. Some of the challenges can be the cost of implementation that can overtake benefits, privacy, and security of personal data, an increase in system complexity, and difficulties in interoperability.

Before implementation, businesses must make a decision to invest in the implementation of automatic identification based on weighing the costs against the potential benefits. In most cases, there are significant investments in software, hardware, infrastructure, and training. New working procedures must be adopted, for which it takes time to achieve effectiveness, essentially in complex industry processes. Also, the problem of integration of new infrastructure, hardware, and software in existing systems can arise, since an improved system should work seamlessly to maximize effectiveness. Regarding privacy concerns relating to personal data, it is essential to implement robust data protection measures.

## 4. Conclusion

Automatic identification is a cornerstone of modern data-driven processes, offering numerous advantages in terms of efficiency, accuracy, and security. As technology continues to evolve, the adoption of automatic identification systems is likely to expand, driving further innovation and improvements in various industries. However, careful consideration of the challenges and a strategic approach to implementation are essential to realize the full benefits of these powerful technologies.

Future research should be focused on the integration of AI and machine learning with AIS in order to accomplish a powerful evolution in the industry sector,

with the potential to greatly enhance safety, efficiency, and environmental sustainability.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ARTIFICIAL INTELLIGENCE AND DEEP LEARNING ALGORITHMS: A POST-SMART PATH FOR CITIES

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***Abstract***

*The Artificial intelligence (AI) and deep learning algorithms have had a significant impact in overcoming the concept of a smart city, as evidenced by the latest scientific research. That trajectory is shifting from smart ontology to deep learning algorithms. The work integrates theoretical and practical knowledge of AI cohabitation with the city and how it changes it, but also a reversible process. AI recomposition is also considered, drawing on a number of urban disciplines and case studies. Through a comparative analysis of a series of case studies in cities where different methods of mutual constitutive relations have been applied, a synthesis of conclusions and a series of criteria and recommendations is reached. The chosen methodology is based on the thesis that every local context is unique, and AI system must be developed in a way that is adapted and corresponds to the specific local context. The research reveals the various impacts of AI on society, education, infrastructure, urban planning and sustainable development. The so-called new postsmart path for cities is confirmed through empirical examples and represents a new era and paradigm of future urban life. The urbanism of artificial intelligence was analyzed and the results may be useful in some future research due to the very interdisciplinary nature of the topic both in the fields of urban studies and architecture, as well as from the point of view of studies of scientific and technological development, education, sociology, culture and politics.*

***Key words****: artificial intelligence (AI), deep learning algorithms, strategies management, sustainable development, urban planning.*

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# 1. Introduction

The life of urban AI intersects with the life of cities, because these are AI technologies designed and programmed to interact with humans and to mediate socio-economic activities that occur primarily in urban spaces, and thus deviate from the many AI employed. Most AI need a material base to operate and all AI need spaces to act upon because their activities always take place somewhere, for example, an apartment whose market value has been calculated by an algorithm (Fields, 2022; Safransky, 2020). The city gives AI a material iteration, situating it in the physical landscape (Cugurullo et al., 2023). AI is being infused into the governance of cities, and it has the potential to create the autonomous city where human agency might be overshadowed by the agency of urban AI (Cugurullo, 2021). The relationship between society and space, which is realized within the framework of the contemporary environment, is determined by a specific constellation of factors in the aspects of politics, economy and culture.

This cooperation creates a form, which is called an organization. Them organization is considered to be an open, dynamic and complex system, which requires a comprehensive approach from every point of view. As a complex system, the organization consists of a large number of integral subsystems that must be coordinated. On the other hand, the organization is a subsystem of a higher-order system, and accordingly, the complexity of the approach gains importance, as well as the process of managing such a system. The openness of the system is conditioned by the interaction between consumers, employees of the organization, as well as all others interested in the operation of the system (Vojnović, 2011).

In this sense, urban AI is not merely a passive tool to inform human decision-makers, but rather an active stakeholder which makes decisions and shapes urban governance. This situation is not accidental. Political decisions made by humans place urban AIs in the position to make decisions about the governance of cities (Cugurullo et al., 2023). Accordingly, it is not possible to isolate urban development from the context of comprehensive development. This paper proves it. The first part deals with the systemic and strategic approach in the classic view, while the second part formulates recommendations for choosing strategies, as well as strategies themselves in the context of urban development. AI urbanism is an emerging urbanism that is transcending smart urbanism, thus posing new challenges that require new questions and debates in urban studies.

## 1.1 Systemic and strategic approach to development

A systemic approach should take into account points of view and aspects of an economic, ecological, legal, cultural, urban and other nature. The system of city organization is limited by a border, which demarcates it from the environment. Considering that it is an open and flexible system, the influences that come from the outside or from the organization itself are followed, thus increasing flexibility and creating the permeability of the system (propulsion) towards the environment. In

this way, the system is integrated into a higher-level system, that is, it becomes a subsystem of another system. Synergy as a feature of the system is particularly evident in the service organization system. In principle, synergy encourages better connections between subsystems, which function much more effectively if they are linked, than when they act independently, each on its own.

Since it is not possible to view the system as a simple sum of individual parts, it should be holistically defined. Therefore, another feature that occupies an important place in the functioning of the system is holism. This is exactly how AI and machine learning permeate the functioning of cities. Traditional analytical methods of studying the urban land use dynamics associated with urbanization are static and tend to rely on top-down approaches, such as linear and mathematical modeling. These traditional approaches do not capture the nonlinear properties of land use change. New technologies, such as artificial intelligence (AI) and machine learning (ML) have made it possible to model and predict the nonlinear aspects of urban land dynamics (Chaturvedi & de Vries, 2021).

## 2. A review of AI managment in urban contexts

We offers an overview of the major considerations facing local authorities as they are make important decisions on how and when to use AI. The report provides a review of AI managment in urban contexts, an analysis of existing AI applications. Through a comparative analysis of a series of case studies in cities where different methods were applied, we have found in which direction and with what intensity the organization will develop and which objectives are formulated as strategic depends on the business policy, which is formulated as basic in the development process. A strategic approach to the problem requires a correct strategic decision. Each local context is unique, and AI systems must be developed starting from, and adapting to, the local context. The successful deployment of AI systems is often determined by how the systems interact with their environment (UN-Habitat, 2022).

### 2.1 Examples of urban planning management with the help of AI and deep learning algorithms

The spatial distribution and infuencing factors of E-A-U space in Yulin City were analyzed utilizing a multi source data representation and a deep learning method with GIS technology. Te results reveal distinct regional characteristics in the distribution of urban-agricultural-ecological space (Li et al., 2024). This study employs deep learning as an approach for suitability assessment, and the constructed deep learning model achieves an accuracy of 89.86% and a Kappa coefcient of 80.77% on the validation set. The outcomes of this research offer a fresh perspective on coordinating urban development, ensuring food security, safeguarding ecological integrity, and achieving sustainability (Li et al., 2024).

Second study develops siting distribution scenarios for astronomical observatory locations in Indonesia using a suitability analysis by integrating the physical and atmospheric observatory suitability indexes, machine learning models, and long-term climate models (Sakti et al., 2023). The correlation value between population and night lights had the highest correlation value of 0.9, indicating that the population in an area can be identified through the brightness of the night lights. This is because the brightness of the night lights can identify socioeconomic activity (Sakti et al., 2023).

As a third case study, the ANN-based model was applied to simulate the urban growth of Saharanpur city in India. In the proposed model, remote sensing and GIS were used to generate site attributes, while ANN was used to reveal the relationships between urban growth potential and the site attributes. Once ANN learnt the relationship, it was then used to simulate the urban growth. Different feed forward ANN architectures were evaluated in this study and finally the most optimum ANN architecture was selected for future growth simulation (Maithani, 2009).

The City of London has engaged in a cross-sectoral collaborative city planning strategy, formalising the relationship between administration, industry and academia. In the effort to manage data and AI research, both Connected Places Catapult and the Alan Turing Institute have partnered with the City of London (UN-Habitat, 2022). Their collaborations help start-ups and scale-ups based in London or operating there to develop their unique ideas. This partnership provides qualifying start-ups and scale-ups with new chances to collaborate with academics on data-driven urban challenges (Alan Turing Institute, 2018).

## 3. Formulation of post-smart urban development recommendations and strategies

In a similar way, as with standard strategies, and with urban development management, it is necessary to define strategies. In the new context of urban development, the Government's role is not only to achieve a good geopolitical positioning and maintain political stability and social cohesion, but also, dominantly, to encourage the development of a new model of economic growth and an appropriate platform for conducting economic policies.

The priority would be: **finding a market, favorable means, modernization of equipment, higher product quality and training of personnel**. Taking into account the topic of this work, and in the context of multidisciplinarity, the following text suggests strategies of urban development, which can, in cooperation with classical factors, form the basis of overall development. A proposal of strategies in the context of urban development is presented.

1. It is essential for citizens and communities to be involved in the development of an AI strategy. This step is **to engage the public**.

2. The next step is **to identify the affected communities targeted by AI systems**, and then actually reach out to them and engage them through established community networks and processes (UN-Habitat, 2022).
3. **Local knowledge can be included**, because misleading conclusions can stem from failing to link both the input and the output of an AI system with local knowledge. Tacit knowledge comes from the things we know from experience and practice, while contextual knowledge includes social and cultural norms and the way things are done locally (Buuren, 2009; Kitchin, 2016).
4. Existing resources can provide opportunities to draw on, as well as set limitations on what is possible, so we have **to build on existing infrastructure and datasets**.
5. **Capacity-building, for an urban AI strategy**, is defined as the process of developing and strengthening the skills, instincts, abilities, processes and resources that organisations and communities need in order to plan, design and deploy AI applications.
6. **Increased awareness and knowledge of AI and AI application in the city** will ultimately facilitate communication with the general public and with the private sector.
7. An entire **ecosystem of interdisciplinary skills** is required for a thriving AI implementation. AI regulation and law, AI ethics and AI business development are all key skills alongside computer programming. As AI finds more and more useful applications in the city, the urban sector will increasingly use cross-functional teams.
8. The balance between **the construction strategy and heritage preservation**, through the development of a sustainable structure in the present, and the tendency of sustainable development in the future, is one of the main goals.
9. The most attractive idea within the consideration of the global future is **the planning of sustainable development as a new paradigm of urban and territorial development**.
10. In addition, **social, ecological and cultural development** stand out as important pillars of further planning. There are various experiences and methodologies from global to local contexts that are increasingly used in urban planning, and which include the opinions of residents.
11. Financialization does not have a final outcome, instead it constantly reshapes the urban landscape (Stojanović & Lošonc, 2017). This adaptive **quality of financial strategy** means that global financial capital seeks new strategies of accumulation, processes of unequal development and undergoes changes and thus tries to respond to the negative externalities of financialization at the local level which it can simply solve by choosing a new location.
12. **Innovation leadership** with is a very interesting way for local authorities to be proactive on digital innovation is to nurture similar

leadership positions as those found in the tech industry (UN-Habitat, 2022).

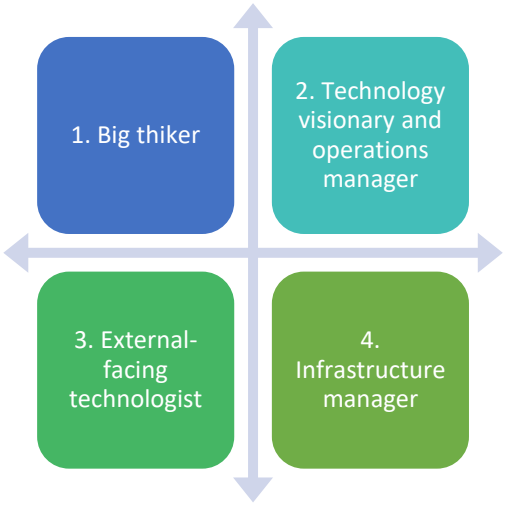


*Figure 1: Innovation leadership as those found in the tech industry*

## 4. Conclusions

The global strategy should retain important local characteristics, to the extent and in a way that will contribute to coherence with European city systems, implying the urban-cultural context of sustainable development (Pušić, 2012). By transcending the smart city, the rise of AI urbanism might lead in the future to the formation of the autonomous city defined as a space where diverse urban AIs perform social and managerial functions that have traditionally been human activities, in an unsupervised manner. This is an urgent question for urban scholars to consider because, 'a city run not by human but by artificial intelligences' would challenge the autonomy of human stakeholders and struggle to be environmentally sustainable due to energy intensive supply chains (Cugurullo et al., 2023).

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# INTEGRATING ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS IN SUSTAINABLE HYDROMELIORATION PRACTICES: A CASE STUDY OF THE VOJVODINA REGION

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***Abstract***

*Environmental and Social Management Plans (ESMP) play a crucial role in promoting sustainable environmental practices within hydromelioration systems. By integrating environmental conservation and development objectives, these plans help mitigate adverse impacts and ensure the long-term sustainability of water resource management initiatives. This paper critically analyzes the ESMP implemented for a hydromelioration project in the Vojvodina region, aimed at minimizing ecological, societal, and cultural impacts during the reconstruction and operation of pumping stations. The ESMP emphasizes sustainable environmental practices to mitigate pollution and preserve biodiversity. It addresses occupational health and safety risks, as well as public health concerns. Socio-economic considerations encompass temporary disruptions to livelihoods and social-economic activities, localized primarily around the pumping station sites, workforce presence, machinery deployment, organizational protocols, and technological applications. The study highlights effective strategies for harmonizing developmental imperatives with environmental and social priorities in hydromelioration projects.*

***Key words:*** *environmental and social management plans, hydromelioration, sustainable practices, biodiversity conservation, socio-economic impacts*

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# 1. Introduction

Hydromelioration systems, particularly agricultural land drainage, play a significant role in modifying landscapes and influencing environmental conditions. These interventions, designed to manage water resources for agricultural productivity, can lead to profound environmental and social changes (Tlapáková et al. 2013). Spaling and Smit (1995) emphasized that drainage systems alter the water regime, influencing not only the spatial distribution of pollutants but also increasing their concentrations and facilitating their transfer from agroecosystems to aquatic ecosystems. Such activities often result in changes to the landscape structure, leading to spatial fragmentation and ecological degradation.

One of the most critical impacts of drainage activities is on wetlands, where large-scale interventions, such as straightening river courses, have led to the degradation of bank ecosystems. The transformation of these areas into simplified and unstable aquatic environments, as observed in the western south-central USA, highlights the need for sustainable management and restoration efforts (Huang et al. 2009). Similarly, Langhammer and Vilímek (2008) identified systematic drainage as a key indicator of landscape changes, with implications for biodiversity, water quality, and ecosystem health.

In Europe, the Water Framework Directive of the European Union underscores the necessity of achieving good surface water status by emphasizing the interconnectedness between catchment development and water quality. However, historical hydromelioration measures, particularly those implemented in the mid-20$^{th}$ century, often prioritized drainage and watercourse training, neglecting long-term ecological sustainability (Tlapáková et al. 2013). Sustainability is of key importance in managing water resources, soil health, and environmental protection. There is a growing demand for modernization and rehabilitation of aging hydromelioration systems in order for them to adapt to climate change, increased water scarcity or other extremes, like flooding, and ecosystem degradation.

AP Vojvodina, covering 2.1 million hectares in northern Serbia, lies within the Pannonian Basin and is bordered by the Sava and Danube rivers. According to the 2022 census, it has a population of 1.74 million. The region's hydrographic potential is dominated by the Danube and its tributaries, with an extensive canal system (Danube-Tisza-Danube Hydrosystem, DTDHs) supporting irrigation, drainage, and transportation.

Vojvodina's economy is largely based on agriculture, utilizing 84% of its surface area for arable land. Around 0.5 million hectares of this land are drained, enhancing productivity on areas originally marshy. The province has 1,460 km of reconstructed flood embankments, safeguarding against flooding along major rivers like the Danube, Tisza, and Sava. However, 204 km of flood embankments remain unconstructed. Additionally, about 1.78 million hectares are drained, with over 20,000 km of drainage canals and 155 pumping stations to support the system.

Approximately 80% of Vojvodina is at risk from inland waters, affecting both directly endangered and partially endangered areas. Remediation efforts are

ongoing, particularly with about 100 structures along the flood embankments needing rehabilitation.

An Environmental and Social Management Plan (ESMP), as a part of the Environmental and Social Impact Assessment (ESIA), represents a comprehensive document designed to address the environmental and social impacts associated with development projects, covering both construction and operational phases. In some cases, additional ESMPs may be required for demolition or restoration phases. The ESMP plays a crucial role in identifying potential environmental and social impacts during project formulation and design, outlining strategies to mitigate negative consequences, ensure compliance with regulations, and manage associated risks. The plan also specifies the timing of each mitigation measure, estimates the costs involved, and assigns responsibility for their implementation.

This paper presents how ESMPs can contribute to sustainable environmental practices in hydromelioration system modernization and optimization project in the Vojvodina region, balancing project activities with environmental protection and social well-being.

## 2. Environmental and social management plan (ESMP)

Environmental and Social Management Plans (ESMPs) have become an essential component in ensuring that mitigation measures identified during Environmental and Social Impact Assessments (ESIAs) are implemented and monitored (Figure 1). Since the 1970s, there has been recognition of the need to link environmental assessment with management and ensure that practices are adaptive (Durning and Broderick, 2018). The use of ESMPs has evolved significantly, particularly since the 1990s, as a way to ensure that outcomes from ESIAs are effectively carried through to project implementation.

A 2011 study by the Institute for Environmental Management and Assessment (IEMA) revealed that 80% of respondents favored making Environmental Management Plans (EMPs) mandatory within Environmental Impact Assessment (EIA) legislation (Durning and Broderick, 2018). Further research by Bennett et al. (2016) found that 95% of UK practitioners regularly worked with EMPs. The growing global use of ESMPs is also driven by International Financial Institutions (e.g., World Bank, EBRD), which require management plans in their project financing policies.

ESMPs have evolved through a "bottom-up approach," shaped by practitioners rather than being strictly governed by top-down legislative frameworks. As a result, the practice is diverse, and terminology varies across contexts. ESMPs can be broad, covering various project stages, or more focused, addressing specific issues like construction or ecological management. They can also exist at strategic or institutional levels and tie into overarching environmental management systems (EMS) (Hui et al., 2001). Despite this diversity, project-level ESMPs follow key principles for ensuring effective implementation and monitoring of mitigation strategies.

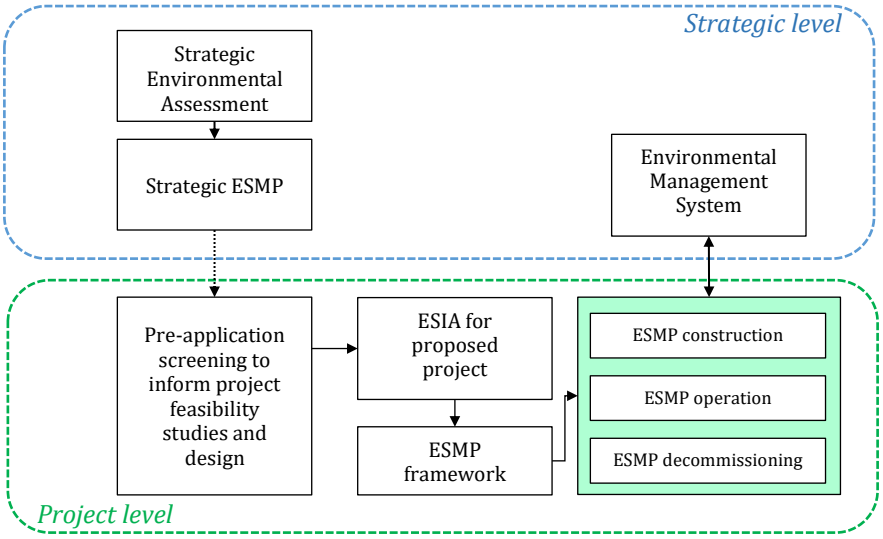


*Figure 1: Integration of ESMPs into environmental and management frameworks (Durning and Broderick, 2018)*

The key benefits of developing an ESMP are ensuring compliance with legal and environmental standards, fostering better communication among stakeholders, and linking the planning and implementation stages of a project. ESMPs also help establish frameworks for monitoring and mitigating potential risks (IEMA, 2024).

ESMPs serve as a crucial link between desk-based ESIA and the on-the-ground implementation of projects. For ESMPs to be effective, they must be clear, practical, and actionable. This includes using accessible language, defining specific actions, assigning responsibilities, setting measurable indicators for success, and specifying the locations and timelines for mitigation and monitoring efforts.

## 3. ESMPs in hydromelioration projects

The type of hydromelioration project, whether it is new construction, reconstruction, or modernization, determines the specific environmental risks involved. These risks may include water quality deterioration, soil erosion, and air quality impacts, such as dust generated during construction activities.

Mitigation strategies should be tailored to each identified risk and corresponding project activity, outlining both the impacts and the proposed mitigation measures. For effective implementation, responsibilities should be clearly assigned to facilitate monitoring and compliance. Mitigation strategies can be categorized according to different project phases, such as planning, design, communication and stakeholder engagement, and execution of works. Assigning a

preliminary cost for each mitigation measure helps in ensuring that resources are allocated properly to manage these risks.

The bulk of mitigation measures for the hydromelioration system modernization and optimization in Vojvodina region are typically needed during the execution phase, where most environmental impacts occur. These measures, which are largely the responsibility of the contractor, include:

- Dust control to prevent degradation of vegetative cover
- Emission control from earth material deposits and truck traffic on unpaved roads
- Management of gas and particle emissions from construction vehicles and machinery
- Noise reduction during heavy machinery operation
- Water turbidity control due to construction activities
- Prevention of water and soil pollution from improper storage, handling, or disposal of materials
- Land and water contamination prevention from fuel and lubricant leaks during construction machinery maintenance
- Proper disposal of municipal, inert, and hazardous waste to avoid water and land pollution
- Safe disposal of sanitary wastewater from construction sites to prevent contamination
- Traffic management to reduce congestion and minimize the risk of accidents in construction areas
- Worker safety measures to mitigate the risk of work-related injuries
- Community health and safety precautions to protect local residents
- Procedures for the discovery of archaeological sites, if encountered
- Processes to address employee and local residents' complaints

Addressing these aspects with diligence allows the ESMP to effectively mitigate the environmental and social risks associated with the hydromelioration project, thereby ensuring compliance with regulations and maintaining long-term project sustainability.

### 3.1 Successful ESMP implementation for the Vojvodina region

Effective stakeholder engagement is essential for successful ESMPs. It is important to incorporate participatory approaches that actively include local communities in decision-making processes. This ensures that their concerns and needs are addressed, particularly regarding potential impacts on their livelihoods, access to water, and cultural practices. Transparent communication and consultation throughout the project cycle can build trust and improve the acceptance and effectiveness of the proposed mitigation strategies (Langsdale & Cardwell, 2022).

Incorporating innovative technologies such as smart irrigation systems, water-saving techniques, and real-time monitoring tools can greatly enhance the environmental sustainability of hydromelioration projects (Djalilov et al. 2024; Klychova et al. 2022). These innovations help in optimizing resource use and reducing environmental footprints, making it easier to achieve compliance with ESMPs. The adoption of best practices from other successful projects can serve as models for future initiatives, facilitating knowledge exchange and improving overall project efficiency.

For ESMPs to be truly effective, their scope should extend beyond project completion. This includes setting up long-term environmental and social monitoring systems that track the impacts of the project on local ecosystems and communities over time. Continuous monitoring will help ensure that the implemented mitigation measures remain effective and that any emerging issues are promptly addressed. Such a commitment to long-term sustainability reinforces the project's overall contribution to environmental protection and social well-being.

## 4. Conclusions and future considerations

This paper demonstrates that Environmental and Social Management Plans (ESMPs) play a crucial role in fostering sustainable environmental practices in the modernization and optimization of hydromelioration systems in the Vojvodina region. By integrating project activities with environmental protection and social well-being, ESMPs contribute to achieving a balance that is essential for long-term sustainability.

The ongoing operation of pumping stations in the Vojvodina region has significantly disrupted the natural balance in their surroundings. The habitats in these areas are subject to continuous human influence, which poses threats to the local fauna. The challenges associated with advancing ESMP practices stem from the necessity of maintaining an adaptive approach, particularly in large and complex projects like hydromelioration system modernization.

Increased human activity during construction phases can exacerbate these challenges, leading to potential habitat destruction, degradation, and fragmentation. Construction activities may also result in pollution—both chemical and physical—along with heightened noise and light disturbances that further threaten local ecosystems.

To mitigate these impacts, it is essential to apply environmental protection measures grounded in robust legal frameworks and aligned with World Bank environmental management guidelines. Through diligent application of ESMPs, stakeholders can minimize adverse effects and promote environmental sustainability, ultimately fostering resilience within the hydromelioration systems of Vojvodina and contributing positively to the region’s ecological and social fabric.There is an urgent need for improved integration of ESMPs in water resource management projects, particularly as these projects face modern environmental challenges like climate change, water scarcity, and biodiversity loss. Strengthening

ESMPs in hydromelioration systems would ensure that they not only address immediate environmental concerns but also anticipate long-term impacts. It is important to have adaptive management practices that can evolve as conditions change, including better incorporation of climate resilience strategies and biodiversity conservation measures. By aligning ESMPs more closely with sustainability goals, they can become powerful tools for both environmental protection and the enhancement of agricultural productivity.

Future research should focus on developing more robust, context-specific ESMP frameworks for water management infrastructure. This includes creating adaptable plans that account for local environmental variations and address emerging issues such as climate variability, extreme weather events, and ecosystem restoration. The research should investigate how ESMPs can more effectively engage stakeholders and ensure compliance through improved monitoring and feedback mechanisms. Governments and international organizations must prioritize policies that support the sustainable use of water resources. This can be achieved by incorporating ESMPs into legislative frameworks, enforcing stronger regulations, and incentivizing best practices in water resource management. Such policy support will be critical in promoting sustainable development and protecting water ecosystems for future generations.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# RIVER SEDIMENT AS ROAD MATERIAL

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***Abstract***

*At the bottom of the canal, there are large deposits of silt. During the cleaning and scouring of the river bed, so-called by-product sediments are formed. Landfills are made along the river bed because it is a relatively close distance. During the preparation of this paper, the idea refers to the examination of sediment with additional binders to see its application in the road industry. The tests that will be presented in the paper are: the granulometric composition of the soil, determination of the maximum volumetric mass at optimal humidity (Proctor's test), determination of the soil's bearing capacity using the California Bearing Index, determination of uniaxial compressive strength after 7 and 28 days and indirect tensile strength after 28 days. The used binders are cement and lime with fly ash and other mineral additives. After the analysis, the cement binder showed slightly better results than the lime binder because the material has its natural humidity.*

***Key words****: sediments, road materials, binders.*

## 1. Introduction

The cleaning of riverbeds and canals, as well as the disposal of by-products, produces sludge, that is, sediments from rivers. This kind of material is deposited a lot on parts of canals and riverbeds and creates large amounts of waste materials. In other surrounding countries in the Balkans, they conducted tests on river sediment after burning, where ash is obtained. They used such ash as a substitute for cement material as a binder. Based on the tests, it was found that ash from burnt sediment has good characteristics for hardened concrete after 7 and 28 days compared to pure cement (Nakić et al., 2018).

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In most EU countries, the problem of sludge management represents a continuous challenge and an economic burden for utility companies because the problem has not been completely solved, nor is it determined by regulations or guidelines. However, it should be pointed out that there are also positive experiences in solving that problem. Considering the various technological possibilities of wastewater treatment and treatment of the sludge itself, as well as its further management, as well as the possible sociological and environmental impact, it is necessary to reach a consensus among the scientific and professional communities on the impact of each country in order to find optimal solutions. EU Directive 91/271/EEC states that sustainable sludge management has to be sociologically and economically acceptable, and meets the conditions of efficient recycling and use of resources while simultaneously minimizing the impact of harmful and potentially dangerous substances and compounds on people and the environment. Thermal treatment of sludge facilitates further management, primarily by reducing the total mass and volume. At the same time, in the process of choosing a concrete solution, the calorific value of sludge should be considered (Fytili & Zabaniotou, 2008). The calorific value of sludge is close to that of brown coal, but it should be kept in mind that this refers to the calorific value of the organic component of the sludge, because the inorganic component has no caloric value. Therefore, it is most often necessary to bring the sludge to the level of ST around 28 – 33 % in order to ensure self-ignition without using significant sources of additional fuel in the process (Donatello & Cheeseman, 2013). Stabilization of sludge with lime contributes to reducing the spread of unpleasant odors and kills pathogenic things, but at the same time it also reduces the caloric value of stabilized and dehydrated sludge by approximately 10 - 20 MJ/kg. About 22 % of the sludge classified at the EU level is incinerated (Lynn et al., 2015), but these quantities are constantly increasing. This trend is due, among other things, to the growing concern over the use of stabilized sludge in agriculture and the increasingly strict conditions under which it is allowed, and in some cases means a complete ban on such practices. Incineration reduces the mass of sludge by approximately 70 % and the volume for 90% (Lynn et al., 2015), but also destroys dangerous organic components of sludge and minimizes problems related to the spread of unpleasant odors (Tantawy et al., 2012).

Authors Kamali et al. did a testing of the river sediment. They used cement as a binder with different moisture content of the material to obtain certain test results. In addition to the change in humidity, the use of different types of sediments from different river locations and different chemical compositions was additionally analyzed. Based on this, the analysis of the work concluded that the sediment with a binder amount of 6 % and humidity of 11 % has the best physical and mechanical properties, that is, the best uniaxial compressive strength (Siham et al., 2007). Also Yoobanpot et al. engaged in sediment testing where cement and fly ash were used as binders. They used optimal humidity to obtain maximum compaction of the material. The following tests were performed: uniaxial compressive strength, indirect tensile strength, USCS material classification, chemical analysis, etc. In this

research, 25 working mixtures were made, and it was concluded that for the mixture containing ash, tests must be done after 28 days, in order to see the increase in compressive strength (Yoobanpot et al., 2020). In the paper (Zhang et al., 2021), a review of the literature on sediment remediation was made and certain conclusions were drawn based on testing.

This paper gives a brief description of the sediment from the Begej River, where certain hydraulic binders (cement and lime with ash admixture) were used, with variable participation of binders, i.e. with 5 and 7 % of binders. The tests followed in this paper are the uniaxial compressive strength after 7 and 28 days, the indirect tensile strength after 28 days, the California Bearing Index (CBR), the content of the optimal amount of water at the maximum compaction of the material, as well as the granulometric composition of the material.

## 2. Testing methods

The test sample was taken from the Begej channel in Zrenjanin, not far from the oil mill. The Begej Canal flows from Timisoara in Romania to the confluence with the Tisa River near Titel in Vojvodina, in the northeastern part of the Republic of Serbia. The subject of this research is surface-deep sediment that was taken from a part of the landfill that was formed during canal cleaning. The tests that have been done include the following groups:

1. Identification - classification tests:
    - Determination of granulometric composition of aggregates (SRPS U.B1.018);
    - Determination of maximum compaction at optimal material humidity (SRPS EN 13286-2:2022)
    - 2. Soil compaction and bearing capacity tests:
    - Determination of the bearing capacity index (CBR) (SRPS U.B1.042);
    - Determination of uniaxial compressive strength after 7 and 28 days (SRPS EN ISO 13286-41:2022);
    - Determination of indirect tensile strength after 28 days (SRPS EN ISO 13286-42:2022).

In order to classify the sediment, an examination of the granulometric composition was carried out using the method of wet sowing with the use of distilled water. 800 g of material was used on a series of 4, 2, 1 mm and 500, 250, 125, 90, 63, 50, 40 and 38 μm sieves.

Proctor's test was performed in order to define the optimal amount of water that is needed to prepare test specimens for mechanical properties testing. To create uniaxial compressive strength according to the standard, a compaction energy of 600 kNm/m$^3$ should be used, but due to the equipment it was not possible to determine the force on the press, so it was decided to make it with a compaction force of 2750 kNm/m$^3$ for the California bearing capacity index.

The California Bearing Index (CBR) is a number that physically represents the indentation resistance of a standard piston in relation to standard values. When designing pavement constructions in the road sector, it is one of the basic parameters of material quality.

The parameters obtained by determining the strength under uniaxial pressure and free lateral expansion are used for a general overview of the characteristics of sediment as a building material and for calculating stability and load-bearing capacity. The diameter of the sample was 250 mm and the height was 200 mm. The sample was compacted in five layers with 25 blows each to obtain the best possible representative sample for testing. The prepared bodies were kept in plastic bags at a temperature of 20°C. The test was done after 7 and 28 days of age, and three samples were made for each mixture.

Indirect tensile strength (Brazilian experience) is used primarily for stabilized bearing layers. The development of this method enables the estimation of parameters, such as: tensile strength, tensile deformation, modulus of elasticity, Poisson's coefficient, at break, and other mechanical properties. Cylindrical bodies with a diameter of Ø = 102 mm and a length of 116 mm specially prepared in a standard mold according to Proctor's method in three layers were used for this experiment. The samples prepared in this way were kept in a humid chamber for 28 days.

## 3. Test results and discussion

The results of the granulometric composition of the aggregate are shown in Figure 1. It can be seen from the figure that it has a lot of clay particles over 20 % and dusty substances around 45 %, while the sandy component is represented by 30 %. The particles belonging to the gravel material are less than 3.5 %, measured on a 4 mm sieve. Based on this curve, it can be concluded that it is a plastic, a clay-dusty material.

The optimal moisture content of the material is used to make samples that are later tested for the California bearing index, for uniaxial compressive strength and indirect tensile strength. Four tests were performed with different moisture content and with an increase of 4 %. The initial value was 8 % of moisture content for the samples that were made of cement material, and for the lime binder the initial amount of moisture was from 9 to 10 %. After obtaining the four points, the optimal humidity value was obtained, which gives the maximum compaction of the material. The test results are shown in Figure 2. It can be seen, as the amount of binder increases, the amount of optimal material moisture also increases.

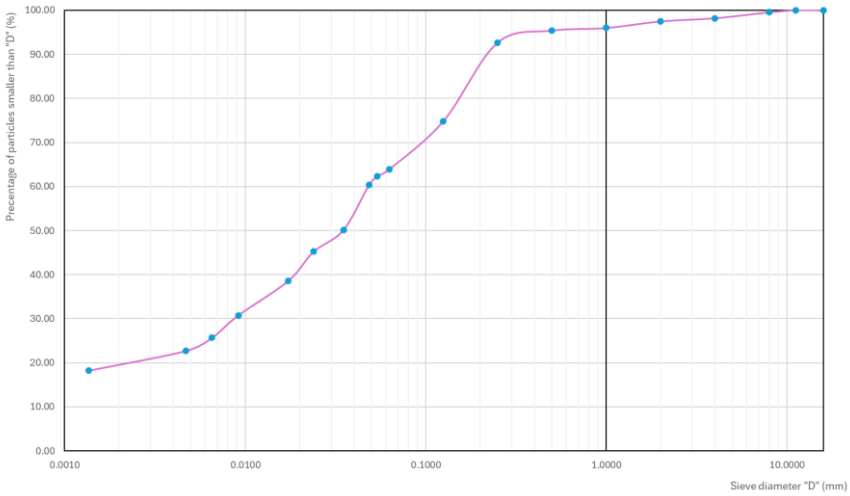


*Figure 1: Granulometric composition*

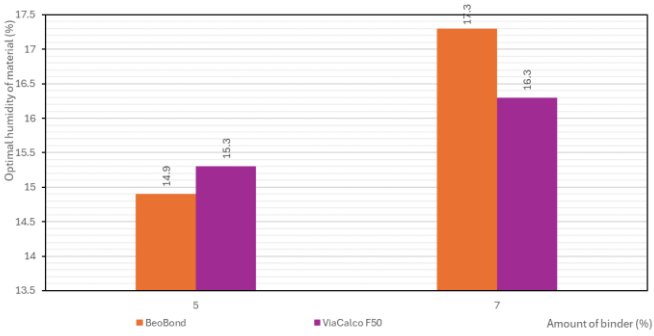


*Figure 2: Optimal humidity of material*

The California bearing index represents the resistance of the piston to be pressed into the sample. Pressing was done in three samples, with different binder content, 5 and 7 %. The values of the test results are shown in Figure 3. It is noticeable that with the increase in the share of binders, there is an increase in the bearing capacity, i.e. the value of the California bearing index. Considerable growth is achieved by the cement binder, and it has proved much better for sediment than the lime binder. Cement binder contains certain percentages of ash and lime.

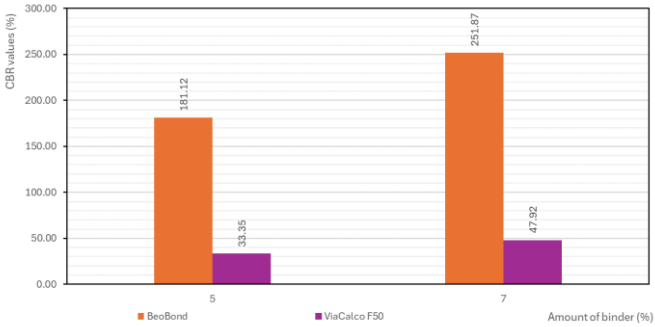


*Figure 3: California Bearing Index (CBR)*

The uniaxial compressive strength shows the results in N/mm$^2$, where it is observed that with the increase in the binder content, there is an increase in strength after 7 and 28 days. A sudden difference can be observed with the use of cement binder from 5 to 7 %, while this is not the case with the lime binder, a rise in results is seen, but not as prominent as with the previous binder. The test results after 7 days are shown in Figure 4, while Figure 5 shows the results of the uniaxial compressive strength after 28 days.

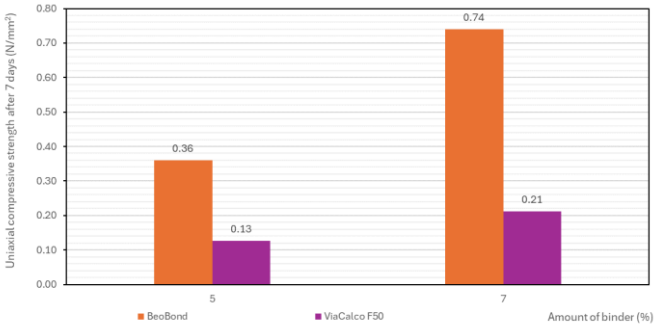


*Figure 4: Uniaxial compressive strength after 7 days*

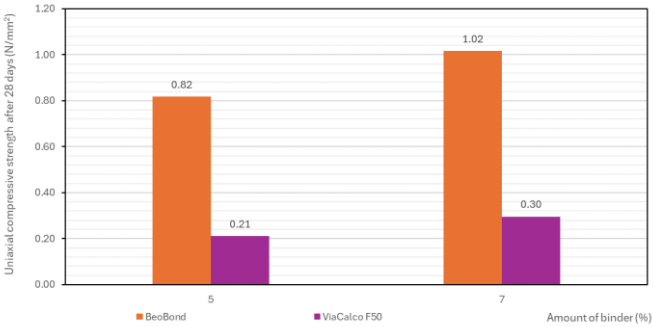


*Figure 5: Uniaxial compressive strength after 28 days*

The indirect tensile strength shows the results in N/mm², where it is observed that with the increase in the binder content there is an increase in strength after 28 days. A sudden difference was observed with the use of cement binder from 5 to 7 %, while this was not the case with lime binder. It was observed that with 5 % binder content no force reading could be recorded. Tests were performed on a small press with a scale of 100 kN load application per second. The results of the test after 28 days are shown in Figure 6.

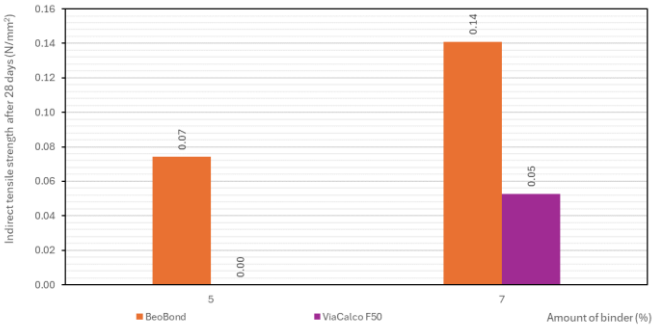


*Figure 6: Indirect tensile strength after 28 days*

## 4. Conclusions

The paper presents an examination of sediment using a cement binder that contains a certain percentage of lime and ash and a lime binder with an admixture of ash. The following tests were done: granulometric composition of the clean sediment material, determination of the optimal amount of water to obtain the maximum compaction of the material, the California load-bearing index of the material, uniaxial compressive strength after 7 and 28 days and indirect tensile strength at splitting after 28 days. Based on the obtained test results, it can be concluded that with an increase in the amount of binder, there is an increase in the

physical and mechanical properties of the material and a better performance is achieved in terms of CBR number, uniaxial compressive strength, as well as indirect tensile strength. An important conclusion is that the cement binder shows significantly better test results than the lime binder because the sludge was dry enough and didn't have too much moisture.

## Acknowledgments

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# CONCEPTUAL DESIGN FOR URBAN STREET RECONSTRUCTION USING THE SHARED SPACE APPROACH

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***Abstract***

*Shared space is an innovative approach to urban design aimed at improving the safety and functionality of traffic areas by integrating different users of the space. This paper investigates the potential application of the shared space concept to Hallerova Aleja Street in Varaždin, a key thoroughfare due to its proximity to educational institutions and high pedestrian traffic. The objective of this research is to assess the expected effects of implementing the shared space approach on traffic safety and user experience in an urban setting. Specifically, the research aims to predict how the removal of traditional traffic elements and the encouragement of direct communication between drivers and pedestrians might influence vehicle speed, pedestrian safety, and levels of noise and pollution. The research is based on a combination of simulations, predictive models, and surveys. Traffic flow and simulations are used to forecast changes in traffic conditions following the implementation of the shared space approach. Predictive risk analysis models evaluate potential impacts on pedestrian safety. It is anticipated that the implementation of the shared space solution will reduce vehicle speeds, enhance pedestrian safety, and decrease levels of noise and air pollution. Predictive models suggest a reduction in the number of traffic accidents and an increase in perceived safety among pedestrians. The research indicates that the application of the shared space concept has significant potential to improve the safety and functionality of urban streets. Predicted outcomes suggest reduced vehicle speeds, enhanced pedestrian safety, and improved environmental conditions.*

***Key words:*** *shared space, traffic safety, urban reconstruction, traffic calming.*

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# 1. Introduction

For most of the 20th century, it was thought that increasing traffic safety was achieved by separating vehicles from other road users. Thus, the cobblestones became concrete or asphalt, traffic signals were set up, pedestrian paths were built and pedestrian crossings were marked as part of the pavement surface intended for pedestrians crossing the pavement. Intersections were considered too complex and were regulated by traffic lights. Probably no city in the world, not a single street, is inconceivable without traffic signs warning traffic participants of the danger that threatens them on a particular road or part of that road, making them aware of the restrictions, prohibitions and obligations that traffic participants must adhere to and provide the necessary information for a safe and uninterrupted flow of traffic (Cvitković, 2022).

Walking with company and presence of high level pedestrian traffic flow in a street can increase the road safety level. Jacobsen (2003) concluded that doubling the pedestrian volume results to 32% reduction of traffic crashes with injuries. This can be explained because drivers are aware of pedestrians' presence and adapt their driving behavior. Higher vehicle speeds increase both the likelihood of a pedestrian being struck by a car and the severity of injury (Rosen and Sander, 2009).

However, the authorities of some small European cities decided to conduct a survey and removed all traffic signs from the roads. The city of Drachten in the Netherlands, the German city of Bomte and others were included in such research. About eight accidents had occurred in Drachten a year earlier, and after the removal of traffic signs, their number was zero. It is important to note that up to 50 traffic accidents occurred in Bomte in a year, but after the traffic signs were removed, all problems were solved. There is only one street sign in the city, informing pedestrians and cyclists, who have to share the road with drivers. Traffic regulation is thus reduced to mutual negotiation and respect for all users. Although it sounds like a framework for creating complete traffic chaos, the model has proven successful. Without traffic lights, drivers slowed down and became more considerate of other city traffic participants. Pedestrians feel safer and life is slowly returning to the centers of some small European cities, which can be seen in economic indicators.

Pedestrians are 1.5 times more likely than passenger vehicle occupants to be killed in a car crash on each trip (Beck et al., 2007). In 2016, 5.320 pedestrians were killed in road accidents in the EU (excluding Lithuania and Slovakia), which is 21% of all road fatalities. During the decade 2007-2016, in the European Union, pedestrian fatalities were reduced by 36%, while the total number of fatalities was reduced by almost 41%. Child pedestrians are unprotected users of the road vulnerable from the speeding vehicles and powerless of making mature judgments to minimize their risk of harm from traffic. While modifying the environment can enhance the safety for child pedestrians (Morris, Wang, & Lilja, 2001).

Modern experimented with simple designs and landscaping which emphasised the 'distinctive history and context' of the village by deliberately

removing or downgrading usual street elements such as signs, road markings, chicanes and road humps. Oudehaske was the first time Monderman tried to “make a village more like a village” (Engwicht, 2006) and even he was surprised when speeds on the street dropped by 40% (conventional 'traffic calming' was achieving reductions closer to 10%) (Hamilton-Baillie, 2008a).

### 1.1 Description of the current situation and traffic counting methods

A pedestrian must use the sidewalk or another surface designated for pedestrian movement, or a surface adjacent to the road suitable for walking. If there are no pedestrian paths, pedestrians must walk along the edge of the road in single file, without obstructing vehicle traffic. On roads outside urban areas, a pedestrian is required to walk along the left edge of the road in the direction of traffic. Exceptionally, a pedestrian may walk on the right edge of the road outside urban areas only when this is safer for them. Furthermore, a review of Google Street shows a large number of pedestrians walking on the road. The presence of pedestrians on the roadway is particularly high during the hours of school start and end times, as shown in the photos below (Cvitković, 2022).

*Figure 1: Google street view photos from Haller Avenue, Varazdin.*

Determining traffic flows is one of the most important pieces of information in traffic planning. The intensity and structure of traffic flows on the road network within the coverage area, as well as transit traffic through Hallerova Avenue, were determined using license plate counting on vehicles.

Traffic flows that were not directly surveyed were obtained through approximation and interpolation methods. Traffic counting established the

relationships in traffic flow within the coverage area, providing an overview of internal traffic movement.

## 2. Results and analysis of traffic data

Since traffic was measured during peak and off-peak hours, the resulting traffic picture serves as a basis for planning traffic under different conditions. The obtained traffic data, along with demographic information and elements of gross domestic product (GDP) growth, can serve as key elements in preparing a traffic forecast.

Traffic counting at the intersection of Hallerova Avenue and Vrazova Street was conducted during a characteristic day of the week. To facilitate determining the intensity of traffic flows, each group of vehicles was weighted with a specific coefficient and converted to a single unit called "PCU" (Passenger Car Unit). The coefficients were as follows: passenger cars 1, heavy vehicles 1.5, buses 2, motorcycles 0.5, and bicycles 0.3.

Pedestrian flows were also counted separately and highlighted in graphical representations.

Traffic counting was conducted between 6:00 AM and 6:00 PM. To accurately determine the characteristics of the analyzed flows and oscillations within an hour, each hour was divided into 15-minute intervals. All counts are presented in the following appendices.

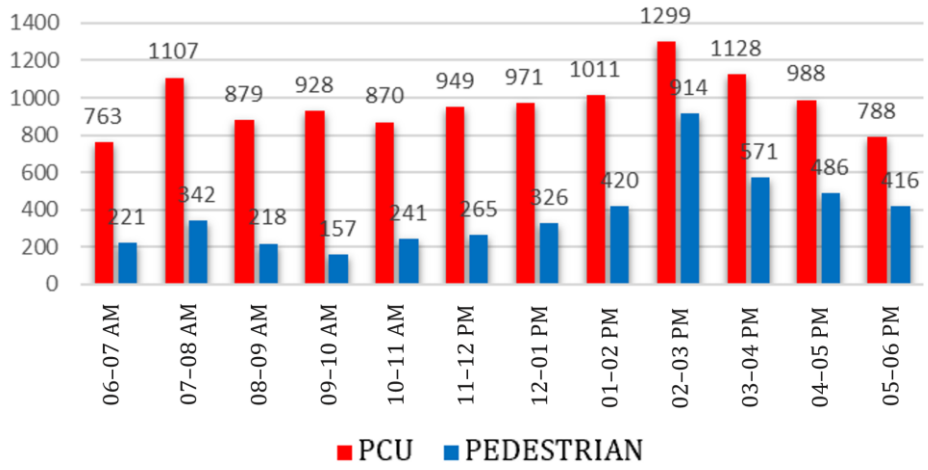


*Figure 2: Hourly Intersection Load – PCU and Pedestrians*

The highest hourly load at the Hallerova Avenue – Vrazova Street intersection was recorded between 2:00 PM and 3:00 PM, amounting to 1,299 PCU, while the pedestrian flow also peaked during this hour with 914 pedestrians passing through the intersection.

The lowest hourly load was recorded during the morning interval from 6:00 AM to 7:00 AM, with 763 PCU passing through the intersection, while the lowest pedestrian load was recorded between 9:00 AM and 10:00 AM, with 157 pedestrians.

These data are essential for easily verifying the modal split and flow distribution. Simulations have shown that the new flow redistribution will not significantly impact increased congestion in this traffic flow.

Traffic Counting - Vehicle License Plate Recording Method involves recording vehicle license plates that pass through a specific area. In the case of this study, counters were placed at the entrances to Hallerova Avenue from Vrazova Street and Gustav Krklec Street, and they recorded the license plates of vehicles entering and exiting Hallerova Avenue during the period from 6:00 AM to 4:00 PM. To accurately determine the characteristics of the analyzed flows and the oscillations within an hour, each hour was divided into 15-minute intervals. Since the objective of this study is to calm traffic in the area and create a "shared space" street, this counting was necessary to determine the number of vehicles that will be "redistributed" to other streets and intersections after the reconstruction of the street, thus discouraging simple transit through the street. Other vehicles that have a purpose to stay in the area for a certain period during the day will be able to move through the street without hindrance, following the rules that will be defined during the reconstruction.

Table 1 show the distribution of vehicles performing transit through the area versus vehicles that remain within the mentioned area.

*Table 1: Distribution of Vehicles Performing Transit Through the Area Versus Vehicles Remaining Within the Area*

| TIME | Entry/Exit | Transit | TOTAL |
|---|---|---|---|
| **6:00 AM - 7:00 AM** | 177 | 111 | 288 |
| **7:00 AM - 8:00 AM** | 338 | 157 | 495 |
| **8:00 AM - 9:00 AM** | 176 | 118 | 294 |
| **9:00 AM - 10:00 AM** | 216 | 86 | 302 |
| **10:00 AM - 11:00 AM** | 160 | 200 | 360 |
| **11:00 AM - 12:00 PM** | 106 | 234 | 340 |
| **12:00 PM - 01:00 PM** | 231 | 194 | 425 |
| **01:00 PM - 02:00 PM** | 298 | 179 | 477 |
| **02:00 PM - 03:00 PM** | 289 | 234 | 523 |
| **03:00 PM - 04:00 PM** | 203 | 247 | 450 |

Based on the obtained data, it can be concluded that transit vehicles make up an average of 44% of the vehicles passing through Hallerova Avenue daily. Given that approximately 10% of these numbers are registrations from other cities (ČK, DA, ZG, and even foreign registrations), it can be inferred that these cars do not use transit through Hallerova Avenue on a daily basis but were only present on that particular day. Therefore, it is likely that the actual percentage is closer to 35% of the total number.

Traffic flow simulation has shown that a certain number of vehicles will redistribute across other parts of the traffic network, and over time, drivers will self-select alternative routes that best suit their daily routines. In this way, Hallerova Avenue will, as expected, become less congested, providing more opportunities for the "new" users of this space, namely pedestrians and cyclists.

## 3. Designing inclusive areas for pedestrians, cyclists, and vehicles through shared space principles

Shared urban spaces represent a paradigm shift in urban planning, one that focuses on reducing the barriers between different users of the streets—pedestrians, cyclists, and vehicles—thus fostering an environment of shared responsibility. Designing such spaces requires a careful balance between functionality, safety, and aesthetic value, ensuring that all users coexist harmoniously.

A key consideration in shared urban spaces is promoting direct interaction between users without the reliance on traditional regulatory infrastructure like traffic lights and signs. Removing these elements encourages individuals—drivers, cyclists, and pedestrians alike—to make eye contact and negotiate right-of-way in real time. This not only enhances safety by fostering attentiveness but also adds to the overall user experience by cultivating a sense of mutual respect and shared community.

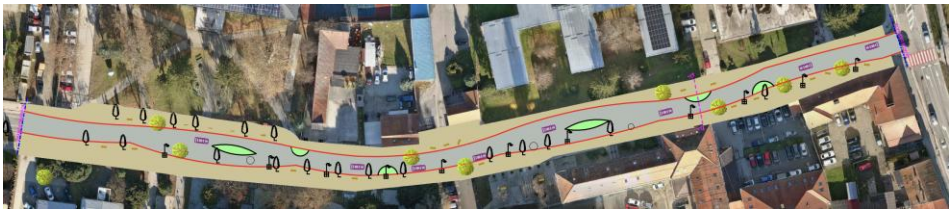

*Figure 3: Situation with representation of the construction solution*

In designing inclusive areas, urban planners must provide the necessary infrastructure that caters to the needs of all users. For pedestrians, this means creating comfortable walking paths, adequate resting places, and ensuring accessibility for people with disabilities. Benches, green areas, and resting zones enhance the experience for pedestrians, transforming streets from merely transit zones to places for leisure and community activities.

For cyclists, integrating safe and direct cycling routes within shared space is essential. Bike racks, dedicated lanes, and clear signals are crucial for maintaining a smooth flow of cycling traffic without conflicting with pedestrian or vehicular paths. Shared spaces should encourage cycling as a practical and sustainable means of transport, offering clear paths that blend seamlessly with pedestrian areas while maintaining a level of safety.

Vehicles, although not the primary focus of shared spaces, must still be accommodated thoughtfully. Traffic calming measures such as narrowing lanes, adding speed humps, and utilizing textured surfaces help reduce vehicle speeds and create a safer environment for all. The design should subtly signal to drivers that the space is not solely for them but shared with more vulnerable users, thereby promoting slower and more cautious driving behavior.

Additionally, landscaping and urban furniture play vital roles in defining the character and functionality of shared spaces. Trees, plants, and well-designed street furniture not only improve aesthetics but also serve as natural separators that guide users through the space. Strategic placement of elements like trash bins, tables, and seating arrangements can subtly direct the flow of movement and indicate areas for rest and socializing.

Urban planners must also ensure flexibility in the design to accommodate varying levels of traffic and different types of activities. During school hours, for example, streets near educational institutions might need to prioritize pedestrian movement, whereas in the evenings, they may serve a more mixed-use purpose. Proper lighting, clear pathways, and adaptable street furniture arrangements are all crucial in making these spaces versatile and welcoming at different times of the day.

After project approval, the next step is the coordination between urban planners, architects, and local authorities to refine the shared space features to align with the community's specific needs. Continuous community engagement and feedback are vital to ensure that the shared spaces truly serve their intended purpose and evolve in response to user experiences.

*Figure 4: Situation with representation of the construction solution*

The figure 3 and 4 shows a conceptual rendering of Hallerova Aleja after its transformation into a shared space. The central roadway is composed of

cobblestone, and is flanked by green planting zones, urban furniture, and wide walking paths.

In the redesign of Hallerova Aleja, the use of urban elements such as benches, trees, and planting zones is crucial for enhancing the functionality and appeal of the area. The benches provide resting spots, encouraging pedestrians to spend time in the area, thus turning the street into a place of leisure and social interaction rather than just a transit route. The planting zones serve as natural dividers between different modes of transport—specifically creating separation between vehicles, pedestrians, and cyclists without using rigid barriers. This soft boundary encourages drivers to lower their speed and be more attentive, fostering a safer environment.

Furthermore, the presence of cyclists and pedestrians moving freely without strict physical barriers promotes an environment of mutual awareness and respect among all road users. This design encourages direct interaction and negotiation between users, reducing the reliance on traditional traffic control devices like lights and signage. By relying on human-scale design and fostering informal communication, the redesigned Hallerova Aleja aims to reduce vehicle speed and prioritize the needs of non-motorized users, ultimately enhancing both safety and user experience.

The image illustrates how shared space principles can be applied effectively to a key thoroughfare in Varaždin, balancing the needs of different users and contributing to the overall aesthetic and environmental quality of the street. This holistic approach not only aims at improving safety but also at revitalizing the urban environment, making it more attractive for residents and visitors alike.

## 4. Conclusions

The implementation of shared urban spaces represents a significant step forward in fostering a more inclusive, safe, and user-friendly urban environment. By removing traditional barriers and encouraging direct interaction between different users of the street, shared space designs not only enhance safety but also create vibrant community spaces that prioritize the needs of pedestrians and cyclists. The integration of urban furniture, landscaping, and thoughtfully planned infrastructure helps in creating a balanced environment where all users, including vehicles, can coexist harmoniously.

Through careful planning, community involvement, and a flexible approach to urban design, shared spaces can transform streets into more than just transit routes—they become places for social interaction, leisure, and community building. The findings of this research suggest that shared space principles have the potential to significantly improve traffic safety, reduce vehicle speeds, and enhance the overall quality of life in urban areas. Moreover, shared spaces can contribute to environmental sustainability by reducing emissions through decreased vehicle use and promoting walking and cycling as primary modes of transport.

Community engagement plays a pivotal role in the success of shared urban spaces. It is crucial to involve residents, local businesses, and other stakeholders throughout the planning and implementation phases to ensure that the design meets the specific needs of the community.

Adaptability is another key factor in the long-term success of shared spaces. Urban environments are dynamic, and the needs of their users can change over time. Designing spaces that can be easily modified or repurposed to accommodate evolving demands is essential. This flexibility can be achieved through modular urban furniture, adaptable landscaping, and periodic assessments of how the space is being used.

The shared space concept also fosters social cohesion by creating environments where people from different backgrounds can come together and interact. By prioritizing human-scale design elements, shared spaces encourage face-to-face communication and reduce the dominance of vehicles, making urban areas more welcoming and accessible to everyone, including children, the elderly, and people with disabilities.

Moving forward, continuous engagement with stakeholders and adaptability in design will be crucial in ensuring the long-term success and acceptance of shared urban spaces. Policymakers, urban planners, and local communities must work together to refine these spaces, learning from both successes and challenges to create urban environments that are truly inclusive, safe, and vibrant for all users.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# ENGINEERS ENTREPRENEURS: ENHANCING SKILLS OF STEM STUDENTS

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***Abstract***

*This paper supports the postulate that entrepreneurship education is crucial for sustainable development, seeking to highlight the criticality of entrepreneurial skills development and their role in boosting employability among STEM students from selected universities in the Balkan region. The study is based on a two-week STEM (self)employment bootcamp, developed and piloted with 53 students from five Western Balkans' universities, in the framework of the project Reconnecting universities and enterprises to unleash regional innovation and entrepreneurial activity – KnowHub, co-financed by the European Union Erasmus+ programme. The impact of the bootcamp concept on the entrepreneurial competences, ambitions and mindset was measured using a customised evaluation tool based on the HEInnovate's EPIC tool. The concept effectively promoted socially relevant competences, including sustainability values and assessment of the social and ecological impacts of ideas, as well as teamwork, communication, diversity and internationalisation. Participating students showed important progress, higher confidence and motivation for inventing new solutions based on their quality and unique ideas, which offers plenty of opportunities for concept adaptation with the aim of making and supporting generations of engineers entrepreneurs – engipreneurs.*

***Key words:*** *Engipreneur, Entrepreneurial education, STEM.*

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# 1. Introduction

It is unknown to what extent entrepreneurship influences engineering students' academic or career choices nowadays. Even though more engineering students are exposed to entrepreneurship education, little study has been done to assess how engineering students feel about it, how it affects their learning, or how it affects their professional competence. Many young people from the Balkans are losing hope and are contemplating leaving their country in search of greater personal and economic fulfilment (Isbendjian, Kinkade, Thorup, & Waddell, 2023). Moving forward, entrepreneurship education is gaining importance in both academia and practice, with increased investments from non-governmental organisations (NGOs), governments, academia, and business in the region's youth.

Entrepreneurship education for engineering graduates is vital as it places the foundation to utilise engineering technical expertise to spinout companies (Sababha, Basal, Al-Qaralleh, & Al-Daher, 2020) and to exploit entrepreneurial opportunities that result from technological innovation (Holzmann, Hartlieb, & Roth, 2018). The STEM Bootcamp which is the focus of this study is a tangible example of academia working collaboratively with local business and government leaders to address local needs practically and sustainably. It has been shown that engineering students have a high potential to become entrepreneurs, and a great number of engineering students actually do create their businesses after graduating.

In this work, the authors present their experience using the HEInnovate's EPIC tool to introduce entrepreneurial training into the existing curriculum for engineering students and the effects EntreComp competences had on shaping their entrepreneurial mindsets.

## 1.1 Efficient entrepreneurial education concepts

Education is fundamental for development and success, aiming to create well-educated individuals who will contribute to economic growth and a better society (Polenakovikj, et al., 2022). Training youth with entrepreneurial skills and more active mindset could empower them to excel in today's challenging world and develop our social and economic outlook (Banha, Coelho, & Flores, 2022). EntreEdu concepts are impact driven and enhance students' abilities to define business purposes, explain marketing plans, implement ideas and create business plans, which are taught or improved through entrepreneurship courses. Most of the initiatives in entrepreneurship education in Europe emerged from the business school sector (Gibb, 2002), but the entrepreneurial competences are broader, aiming to bridge the educational and working world, to be used and adapted to different contexts and to serve as an inspiration to introduce changes for a better future (Bacigalupo, Kampylis, Punie, & Van den Brande, 2016). When considering incorporating entrepreneurship education into engineering curricula, Sanchez et al. (2018) examined how entrepreneurial incentives affect future engineers' business intentions, showing that entrepreneurial training influences students' propensities

to start their own businesses. Motivation is driven by showcasing successful startups, idea-generation workshops, business plan creation and competitions (Barba-Sánchez & Atienza-Sahuquillo, 2018). Extracurricular initiatives such as competitions, fairs, community projects, can also boost student success rate (Penaluna, Penaluna, & Polenakovikj, 2020).

The first impact of introducing entrepreneurship education into existing curricula at university or designing and developing entrepreneurial skill programmes for students is the creation of new companies. Indeed, there is a positive relationship between ecosystems and the propensity to create companies in the regions into which they are located, by disseminating the economically exportable knowledge and improved competitiveness resulting from a higher competitiveness among ecosystem actors (Banha, Coelho, & Flores, 2022). Moreover, entrepreneurial activities help solve environmental problems by encouraging innovation for environmentally friendly products, services and responsible processes (Doh, Tashman, & Benischke, 2018).

## 2. The case of the KnowHub STEM (Self)employment Bootcamp. Measuring the impact of results.

This paper focuses on the results of a two-week STEM (Self)employment camp, developed and piloted in the framework of the project Reconnecting universities and enterprises to unleash regional innovation and entrepreneurial activity – KnowHub. The target group is STEM students from all three cycles of tertiary education. The first week includes forming diverse student teams, receiving theoretical input and mentoring based on the EntreComp competences. The second week focuses on intensive work on business concepts, supported by daily coaching, and concluding with a pitching event with positive competitive environment that serves as an additional motivator and dedication booster.

The impact of the bootcamp concept was measured using a customised evaluation tool based on the HEInnovate's EPIC tool, both before and after the bootcamp. A total of 35 questions were developed to evaluate the participants' self-perceived entrepreneurship competencies, clustered into four dimensions: Entrepreneurial Competences, Entrepreneurial Intentions and Attitudes, Entrepreneurial Mindset & Enterprising Behaviours, and Educational Effects, with responses rated on a Likert scale ranging from 1 (lowest) to 7 (highest). This section highlights key findings from the two EPIC-based evaluations of the pilot bootcamp, held in Girona, May 2022. The bootcamp involved 53 students from five Western Balkan universities, with 46 of them submitting valid evaluations.

### 2.1 Result at dimension level

Considering the level of the target core-competences in Table 1, a significant improvement is noticed in each of the four dimensions. The perceived benefit of the bootcamp ranges from +24% in Entrepreneurial Competences to +8% in

Entrepreneurial Intentions and Attitude. The underlying concept seems to be particularly successful in the entrepreneurial competences component. Additionally, a rise of +12% is seen in the Educational Effect dimension, which measures the bootcamp's learning impact.

*Table 1. Scoring PRE/POST bootcamp and perceived relative effect per target dimension*

| Dimension | PRE Bootcamp | POST Bootcamp | Increase/ Decrease |
|---|---|---|---|
| **Entrepreneurial Competences** | 4,6 | 5,7 | 24% |
| **Entrepreneurial Intentions and Attitudes** | 5,3 | 5,7 | 8% |
| **Entrepreneurial Mindset & Enterprising Behaviour** | 4,9 | 5,5 | 12% |
| **Educational Effect** | 5,1 | 5,7 | 12% |

## 2.2 Result at individual participant level

The results on individual participant level in Table 2 show that 34 of the 46 participants who provided a valid assessment (73,9%) had benefited from the bootcamp. However, the significant number of participants (12) who reported back the opposite, ranging from -4% to -34% could be contacted for more detailed feedback to revise the underlying concept or at least parts of it.

*Table 2. Perceived impact on individual participant level*

| Participant ID | PRE Bootcamp | POST Bootcamp | Increase/ Decrease |
|---|---|---|---|
| **1** | 4,9 | 5,2 | 6% |
| **2** | 5,7 | 5,0 | -12% |
| **3** | 4,1 | 6,3 | 54% |
| **4** | 4,7 | 6,9 | 47% |
| **5** | 4,3 | 6,1 | 42% |
| **6** | 6,0 | 7,0 | 17% |
| **7** | 4,3 | 5,6 | 30% |
| **8** | 5,4 | 6,2 | 15% |
| **9** | 4,2 | 7,0 | 67% |
| **10** | 4,4 | 4,9 | 11% |
| **11** | 5,7 | 5,5 | -4% |
| **12** | 6,3 | 6,6 | 5% |
| **13** | 5,0 | 5,8 | 16% |
| **14** | 4,5 | 6,8 | 51% |
| **15** | 4,9 | 6,5 | 33% |
| **16** | 5,2 | 6,1 | 17% |
| **17** | 6,1 | 5,9 | -3% |
| **18** | 4,9 | 4,0 | -18% |
| **19** | 4,5 | 6,2 | 38% |
| **20** | 3,7 | 6,9 | 86% |
| **21** | 3,3 | 4,5 | 36% |

| Participant ID | PRE Bootcamp | POST Bootcamp | Increase/ Decrease |
|---|---|---|---|
| **22** | 5,3 | 4,1 | -23% |
| **23** | 5,7 | 5,9 | 4% |
| **24** | 5,5 | 4,9 | -11% |
| **25** | 5,3 | 6,0 | 13% |
| **26** | 4,4 | 6,5 | 48% |
| **27** | 5,2 | 6,5 | 25% |
| **28** | 5,0 | 3,3 | -34% |
| **29** | 5,3 | 4,3 | -19% |
| **30** | 5,3 | 5,1 | -4% |
| **31** | 3,9 | 5,9 | 51% |
| **32** | 5,8 | 6,8 | 17% |
| **33** | 5,5 | 5,3 | -4% |
| **34** | 6,1 | 5,1 | -16% |
| **35** | 4,7 | 7,0 | 49% |
| **36** | 4,1 | 4,2 | 2% |
| **37** | 4,3 | 6,1 | 42% |
| **38** | 3,8 | 6,5 | 71% |
| **39** | 5,5 | 5,7 | 4% |
| **40** | 3,8 | 4,5 | 18% |
| **41** | 3,5 | 6,1 | 74% |
| **42** | 5,6 | 6,2 | 11% |
| **43** | 3,7 | 5,1 | 38% |
| **44** | 5,3 | 6,4 | 21% |
| **45** | 3,2 | 6,2 | 94% |
| **46** | 4,8 | 4,3 | -10% |

### 2.3 Result at individual question level

On the level of the individual question, each single question does show an increase PRE/POST bootcamp, Table 3. This allows the general conclusion that the developed training concept is successfully implemented into the bootcamp.

*Table 3. Result per individual question*

| Dimension | Individual Question | PRE Boot-camp | POST Boot-camp | Increase/ Decrease |
|---|---|---|---|---|
| **Entrepreneurial Competences** | Identify opportunities for innovative value creation within your field of expertise | 4,2 | 5,5 | 31% |
| | Achieve goals that you set for yourself | 5,1 | 5,7 | 12% |
| | Be the one who takes the initiative | 4,6 | 5,7 | 24% |
| | Anticipate which opportunities will be of high value | 4,3 | 5,4 | 26% |
| | Create a project plan | 4,7 | 5,9 | 26% |
| | Finish tasks that you have started, even if you are tired of them | 5,1 | 5,7 | 12% |
| | Come up with innovative ideas | 4,4 | 5,6 | 27% |
| | Actively network in order to increase your number and quality of contacts | 4,8 | 5,8 | 21% |
| | Deal with uncertainty when implementing new activities | 4,3 | 5,8 | 35% |
| | Come up with new and different solutions | 4,5 | 5,6 | 24% |
| | Estimate a budget for a new project | 4,3 | 5,5 | 28% |
| | Work with many different people | 5,6 | 6,5 | 16% |
| | Assess the social and ecological impact of your ideas | 4,2 | 5,7 | 36% |
| | Look for new opportunities to develop new knowledge and skills | 5,8 | 6,4 | 10% |
| | Make people enthusiastic about your ideas | 4,9 | 5,6 | 14% |
| | Apply sustainability values (social and ecological) to your own practice | 4,3 | 5,6 | 30% |
| | Identify the novel value in new ideas within your field of expertise | 4,2 | 5,5 | 31% |
| | Assess which needs and requirements are necessary to solve the most important challenges within your field | 4,6 | 5,6 | 22% |
| | Assess various ways in which your ideas can develop successfully | 4,5 | 5,6 | 24% |
| **Entrepreneurial Intentions and Attitudes** | My goal is to become an entrepreneur | 5,0 | 5,4 | 8% |
| | Negative/positive | 5,9 | 6,2 | 5% |
| | Start my own company | 4,4 | 5,7 | 30% |
| | To be my own boss | 5,8 | 5,9 | 2% |
| **Entrepreneurial Mindset & Enterprising Behaviour** | I often get unique ideas | 4,6 | 5,5 | 20% |
| | Solve problems in new ways | 5,6 | 5,7 | 2% |
| | Inventing new solutions to problems is an important part of who I am | 4,6 | 5,7 | 24% |

| Dimension | Individual Question | PRE Boot-camp | POST Boot-camp | Increase/ Decrease |
|---|---|---|---|---|
| | It motivates me more to work on my own ideas rather than to work on ideas from others | 5,2 | 5,5 | 6% |
| | I believe in the quality of my own ideas from the very start | 4,9 | 5,7 | 16% |
| | It is easy for me to use my experience to find patterns in novel contexts | 4,6 | 5,6 | 22% |
| **Educational Effect** | I asked questions in class because I wanted to learn new things | 5,2 | 5,6 | 8% |
| | Listened to my ideas | 5,3 | 5,8 | 9% |
| | Readings and textbook-based assignments | 4,7 | 5,4 | 15% |
| | I felt good about myself when I was at my educational institution | 5,6 | 5,9 | 5% |
| | Student-led and/or student-designed projects | 5,0 | 6,0 | 20% |

The holistic view on the data independent of the individual participants, dimension and individual questions shows a general increase from 4.8 to 5.7, which represents an overall increase of 18%. This increase suggests that the concept was well adapted and contributed to development and enhancement of entrepreneurial skills, as well as fostering a more proactive approach among STEM students.

## 3. Discussion and conclusions

Encouraging engineering students to launch technical businesses is crucial for countries with slow economic growth and positively influences their intentions and decisions to launch own firms. The concept of the STEM Bootcamp allows the participating students to address real-life challenges a specific industry is facing and try to bring an innovative solution. Thus, it is confirmed that entrepreneurship education is not to be dissociated from engineering education. Based on the positive assessment, such initiatives and training concepts offer opportunities for further adaptation and implementation in various contexts and various target groups.

This also brings about the idea of how we consider the relation formal education versus non-formal education. Non-formal education is centred on the learner, it inevitably has features that are flexible concerning the procedures, goals, and materials that were initially defined and implemented. As a result, it is easier to respond to changes that may impact the needs of the community and of students.

The piloted STEM bootcamp integrates research, technology transfer and teaching, with the aim to enhance collaboration between companies and higher education institution, ultimately fostering the employability of graduates.

Engineering could be strengthened and improved through innovation and entrepreneurship. The trainings concentrating on the competences from the

EntreComp Framework have addressed the absence of innovation and entrepreneurship activities at the universities in the Western Balkans. Synergies with other projects and initiatives were created to achieve cost effectiveness and conduct trainings with high quality materials. The materials were designed in a modular manner to accommodate various competency levels.

Conducting two assessments before and after the event allows quantitative evaluation of the perceived benefits of the participants. The results showed that most of the participants felt significantly better informed about entrepreneurship after the workshop. Thus, the benefit of the concept seems to be proven. The continuation of such entrepreneurship training seems sensible and justified.

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# ENVIRONMENTAL ENGINEERING

Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

https://doi.org/10.24867/FUTURE-BME-2024-127 Original scientific paper

# VISION OF IDVOR AS A SMART VILLAGE OF THE 21ST CENTURY

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***Abstract***

*The increasing depopulation of rural areas throughout the EU is an alarm for finding sustainable solutions in the shortest possible time. Progressive and sustainable rural development is an important factor for the survival of villages of the Republic of Serbia, which would lead to sustainable revitalization of rural areas in the future. Using a case study specific to the Republic of Serbia, where rural areas make up a large part of the territory, integrated strategies and policies, using AI and smart systems, that would result in rural revitalization in the Republic of Serbia and across the EU are examined. The best practices of entrepreneurship, precision agriculture, solving social and legal issues, solving waste, as well as diversification of energy, tourism, etc. are considered. There are no fully realized smart villages in the Republic of Serbia. The contribution of this work would be a model of a specific village, on the example of which the implementation of the concept of a smart village could be continued, as a solution for depopulation, migration, lack of labor and the deterioration of the fertile land that the territory is abundant in. It represents a very important economic resource and the possibility of competitiveness and placement on the world market. Through the research, concrete suggestions of activities for which there is potential for development through the concept and context of the village of Idvor, which has various potentials, especially cultural-historical, agricultural, archaeological, etc., were offered.*

***Key words:*** *artificial intelligence (AI), Idvor, Republic of Serbia, smart village, sustainable rural development.*

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# 1. Introduction

Artificial intelligence (AI), a new revolution in history, is fundamentally changing societies, like all the previous ones. We will analyze the effects of AI on the possibilities of forming the future form and function of the village. By coordinating between urban planning, computer science and economics, within a legal framework, to control the application of AI, rural spaces can be turned into smart ones. There are entrenched assumptions that the urban population will increase according to the neoliberal practice of urban growth, due to the migration of people from the countryside to the cities in search of work, but AI overcomes some forms of human labor and tends to completely eradicate them as a necessity, and human labor is traditionally attracted people to the cities (Kassens-Noor & Hindze, 2020).

It is necessary to investigate the possibilities of applying the concept of a smart village at the level of a concrete example. The proposal of the future village concept model aims to strengthen readiness and cooperation for the application and acceptance of digital technologies. Possible limitations and obstacles are increasingly difficult and unprofitable agricultural activities, lack of education, as well as the lack of application of modern technological solutions.

## 1.1 Methods

Changes in rural areas carry risk, but they also encourage the local community to create guidelines for its sustainable development. Therefore, smart villages are primarily oriented towards the local population and their potential resources and needs. This paper is a part of a wider project within which the state of rural areas in the Republic of Serbia was analyzed on the example of several specific villages. The work deals with the research of the potential of the village Idvor in Vojvodina, as an opportunity to include that village in the network of smart villages, which are included in the wider project and program of the development of smart villages in the Republic of Serbia until 2030. The village Mošorin is included in the project, data was collected and it was determined to have potential. It is necessary to research on the basis of a comparative analysis the potentials of Idvor in Banat. Strengths, weaknesses, opportunities and risks were examined, on the basis of which the visions of the development of smart villages, with goals, priorities and frameworks, were defined.

Analysis of the current condition of rural areas, goals and visions are:

- Production and services with the help of digital technologies, AI and green sustainability, taking into account the ecological component.
- Infrastructure: traffic, communal, ICT, social, etc.
- Cultural, educational, entertainment, health, etc. connection through a sense of solidarity and belonging to the local community
- IT oases for digital nomads
- Digital agriculture and market
- Tourism (Borović et al., 2022)

It is necessary to make an assessment of the necessary means for the implementation of the goals. The methods used are the analysis of secondary sources of data, field recording of the situation, survey, interview, workshop, focus group. After the analysis of the current situation, a SWOT analysis and a strategic project of the concept of a smart village aligned with the higher strategic documents and development programs are carried out.

## 2. Results

Smart cities are defined as cities where information and communication technology (ICT) is combined with traditional infrastructure, coordinated and integrated using new digital technologies (Batty et al., 2012). In a similar way, we define smart villages that use new technologies to improve local challenges, focusing on the key potentials and strengths of a specific region in order to achieve sustainable development and the attractiveness of the area itself, according to the European Network for Rural Development – ENRD. Europe achieved its first concrete examples in 2017 (European Network for Rural Development. Thematic Group on Smart Villages, 2018), which are an inspiration for the Republic of Serbia. By analyzing specific local agriculture in the Balkan countries, it is concluded that the creation of smart villages would contribute to the growth of the quality of life, preservation and promotion of local values. Artificial intelligence is one of those increasingly influential factors, whose diverse spectrum of influence and consequences, in particular, must not be neglected (Xiaopeng, 2022).

A research project by, among others, Oxford University recently proved that about half of current occupations are sensitive to technical automation. If such automation were to be implemented, the inevitability would be the loss of jobs for many and thus the potential displacement of residents. The contemporary trend of shaping cities, especially global ones, is financing (Stojanović, Lošonc, 2017). However, the question arises, what would these cities look like if at least half of the professions were replaced by artificial intelligence. Smart villages represent alternatives to city life. Researches (Akhimien et al., 2018; Nikologianni et al., 2022) show that landscape, built environment and digital transformations can become the basis for a resilient future.

### 2.1 The proposal of the future village concept model in the Republic of Serbia

The specific village Mošorin in Vojvodina has 2750 inhabitants, 469 children and this year 2 first classes, 50000 liters of milk are produced per day, while the state of the livestock fund is 18220 head, which was significantly reduced in previous years, but is now stabilized. Many Serbian greats Svetozar Miletić, Isidora Sekulić and others were born in Mošorin. The previous research determined that there is a potential for the inclusion of Mošorin in the program of development of smart villages in the Republic of Serbia.

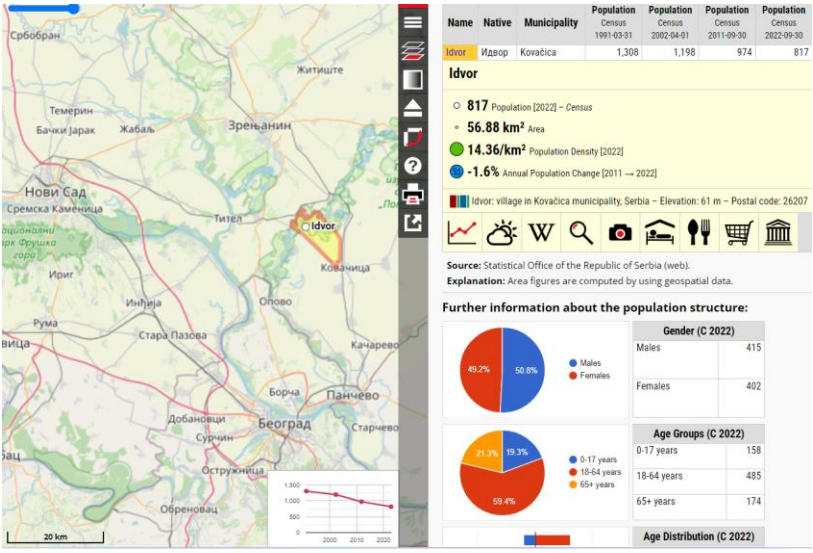


*Figure 1: Spatial position of the village Idvor and equal distance from Belgrade and Novi Sad*

The village Idvor has 817 inhabitants, 262 young people under the age of 29. However, this village has great potential in culture and tourism. World great, scientist - physicist Mihajlo Pupin was born in Idvor. There are archeological sites in this area dating back to the time of the Avars, and the achievements of many later historical periods chronologically have their remains. However, the most significant are the native complex of Mihajlo Pupin, which includes his birthplace, the museum collection in the old building of the elementary school where Pupin went to, now a museum, a people's home, and the church where he was baptized. Idvor belongs to the municipality of Kovačica, where the Gallery of Naive Art is located, which was declared by UNESCO to be the world center of the publishing activity of naïve painting. In addition to the elements necessary for the development of a smart village, which we found in the example of Mošorin, in Idvor there is an emphasis on Mihajlo Pupin's legacy.

Smart solutions should be represented in all rural areas. The "Pilot project for the development of smart villages in the RS, Idvor and Mošorin" will be implemented.

Project assignment:

1. Situation analysis 2. Vision 3. Objectives and priorities 4. Examples of good practice 5. Action plan 6. Risk analysis

Expected results:

- visions, goals and priorities of smart villages in the Republic of Serbia
- development projects
- a presentation of project details with all activities, actors of implementation, required time, finances, and potential sources

## 3. Discussion

Balkan villages, although structurally completely neglected, still have a very high untapped potential that can create great added value. German Foundation Heinrich-Böll commissioned a study on this topic: "The pitfalls of change: sustainable agriculture as a path to prosperity for the Western Balkans". In our region specifically, smart villages would imply the upgrading of traditional agricultural practices with new technological solutions. The circular economy would imply improvements in energy efficiency and recycling, then a significantly higher share of energy obtained from renewable sources, but also the use of modern information and IT tools for easier upgrading of knowledge and better productivity (UN-Habitat, 2022).

In an ideal scenario, connecting renewable energy sources with ecological agriculture would also lead to an increase in value in the food production process. Ecological production has a number of economic advantages in comparison to conventional conventional production. Organic matter in the soil is particularly important for water retention in the soil. It certainly helps in mitigating the consequences of floods, which have already become a regular natural disaster in the Balkans. That is why the villages have an advantage over the cities in this respect. By establishing short supply chains, solidarity exchange groups and encouraging the community supported agriculture model, the purchase of produced agricultural products would be ensured.

## 4. Conclusions

It is necessary to make the villages desirable and to revive the village in terms of personnel, which then becomes even more desirable for life, the socio-economic cycle is started and cultural, sports and other activities can be built on it. The European strategy for broadband internet in rural areas is the first step on this long road. Digitization can support sustainable development in open spaces and help positive landscape correlations with climate change.

All the previous facts prove that AI will displace people far from the cities, because the new industrial or technological revolution will once again, as it happened throughout history, replace jobs. None of the possible new ways of life require cities, but rather human interaction and access to nature. Cheap labor will initially prevent the mass introduction of AI in cities. There are claims that AI will turn metropolises into ghost towns which will depend on the level of AI adoption, policies and unpredictable events like COVID-19, wars etc. (Cugurullo et al., 2023).

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# APPLICATION OF COALESCENCE FILTRATION IN SUSTAINABLE ENVIRONMENTAL PRACTICE

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***Abstract***

*This paper presents how coalescence filtration could be applied in sustainable environmental practice. The coalescence filtration is a separation method that could be used in a wide range of industries (petrochemical, chemical, food, pharmaceutical, power plants, etc.) mostly for the separation of liquid/liquid and gas/liquid dispersed systems, like oily wastewater and metalworking fluid (MWF) aerosols. Filter media in coalescence filtration could be varied from different polymers up to stainless steel. It is very important to point out that the latest literature review shows that waste polymer materials (like polypropylene bags, waste from the carpet industry, etc.) could be efficiently used as filter media in coalescence filtration. Optimal design of coalescence filtration could provide highly efficient separation treatment of oily wastewater and MWF aerosols after which the wastewater could be reused, as well as collected MWF. In addition, this method could be designed to work continuously without the need for filter washing or frequent filter change, i.e. there is no waste generation (wastewater or waste filter). The continuous mode of coalescence filtration provides much lower energy consumption than when the mode is discontinuous. By optimization of working parameters, like fluid velocity, porosity, and permeability of filter media, etc., a mobile coalescer could be designed. Mobile coalescer is small, and light, and as such, it could be easily moved, transported, and used for oily wastewater treatment outside of industry, for example at carwash stations and on ships where bilge water is generated.*

***Key words****: coalescence filtration, sustainable development, oily wastewater, MWF aerosol, water reuse, energy efficiency*

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# 1. Introduction

Very small droplets that are dispersed in the fluid (gas or liquid) could not settle, because they are very light. However, if they coalesce i.e. merge in one bigger droplet, they could become heavy enough to settle and separate from the fluid in which they are dispersed. Coalescence filtration is separation method in which this phenomenon is applied and coalescers are devices in which coalescence filtration occurs (Govedarica & Sokolović 2014).

The coalescence filtration is widely used method for separation of liquid/liquid and gas/liquid dispersed systems in many industries like, petrochemical, chemical, food, pharmaceutical, power plants, etc, as well many other nonindustrial activities, where this kind of separation is need. For example, at car wash station, at ships, in kitchen, etc.

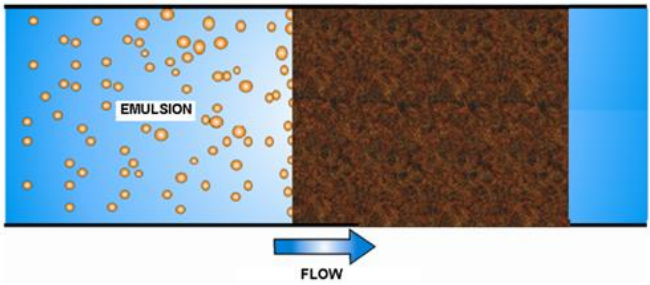
The filters that are used in coalescence filtration could be of very different kind and construction. They could be surface filters or filters made from packing materials that form filter bed. Surface filters are usually constructed as lamellae or porous surface of stainless steel or some other material. Filters made as bed material are constructed like deep bed filters and could be made from different materials. Coalescence on surface filter occurs on surface of filter, afterwards the drainage of liquid from the surface occurs. However, in filter beds coalescence occur in the volume of the bed, afterwards the droplets could settle.

In this paper is presented how coalescence filtration by filter bed coalescer could be applied in sustainable environmental practice. Firstly, the operating mode that is sustainable, key parameters and its optimization are described. Secondly, the filter bed materials that are eco-friendly are presented. And finally, application of sustainable operating mode of bed coalescer with eco-friendly filter bed material in sustainable environmental practice is presented.

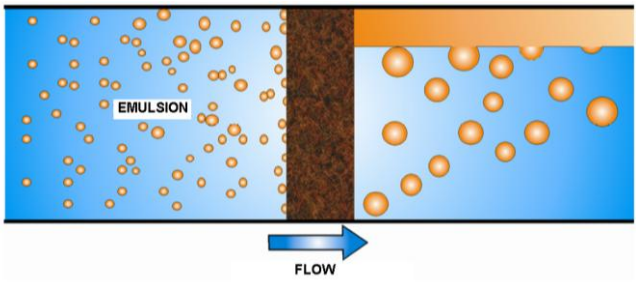
# 2. Sustainable operating mode and key parameters of bed coalescer

## 2.1 Operating mode of bed coalescer

The bed coalescers could operate discontinuously and continuously, Figure 1. a) and b).




a) Discontinuous mode of bed coalescer




b) Continuous mode of bed coalescer

*Figure 1. Modes of bed coalescer for liquid/liquid dispersed system (Šećerov Sokolović et al 2016)*

When bed coalescer operates discontinuously, Figure 1. a), the pressure drop rise until some maximal value, after which the bed cannot accumulate, i.e. merge any new amount of upcoming droplets of dispersed phase (Šećerov Sokolović et al 2016) i.e. coalescence is no longer possible. At that point filtration cycle if over, coalescence filtration ends and washing cycle of filter bed begins. This is a huge disadvantage of discontinuous operating mode of bed coalescers, due to generation of extra oily wastewater during the filter bed washing (Šećerov Sokolović et al., 2016). This has a negative impact on the sustainable development practice.

On the other hand, when the bed coalescer operates in continuous mode there in no need for filter bed washing i.e. there is no washing cycle, and therefore there is no generation of an extra amount of oily wastewater. In continuous operation mode the pressure drop rise only until steady-state regime is reached. State-state regime is reached when "capillary-conducted" phase is formed in filter bed (Šećerov Sokolović et al., 2016). When this condition is fulfilled, the bed coalescer could work continuously for a very long time.

In Figure 1. b) it is presented the operating scheme of bed coalescer in continuous working mode. Small droplets that are suspended in the fluid, flow until they reach the filter bed, where they coalesce. Upcoming droplets coalesce in filter bed by three different mechanisms in filter bed. Figure 2. presents the key

mechanisms how coalesce occur in filter bed: a) in capillary-conducted" phase i.e. saturated liquid, b.) the adjacent droplets in the pore space and c.) on the filter surface (Spielman et al., 1972a, 1972b, 1973). Afterwards the bigger liquid droplets exit from the filter bed and settle in the settling section of bed coalescer, from where the oil is discontinuously discharged.

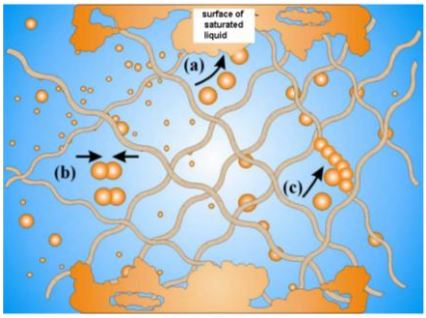



*Figure 2. Coalescence mechanisms in filter bed (Govedarica& Sokolović 2014)*

Sustainable operation mode of bed coalescer is continuous mode, because under this operating mode of coalescer there is no generation of oily wastewater due to filter wash. On the other hand, it works under constant pressure drop in steady-state regime, and therefore the energy demand is much lower than in discontinuous operating mode.

### 2.2. Key parameters of bed coalescer

Bed coalescence operating in steady-state mode is affected by many factors. However, the key parameters are fluid flow orientation, fluid velocity, bed properties, etc.

Bed coalescer could work at vertical up, vertical down, and horizontal fluid flow orientation. A long time ago, Šećerov-Sokolović et. al has shown that horizontal fluid flow orientation is the most effective fluid flow orientation for steady-state regime of bed coalescer (Šećerov-Sokolović et al., 2006), although today there are still many coalescers in vertical fluid mode.

Fluid velocity is for sure the key parameter of the coalescer because it determines not only its capacity but also its size. When it is necessary to construct small portable coalescers then the fluid velocity must be very high. However, there is critical velocity, the maximal velocity under which the emission limit value (ELV) could be obtained. After the critical velocity, coalescer could not treat wastewater any more effectively, because the ELV will be exceeded. Therefore, it is very important to determine critical velocity for every coalescer. This is determined by increasing of fluid velocity i.e. its optimization, until the value at which concentration of oil in effluent exceeds ELV.

Filter bed properties that affect the coalescence filtration are bed length, bed porosity and bed permeability. Bed length depends on construction of coalescer, and

for every coalescer there is one the most effective bed length under which there is no redispersion of coalesced liquid. Bed porosity and bed permeability depends on each other. If the bed porosity is changed bed permeability will be changed as well. However, bed permeability has direct influence on critical velocity (Šećerov Sokolović et al., 1997). Therefore, it is obvious that bed porosity, bed permeability and critical velocity are key parameters of bed coalescer that affect one on other (Hadnađev et al., 2022).

Variations in bed properties influence the modification of energy consumption and pressure drop of coalescer. By increasing the bed permeability, the critical velocity increases and the size of coalescer is reducing as well as its weight (Šećerov Sokolović et al., 2016; Šećerov-Sokolović et al., 1997). Therefore, the coalescer is portable, less space for its accommodation and less material for its contraction and foundation is needed (Šećerov Sokolović et al., 2016). All this has positive impact on sustainable development.

Unfortunately, the optimization of key parameters that will have the highest operation efficiency and that will be sustainable could be done only be performing experiments. The reason is that there are many parameters that are interconnected, and all of them are influenced by the nature of filter bed material.

## 3. Eco-friendly filter bed materials

There are many different materials that could be used as filter bed materials, from different polymers up to stainless steel. They could be in the form of globules or fibres. The most frequently used form of filter bed materials in coalescers are fibres. Because the fibres are compressible, and therefore filter beds of different porosity and permeability in the wide range could be easily formed.

The latest literature review shows that waste polymer materials for example polypropylene bags, waste from the carpet and furniture industry could be efficiently used as filter media in bed coalescers (Sokolović et al., 2016; Sokolović et al., 2019; Hadnađev et al., 2022; Sokolović et al., 2024). This waste materials are usually from polyethylene terephthalate, polypropylene, polyurethane, etc.

Since this waste is not disposed on landfills, due to its application as filter bed materials the concept of circular economy and sustainable development is reached. This application of waste fibres has also an impact on environmental pollution reduction. Also, it is very important to point out that filter bed materials formed from this waste fibres, could operate very long without need for its washing or changing, so therefore there is no generation of any waste or wastewater. Therefore, this waste fibres represents eco-friendly bed materials.

Beside these materials, materials that have unlimited life-time like for example expanded polystyrene (EPS) are also economically and eco-friendly, because there is no need to wash or change them (Sokolović & Šećerov Sokolović, 2024).

All these materials are very light and therefore, the coalescers with filter beds made from these materials could be easily moved from one place to another if needed.

## 4. Application of bed coalescers in Sustainable Development

In many industrial processes and activities oily wastewater is generated. For example, in petrochemical and chemical industry, food industry, petroleum refining, leather production, metal finishing (Govedarica & Sokolović, 2014). Oly wastewater is also generated in some non- industrial activities, like at households, at carwash stations, on ships, etc.

There are many published papers that have shown effective treatment of oily wastewater (liquid/liquid dispersed system) by bed coalescers.

Šević has shown that oil-reservoir water separation could be effectively done by coalescent filtration (Šević, 1992). On the other hand, Šećerov Sokolović et. al has shown that formation water and wastewater from hardening shop could also be effectively treated by coalescence filtration (Šećerov Sokolović & Sokolović, 2009). Newly published paper confirms effective treatment of car wash wastewater by combined methods in which one of the methods is coalescence filtration (Sokolović & Šećerov Sokolović, 2024). In some cases after the treatment of oily wastewater by bed coalescers, the treated water is of high quality that it could be reused in process.

The bed coalescers could be also effectively used for Metal Working Fluid (MWF) aerosols (liquid/gas dispersed system) that are generated in metal working industry because of MWF applications for cooling and lubrication of machine working paces (Sokolović & Laminger, 2021).

All this confirms that coalesce filtration has a great positive impact in sustainable environmental practice.

## 5. Summary

Coalescence filtration could be used in sustainable environmental practice for efficient treatment of oily wastewater treatment on one hand, and for MWF aerosol removal from the working atmosphere on the other hand.

Application of coalescence filtration for oily wastewater has a huge positive impact on Environment Protection and Sustainable Development, because when the bed coalescers is well optimized, oily concentration in treated water could reach values low below emission level limits (ELV), sometimes so low, that the water could even be reused in process (Sokolović & Šećerov Sokolović, 2024).

On the other hand, application of bed coalescers for MWF aerosol removal has a great impact on Occupational Health and Safety, as well as on Environment Protection (Mead-Hunter & King Mullins 2014; Sokolović & Laminger, 2021). MWF aerosols are generated in metal working industries, and if they are not properly removed from the working environment the workers would be exposed to this mist, and that could cause serious disease (Sokolović & Laminger, 2021). On the other

hand, if they are discharged in the atmosphere without previous treatment they could cause huge environmental problems in atmosphere.

Furthermore, if bed coalescer is designed to work in continuous mode, its contribution in sustainable environmental practice is even greater. Because in continuous operating mode of bed coalescers there is no need for filter wash so there is no generation of oily wastewater consequently. On the other hand, the energy demand is much lower than in discontinuous operating mode, because the coalescers works under constant pressure.

Last, but not least, if the eco-friendly filter bed materials are used, like waste fibres from carpet and furniture production, or waste polypropylene bags, the concept of circular economy and sustainable development could be fulfilled, because this waste fibres are not disposed on landfills, instead of that they are used as filter bed in coalescer. Also, it is important to say that most of these materials has unlimited lifetime, so there is no need for their change i.e. there is no generation of exhaust filter media that would represent waste.

## Acknowledgments

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# ADVANCEMENTS IN THE GLOBAL GREEN HYDROGEN ECONOMY

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***Abstract***

*Hydrogen has proved itself to be a viable alternative to the fossil fuels due to its flexibility in applications and easy production. The authors have through their extensive research on the viability of transforming the present fossil-based economy to a much cleaner and robust hydrogen-based economy, have suggested methods for a smooth transition. According to them it is possible to transform the global economy to almost 25% cleaner energy-based economy by 2035 if sufficient measures are taken by the countries in a unified manner. Through a survey undertaken globally, the authors have proved that cost of green hydrogen production will fall, and it will be a deciding factor in the decades to come.*

***Key words:*** *Green Hydrogen Economy, Net-zero emission, Carbon neutral, Global green hydrogen cost and Electrolysers.*

## 1. Introduction

Hydrogen is the smallest and the lightest element on earth and available in abundance in air and water. Our task is to harness the potential available in our earth to meet our energy needs in the cleanest possible manner. Green Hydrogen which is produced from electrolysis process as normal hydrogen but the fuel used to power the process is obtained from renewable energy sources like wind , solar and hydro –power. Thus the carbon emissions in the whole process is minimized leading to a cleaner environment. A lot of research is going on around the world on Hydrogen production , storage and transportation which involves a lot of brain-storming to minimize costs. First to get renewable energy sources which will be used in electrolysers to produce green hydrogen, then storing hydrogen in compressed gas form or liquid form ( -253 degree Celsius) in cryogenic containers and then transporting the same to places of end usage involves a lot of costs and care.

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It also involves trained personnel to handle the very volatile gas. For rich countries like USA , EU countries and China , the whole process may be a small percentage of their GDP but for emerging economies like India , Pakistan , African countries and even South American countries , the costs involved are a substantial part of their GDP. We need to have a parity wherein all countries rich and poor may utilize their resources towards a common goal of making our planet carbon neutral (Kakoulaki et al., 2021).

## 2. Developments in the Electrolyser front

The cost of electrolysers could reduce by 40 per cent by 2030 with 100 GW of capacity deployment; and in a close to zero emissions system, the cost of electrolysers is expected to reduce by about 70 per cent by 2050 with a deployment of 1700 GW. These estimates are in line with the estimates provided by the Hydrogen Council which aims at 60 per cent reduction in cost by 2030, India has recently announced the National Hydrogen Mission which aims for generation of hydrogen from green power resources. The proposed mission would aim to lay down Government of India's vision, intent and direction for hydrogen energy and suggest strategy and approaches for realisation of the vision. The mission aims to develop India into a global hub for manufacturing of hydrogen and fuel cells technologies across the value chain. Major activities under the Mission include: creating volumes and infrastructure; demonstrations in niche applications (including for transport, industry); goal-oriented research & development; facilitative policy support; and putting in place a robust framework for standards and regulations for hydrogen technologies . The India H2 Alliance, led by Chart Industries and Reliance Industries, has come against the backdrop of the proposed National Hydrogen Mission, which may mandate fertilizer, steel and petrochemicals industries to shift to green hydrogen.

The increasing ambition of climate targets creates a major role for hydrogen especially in achieving carbon-neutrality in sectors presently difficult to decarbonise. This work examines to what extent the currently carbon-intensive hydrogen production in Europe could be replaced by water electrolysis using electricity from renewable energy resources (RES) such as solar photovoltaic, onshore/offshore wind and hydropower (green hydrogen). The study assesses the technical potential of RES at regional and national levels considering environmental constraints, land use limitations and various techno-economic parameters. It estimates localised clean hydrogen production and examines the capacity to replace carbon-intensive hydrogen hubs with ones that use RES-based water electrolysis.

A major finding in our study is that most of the examined European regions have sufficiently high technical potentials to be self-reliant using renewable energy. Furthermore, clean hydrogen offers new opportunities for re-designing Europe's energy partnerships with both neighbouring countries and regions and its international , regional and bilateral partners, advancing supply diversification and helping design stable and secure supply chains. As for example several major

hydrogen-producing regions and especially densely populated regions (large cities, metropolitan areas) would not have sufficient green electricity to cover both current electricity consumption as well electrolytic production of hydrogen.

Switching the current annual EU hydrogen production of 9.75 Mt to electrolysis would require 290 TWh of electricity (about 10% of current production). The available technical potential for producing green electricity from wind, solar and hydro is easily sufficient to cover all current electricity consumption as well as this additional demand for green hydrogen, showing that a partial utilisation of prime locations could suffice. It was possible to geo-locate approximately 75% of current hydrogen production to 109 out of the 309 regions in the EU and UK. (Data collected is of 2019 from Bloomberg , ARENA and Indian Government websites ).

## 2.1 Strides by the EU in the green hydrogen arena

The European Union aims at becoming a world leader in green hydrogen. The European Commission's hydrogen strategy represents an ambitious goal, given that it aims at making hydrogen an integral part of the future energy mix, accounting for 13- 14% of Europe's energy mix by 2050 – now it is only 2%. The European interest for green hydrogen results from its commitment to become carbon neutral by 2050. Thus, the EU seeks to represent itself as the major global player in renewable energy, developing the most advanced technologies and pursuing innovative policies. Moreover, the EU seeks to diversify its energy sources, becoming independent from oil and natural gas imports, and enhancing security of energy supply. The European Union also counts on partnerships with third countries for imports of renewable hydrogen, mainly using the existing gas pipelines which connect Southern Europe to North Africa. The European Union has always been a leader in climate policies, implementing the Paris Agreement and adopting carbon-neutrality goals as part of its agenda. In July 2020, following its commitment to reach carbon neutrality by 2050, the EU decided to adopt a Hydrogen Strategy48. Even though the European Union is composed of diverse realities, with countries following different pathways towards climate neutrality, its common strategy sent a clear message, believing in the potential of hydrogen as a sustainable energy carrier. Particularly, the EU encouraged the production and use of green hydrogen, as a long-term alternative to fossil fuels. Part of the European Green Deal, the Hydrogen Strategy will contribute to consolidate the EU's global position as a norm and standard setter on energy transition, promoting its technological leadership, increasing its energy security, and strengthening partnerships with third countries. The EU Hydrogen Strategy, linked to funds from the EU Recovery Plan, represents an opportunity for Southern European countries, including Italy and Spain, which could become renewable hydrogen hubs, by importing hydrogen produced in North Africa from solar power and exporting it to other European countries, through the existing gas pipelines (Kakoulaki et al., 2021).

## 3. Discussions

A clean hydrogen economy offers promising opportunities not only to fight climate change, but also to redraw geopolitical relations between states. The energy transition is already taking place, with renewable energies gradually eroding the global energy system based on fossil fuels. A global transformation, set in motion by the need to decarbonise the energy system, will have the potential to redraw international alliances and conflicts. In this context, hydrogen may play a crucial role (Fan et al., 2021).

By 2050, hydrogen could indeed meet up to 24% of the world's energy needs, thus highly influencing the geopolitical landscape. In this regard, the choice over which pathway to take for the creation of hydrogen value chains will have a huge geopolitical impact, resulting in new dependencies and rivalries between states. Conclusively, if national governments are willing to spur the emergence of a green hydrogen economy, they should heavily invest in research and development, encourage the development of a clean hydrogen value chain, and promote common international standards. Moreover, they should also take into account hydrogen's geopolitical implications. If the hydrogen economy is well-managed, it could indeed increase energy security, diversify the economy, and strengthen partnerships with third countries.

## 4. Figures

The authors had framed 30-questions and took feedback from a wide cross-sections of the society globally including DBA students, industrial experts , professors , Doctors and environmentalists. The results are produced below:

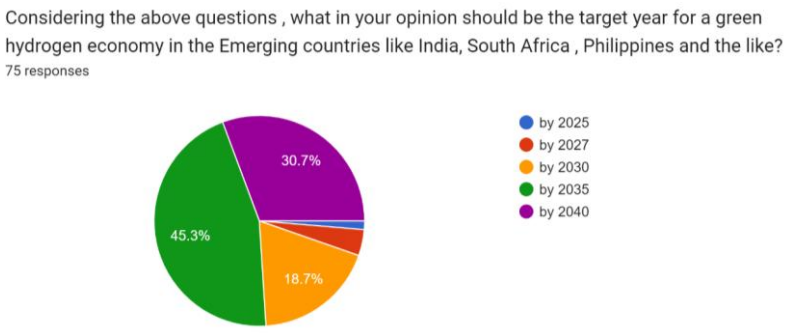


*Figure 1. Opinion regarding the target year for green hydrogen economy*

The above responses reflect that globally people are aware of a transition towards a "Green Hydrogen Economy" and are hopeful of getting the results by 2035-2040. The responses from 75 persons on the questionnaire, supports our findings from our research model and our conviction that a "Green Hydrogen Economy is possible by 2035" is confirmed. The cost reduction to about $ 2 per Kg

by 2035, predicted by our model is also supported by the survey . For emerging nations of Asia , Africa & Europe to have a 25% contribution from green hydrogen of their total energy requirements , they would spend about $ 500-600 billion on green hydrogen and other renewable energies during 2030-2040. Support from developed countries in this matter is also a must. The survey also supports that a larger public-private participation is required in all the emerging nations , to contribute to enhanced production of electrolyzers and for funding of a larger infrastructure to enable green hydrogen production , storage and transportation. The following table shows the expenditure profile of various countries on the green hydrogen front.

*Table 1: Datasheet on Green Hydrogen in Emerging Nations*

| Serial No | Country | Cost of production (in $/kg) | Expenditure/ Investments (in billion $)in 2019 | Growth % on 2018 | Stakeholder participation (Govt/private) |
|---|---|---|---|---|---|
| 1 | India | 6-10 | 9.3 | -14 | Both |
| 2 | Taiwan | 6-9 | 8.8 | 390 | Both |
| 3 | Vietnam | 6-10 | 2.6 | -64 | Both |
| 4 | Brazil | 6-12 | 6.8 | 74 | Both |
| 5 | UAE | 6-10 | 4.5 | 1223 | Both |
| 6 | Mexico | 6-9 | 4.3 | 17 | Both |
| 7 | Korea (Republic) | 6-11 | 2.4 | 31 | Both |
| 8 | Sweden | 6-9 | 3.7 | -19 | Both |
| 9 | South Africa | 6-10 | 1.0 | -76 | Both |
| 10 | Netherlands | 6-9 | 5.5 | 25 | Both |
| 11 | Poland | 6-10 | 1.8 | 349 | Both |
| 12 | Italy | 6-8 | 1.3 | -35 | Both |
| 13 | Finland | 6-8 | 1.5 | 41 | Both |
| 14 | Australia | 6-11 | 5.6 | -40 | Both |
| 15 | Spain | 6-9 | 8.4 | 25 | Both |

*Source: Expenditure in 2019 & growth over 2018 has been taken from UNEP Centre-Bloomberg NEF*

## 5. Conclusion

The authors have concluded from their extensive research that the present trend in renewable energy investments is about 10% growth year to year. In the next 10 years with the average trend of 10% per year, we can forecast an investment of 100 % over the investment in 2019, i.e of around billion US $ 135 , which comes to around billion US $ 9 for each of the 15-countries shown in Table-1. For six countries like India, Brazil, Taiwan, Netherlands, Australia & Spain, whose investments in 2019 are more than 5 US billion $, the forecasted investments in2029 will be about 10-18 billion US $. This will further increase to 16 – 29 billion US $ in 2035 with the same trend.

Similarly in developed countries if we consider the same trend of 10% growth in investments per year, the investments in 2035 for renewable energy would be in billion US $ for : USA- 153, Europe- 152 & China – 234. So total investments in 2035 for the 3-developed countries as above would be 539 billion US$. Whereas the 15-

developing nations would require an investment of 345 billion US$. The above investments in renewables and green hydrogen in the countries considered above would depend upon the socio-political scenario as well as the economic strength of the individual countries.

**PwC** *evaluated the production cost trajectory of green hydrogen worldwide and the key findings are:* Hydrogen production costs will decrease by around 50% through 2030, and then continue to fall steadily at a slightly slower rate until 2050. By 2050, green hydrogen production costs in some parts of the Middle East, Africa, Russia, China, the US and Australia will be in the range of €1 to €1.5/kg. The above results corroborate our findings on the "Green Hydrogen Economy" and re-iterate the importance of the world order shifting towards green hydrogen from the dependency on fossil-fuels at present.

## Acknowledgments

We acknowledge the contributions of all 75 persons who gave their honest feedback on the future of Green Hydrogen Economy from all over the world. We are also thankful to the authors whose references are given below for helping us in our research work.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# REACTION TO FIRE OF MASONRY MORTAR BLENDED WITH ENVIRONMENTALLY-FRIENDLY MATERIALS

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***Abstract***

*Sustainable development in the twenty-first century necessitates the strategic use of renewable, environmentally-friendly materials as well as inventive thinking. Hence, it is unavoidable to assess their performance and engineering properties to be accepted by the civil engineering community. Traditional masonry structures have relied heavily on conventional cement-lime mortars. Owing to enormous natural resources consumption (limestone and clay) and a large amount of $CO_2$ discharged into the environment due to the thermal treatment of raw materials, these mortars might be classified as unfriendly in contemporary engineering practice. Therefore, in recent years, extensive research has been conducted on the application of various pozzolanic materials as a feasible option for developing new, alternative types of greener masonry mortars. However, just a few studies have addressed the fire behaviour aspect of masonry mortars, particularly those containing supplementary cementitious materials. This paper focuses on the reaction to fire of nine different masonry mortar mixtures incorporating locally accessible waste materials: ceramic waste powder, fly ash, and biomass ash, as cement substitutes. Non-combustibility and the gross heat of combustion tests were performed with the aim of categorizing investigated mortars into fire reaction classes. The results indicate that all mortar combinations meet the requirements for the A1 fire reaction class, while all blended mortars had lower mass loss and heat release in relation to the reference cement-lime mortars.*

***Key words:*** *masonry mortar, fire reaction class, environmentally-friendly materials.*

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# 1. Introduction

Nowadays, sustainability involves the strategic use of renewable and environmentally acceptable building resources, such as waste materials produced as by-products of industry and agriculture.

To be accepted by the civil engineering community, sustainable materials must be evaluated for their performance and engineering properties. This includes assessing their durability, structural integrity, energy efficiency, thermal performance, and fire safety.

Fire safety represents one of seven basic requirements that construction products and buildings must satisfy for an economically reasonable working life, subject to normal maintenance (Zakon o građevinskim proizvodima No 83/2018), (Regulation (EU), No 305/2011). Preventing ignition and fire development by using building materials with adequate reaction to fire characteristics represents the first phase of passive fire protection (Martin, 2017). Reaction to fire is defined as "*a response of a product in contributing by its own decomposition to a fire to which it is exposed, under specified conditions*" (SRPS EN 13501-1: 2018).

Traditional masonry structures have relied heavily on conventional cement-lime mortars. Owing to enormous natural resources consumption (limestone and clay) and a large amount of $CO_2$ discharged into the environment due to the thermal treatment of raw materials, these mortars might be classified as unfriendly in contemporary engineering practice.

In recent years, extensive research has been conducted on the application of various pozzolanic materials as a feasible option for developing new, alternative types of greener masonry mortars. However, just a limited number of studies have addressed the fire behaviour aspect of masonry mortars, particularly those containing supplementary cementitious materials (SCMs). According to the findings of Mohit et al., ceramic waste powder as cement replacement improves the thermal resistance of mortar mixes (Mohit & Sharifi, 2019). Silica fume has a favourable effect on improving the fire performance of thermal-insulating mortar and can significantly mitigate the adverse effects of high-temperature deterioration, which is helpful for the fire performance of insulation mortars applied to building facades (Ding, 2023). Textile reinforced mortars can provide effective protection and prevent cracking of masonry due to fire (Estevan, 2023). High strength mortars that have equivalent residual strength after exposure to 700°C to that of control cement mortar specimens before exposure to high temperature can be produced by replacing cement with high-volume fly ash and using colloidal nanosilica (Ibrahim, 2012). Cement mortars with mineral wool from construction and demolition waste recycling can be a sustainable alternative to the commercial ones currently being used, improving mechanical-thermal behaviour after the fire and preventing the explosive behaviour of the mortars (Piña Ramírez, 2020). SCMs such as fly ash, ground granulated blast-furnace slag, silica fume, nanoclay, and nanosilica, preserve mechanical properties of the coating mortar at high temperatures and also reduce

harmful effects of the expansion of $Ca(OH)_2$ at high temperatures and its deleterious effect during rehydration (Matias Martins, 2024).

The paper focuses on the reaction to fire of nine different masonry mortar mixtures incorporating locally accessible waste materials: ceramic waste powder, fly ash, and biomass ash, as cement substitutes. Non-combustibility and the gross heat of combustion (calorific value) tests were performed with the aim of categorizing investigated mortars into fire reaction classes.

## 2. Materials and methods

### 2.1 Materials

Portland Cement (PC), produced by the Lafarge cement plant in Vojvodina, was used. The cement has a Blaine fineness of 4.000 $cm^2/g$ and a density of 3.1 $g/cm^3$.

Fly ash (FA), corn cob ash (CCA), and ceramic waste powder (CWP) were used as SCMs in the cement-lime masonry mortars.

FA was provided by the thermal power plant Nikola Tesla B in Obrenovac, Serbia.

CCA was collected from ALMEX-IPOK in Zrenjanin, Serbia. This starch factory uses biomass waste, i.e. corn cobs, as an energy source and generates substantial amounts of CCA as a by-product.

CWP was produced from ceramic manufacturing waste, consisting of damaged clay hollow blocks discarded in the production facility NEXE Stražilovo in Petrovaradin.

As the fineness of FA was satisfying, no additional mechanical processing was necessary, while CCA and CWP had to be additionally ground in the lab ball mill up to the appropriate level of fineness.

The results of testing the chemical composition of SCMs are summarized in Table 1.

*Table 1: Chemical compositions of SCMs*

| | FA | CCA | CWP |
|---|---|---|---|
| **$SiO_2$** | 53.64 | 45.76 | 60.86 |
| **$Al_2O_3$** | 25.74 | 5.91 | 16.38 |
| **$Fe_2O_3$** | 7.36 | 3.37 | 6.81 |
| **$Na_2O$** | 0.30 | 0.00 | 0.77 |
| **$K_2O$** | 1.48 | 13.10 | 2.39 |
| **MgO** | 3.09 | 8.30 | 3.89 |
| **CaO** | 7.15 | 14.08 | 9.38 |
| **$SO_3$** | 2.75 | 1.26 | 0.80 |
| **$P_2O_5$** | 0.06 | 2.81 | 0.14 |
| **Content Cl** | 0.01 | 0.50 | 0.002 |
| **Reactive $SiO_2$** | 48.16 | 38.21 | 50.26 |

Owing to the favourable chemical composition, when it comes to SCMs, all tested materials displayed positive pozzolanicity, whereas FA and CWP showed a pozzolanic activity of Class 10, while CCA demonstrated a pozzolanic activity of Class 5, in line with SRPS B.C1.018:2015. All SCMs met the requirements regarding the activity index in accordance with SRPS EN 450-1:2014.

River sand was employed as fine aggregate in the production of mortar. Its specific gravity was determined to be 2.3 g/cm$^3$ and its fineness modulus to be 0.97.

Masonry mortar was prepared with tap water.

### 2.2 Methods

The chemical composition of raw materials was analysed in accordance with SRPS EN 196-2:2015 and ISO 29581-2:2010.

Non-combustibility and the gross heat of combustion (calorific value) tests were performed according to SRPS EN ISO 1182:2021 and SRPS EN ISO 1716:2018 standards.

Fire classification of masonry mortars into fire reaction classes was carried out according to SRPS EN 13501-1:2018.

### 2.3 Mixing and proportioning of mortars

Nine different mortar mixtures were used in the experimental investigation. The mixing ratios of reference cement-lime mortar (C) were: 1:0.7:4.2, and 1:1:4 (cement/lime/sand), by volume. In the remaining mixtures, substantial amount of cement (up to 60%) was replaced by FA, CCA, or CWP for each mixing ratio by volume. The mixing ratios and the levels of cement substitution were chosen based on the previous laboratory trials.

The water-to-binder ratio (w/b) was adjusted aiming to achieve the required workability of masonry mortar (175±10 mm), as prescribed by SRPS EN 1015-2:2008.

The labels and quantities of component components for each masonry mortar are shown in **Error! Reference source not found.**.

*Table 2: Labels and component materials quantities for designed masonry mortars*

| Mortar | $m_c$ (g) | $m_l$ (g) | $m_s$ (g) | $m_{scm}$(g) | w/b | $m_w$ (g) |
|---|---|---|---|---|---|---|
| **C2** | 193.7 | 59.2 | 1350 | / | 1.05 | 265.6 |
| **FA2-50** | 96.9 | 59.2 | 1350 | 59.6 | 1.25 | 269.5 |
| **CCA2-50** | 96.9 | 59.2 | 1350 | 68.7 | 1.18 | 265.2 |
| **CWP2-50** | 96.9 | 59.2 | 1350 | 74.2 | 1.20 | 276.3 |
| **C3** | 201.8 | 92.5 | 1350 | / | 0.90 | 264.9 |
| **FA3-50** | 100.9 | 92.5 | 1350 | 62.0 | 1.05 | 268.2 |
| **CCA3-50** | 100.9 | 92.5 | 1350 | 71.6 | 1.00 | 265.0 |
| **CCA3-60** | 80.7 | 92.5 | 1350 | 85.9 | 1.03 | 266.9 |
| **CWP3-50** | 100.9 | 92.5 | 1350 | 77.3 | 1.00 | 270.7 |
| *$m_c$-mass of cement; $m_l$-mass of lime; $m_s$-mass of sand; $m_{scm}$-mass of SCM; $m_w$-mass of water; w/b-water to binder ratio.* | | | | | | |

# 3. Test results and discussion

## 3.1 Non combustibility test

The cylindrical test specimens, five of each series, having a diameter of (45±2) mm and a height of (50±3) mm, were prepared, as illustrated in Figure 1.

*Figure 1: Test specimens, prepared for combustibility test*

The specimens were dried in a ventilated oven maintained at (60±5)°, for 24h, and cooled to ambient temperature prior to testing. The test lasts 30 minutes, and the sample is exposed to a temperature of (750±5) °C in hot furnace. The mass, before and after the test for each specimen was recorded.

The result of the measurement is the mass loss of the samples in percentages after the combustion process. Figure 2 shows the mass loss in nine different masonry mortar mixtures.

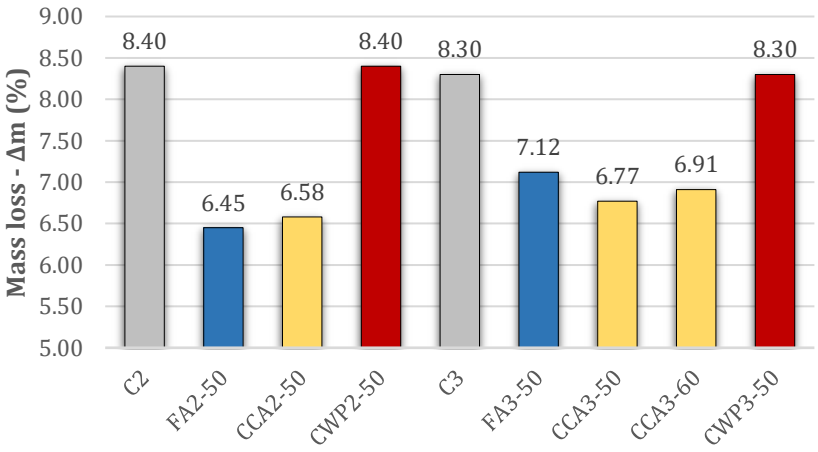


*Figure 2: Mass loss of test specimens after the combustion process*

The test findings revealed that reference cement mortars and mortars with CWP have the highest mass loss, ranging from 8.3 to 8.4%. Masonry mortars blended with FA and CCA displayed the lowest values of mass loss, ranging from 6.4 to 7.1%.

All tested masonry mortars met the requirements for non-homogeneous materials categorized in A1 fire reaction class (Δm≤50%), according to SRPS EN 13501-1:2018 mass loss classification criterion.

Figure 3 depicts the specimen following the combustion process. The majority of test specimens retained their cylindrical shape following the test; nonetheless, their structure was friable and prone to collapse. It should be emphasized that no persistent blazing or consistent blue-coloured luminous gas zones were detected during the test. All evaluated specimens showed no sustained flame, indicating that all mortar combinations met the threshold for the A1 fire reaction class ($t_f$=0s).

*Figure 3: Test specimens after the combustion process*

### 3.2 The gross heat of combustion

Heat of combustion (calorific value, Q) is defined as "thermal energy produced by combustion of unit mass of a given substance" (expresed in MJ/kg). Gross heat of combustion (PCS) represents "heat of combustion of a substance when the combustion is complete and any produced water is entirely condensed under specified conditions" [SRPS EN ISO 1716:2018].

Five test specimens of each mortar combination were broken and burned under standardized conditions, in a bomb calorimeter. The gross heat of combustion was calculated based on the observed temperature rise, taking into account heat loss and the latent heat of vaporization of water.

Figure 4 shows the average values of the gross heat of combustion computed from measurements on three specimens of each mortar type.

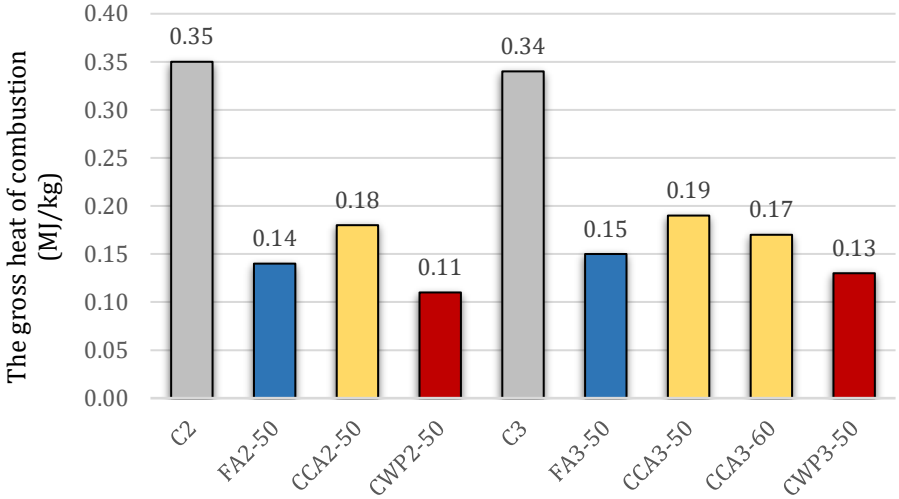


*Figure 4: The gross heat of combustion of masonry mortars*

The obtained results indicate that reference cement mortars are characterized by the highest heat release values. All mortar types containing SCMs demonstrated lower values of heat release, with minimal variances between them.

Based on the classification criterion related to the gross heat of combustion, specified in SRPS EN 13501-1, all tested masonry mortars met the requirements for non-homogeneous products classified in A1 fire reaction class (PCS≤2.0 MJ/kg).

## 4. Conclusions

Reaction to fire test is used to evaluate the contribution of a material and building elements to fire growth. In this experimental research, innovative mortar mixtures were prepared with locally available environmentally friendly materials, derived as by-products from industry and agriculture: corn cob ash, ceramic waste powder, and fly ash. Nine different masonry mortar formulations were designed, produced and subjected to the fire reaction test, whereas non-combustibility and gross heat of release were determined. The main findings of this study are briefly listed below.

- Regarding non-combustibility test, all masonry mortars met the requirements for non-homogeneous materials categorized in A1 fire reaction class (Δm≤50%). With this regard, mortars blended with fly ash and corn cob ash displayed superior performance (the lowest mass loss).
- All evaluated specimens showed no sustained flame, indicating that all mortar combinations met the threshold for the A1 fire reaction class ($t_f$=0s).

- SCM-blended mortars demonstrated lower values of gross heat release, in relation to the reference cement-lime mortar. Nevertheless, all tested masonry mortars met the requirements for non-homogeneous products classified in A1 fire reaction class (PCS≤2.0 MJ/kg).

It can be stated that novel, environmentally friendly masonry mortars, produced with higher share of locally accessible waste materials, satisfy requirements regarding A1 fire reaction class and may, thus, be effectively utilized as integrated part of fire-rated masonry structures.

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# ACCESS TO JUSTICE IN THE FIELD OF THE ENVIRONMENT WITH SPECIAL REFERENCE TO LIABILITY FOR ENVIRONMENTAL DAMAGE, ENVIRONMENTAL CRIMINALITY, AND ENVIRONMENTAL FORENSICS IN THE REPUBLIC OF SERBIA

*Tina Janjatović*[1]

***Abstract***
*The paper discusses aspects of access to justice, ie, the concept of liability regarding the damage to the environment and environmental crime. An overview of the provisions of the Directive on environmental liability regarding environmental damage is given. Cases of access to justice related to environmental crime and environmental forensics are presented. The main aspects of access to justice under the Aarhus Convention are explained. Problems, challenges, and dilemmas in the implementation of access to justice in the field of environmental crime are pointed out. An assessment of the implementation of access to justice in the segment of liability for environmental damage and punishment for torts in the field of the environment is given. It is considered whether the concept of liability for environmental damage is more effective than criminal environmental protection in terms of actual environmental protection.*

***Key words****: access to justice, environmental crime, environmental forensics, liability for environmental damage, Aarhus Convention.*

## 1. Liability for Environmental Damage

After the Chornobyl environmental accident that occurred on April 26, 1986, Europe was rocked by another major environmental accident, the spill of toxic chemicals stored by the Sandoz company into the Rhine River near Basel (Lucas, 2001). This environmental accident, which took place on November 1, 1986, caused water pollution to such an extent that a red toxic flow was visible for weeks in a length of 70 kilometers. The pollution affected the course of the river that passes

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through four states. The entire population of fish in the Rhine River was destroyed, as well as the flora and fauna that inhabited the banks of the Rhine. On this occasion, criminal proceedings were initiated against the persons responsible for the company, but the question of how the damages will be compensated is also open. Lawsuits for compensation for damage, which were filed by Switzerland, Germany, France, and the Netherlands, ended with a settlement, so on this occasion, judicial practice did not formulate positions that would be applied in future cases of compensation for environmental damage (Drenovak-Ivanovic et al. 2013: 52-53). Encouraged by this case, in the absence of rules on compensation for environ mental damage at the European Union level, the European Commission submitted a proposal for a future policy to solve this issue with established guidelines for its regulation. In this proposal, it is emphasized that the issue of compensation for damage to the environment must be regulated in accordance with the general principles of civil law, i.e. with the idea that the person who causes the damage has an obligation to compensate it. When it comes to compensation for environmental damage, the general rules of civil law are not sufficient to achieve environmental protection, so it is necessary to form a special legal regime that corresponds to its complex nature (Green Paper on Remedying Environmental Damage, 2003). After consideration of this proposal, Directive 2004/35/EC of the European Council and the European Parliament on Environmental Liability with Regard to the Prevention and Remedying of Environmental Damage was adopted in 2004 (hereinafter: Directive on Liability for Environmental Damage).

The Directive on liability for environmental damage aims to establish a common legal framework for the prevention and remedying of environmental damage and to supplement the existing nature protection regime established at the EU level, regulated by the Directive on the protection of wild birds (Council Directive 79/409/EEC) and the Directive on habitats (Council Directive 92/43/EEC). The aforementioned directives do not contain provisions on liability, which makes it impossible to establish liability for damage caused to protected species and habitats protected by the aforementioned directives, to implement remediation measures, i.e. to eliminate damage, or to reimburse the costs of these measures if public authorities implement them (Brans, 2013: 31-32).

The purpose of this directive is to establish a framework plan for environmental liability based on the "polluter pays" principle, in order to prevent and eliminate environmental damage, as well as to provide legal conditions for environmental polluters to become financially responsible for remediation and prevention of environmental damage (Janjatovic et al., 2015). The Environmental Liability Directive aims to prevent and remedy environmental damage, without affecting the right to compensation for ordinary damages arising from the right to compensation for damages in accordance with the rules of civil law or the right to compensation for damages arising from from an international agreement that regulates civil liability for damages (Directive on Environmental Liability 2004/35/EC). This further means that this directive does not apply to compensation for bodily injury, compensation for damage caused to a person's property, or

compensation for actual damage. The performed analysis shows that Directive 2004/35/EC provides additional legal protection than that guaranteed by the rules of civil law, which starts from the fact that damage always implies the existence of an injured person (Krämer, 2012: 174). Damage in the environment is very complex and cannot be reduced only to damage suffered by a specific person. In practice, one can find examples in which fish have been destroyed on a river into which wastewater is discharged by several operators, or in which it is not possible to identify the person who suffered specific damage, but it is an injury that has a predominantly public law character, such as, for example, pollution of the river or forest land.

The directive foresees objective and subjective responsibility for damage to the environment depending on the operator's activity. An operator who causes damage to the environment or is in immediate danger of damage to one of the activities listed in Annex III of the Directive is responsible according to the principle of objective responsibility, regardless of fault. An operator who causes damage or immediate danger of such damage to protected species and natural habitats through some other activity that is not listed in Annex III of the Directive is liable according to the principle of subjective responsibility - if he makes a deliberate mistake or makes a mistake through negligence. Activities listed in Annex III of the Directive refer to activities covered by Directive 96/61EC on integrated prevention and control of environmental pollution, as well as EU regulations related to the transport of hazardous substances, waste management, and the release of genetically modified organisms. These activities from Annex III represent activities that are extremely dangerous for the environment (Brans, 2006: 5).

In the Republic of Serbia, liability for environmental damage is regulated by the rules of civil and criminal law. The Law on Environmental Protection ("Official Gazette of RS", No. 135/04, 36/09, 72/09, 43/11, and 14/16) (hereinafter: LEP) in Art. 107 and 108 regulate liability for environmental damage. The LEP stipulates that anyone who suffers damage has the right to compensation. Compensation claims can be submitted directly to the polluter. Proceedings before the court for compensation of damages are urgent. The general rules of the Law on Obligations (hereinafter: LO) are applied to issues of liability for environmental damage that are not specifically regulated by this law. In terms of liability for environmental damage following the requirements of the Directive, the provisions of the LO cannot be applied as a subsidiary because they refer to ordinary damage that is not the subject of this **directive** (Todic & Janjatovic, 2018:318-319).

## 2. Environmental Crime and Environmental Forensicss

In the criminological sense, environmental crime is defined as any act that is contrary to the environmental-legal norm (Kostic, 2009: 175).

Countering a serious global problem such as environmental crime and effective enforcement of environmental regulations requires the involvement of as many relevant actors as possible. This approach is a consequence of the

understanding that environmental protection is primarily achieved through a system of preventive and repressive measures prescribed by law in the area of administrative, civil, economic and financial law, which are mostly implemented by inspection bodies. Criminal protection of the environment is a last resort, but a very effective and necessary option, and the effective implementation of environmental legislation is of vital importance for the suppression and prevention of this type of crime (Lukic, 2009).

Discovering and proving environmental crime requires the cooperation of all competent authorities, the police, the public prosecutor, forensic experts, experts, and environmental protection inspectors. When conducting an investigation, the authority of the procedure (public prosecutor, court or other state authority before which the procedure is conducted), as a rule, requests the help of an expert from the forensic or other profession, who, if necessary, undertakes to find, secure or describe traces, perform the necessary measurements and recording, makes sketches, takes necessary samples for analysis or collects other data (Article 133, paragraph 3 of the Criminal Procedure Code).[1] An expert can also be invited to the investigation if his presence would be useful for providing findings and opinions. Bearing in mind the nature of criminal acts against the environment, the presence of such experts is almost always necessary at the investigation because hardly any of the prosecutors or the police have professional knowledge in the field of engineering, technology, chemistry, mechanical engineering, chemistry, biology, veterinary medicine, etc. to the extent that he would be able to conduct an investigation independently. The presence of environmental protection inspectors during investigations is also of great importance because they have all the necessary professional knowledge in order to indicate to the police and the prosecutor in which direction to reveal evidence, which documents to examine, where there would be traces of a criminal act, etc.] (Vuckovic et al., 2022:54).

Inspection bodies that provide professional assistance in the field, carry out sampling (water, soil or other) independently or by hiring reference laboratories that have appropriate licenses for conducting expertise, or measurements (air pollution) and deliver the obtained results to police officers or the prosecutor's office for further action. Police officers carry out operational tactical measures and actions and evidence actions provided for in the Code of Criminal Procedure, and if necessary, for certain types of analysis, they can engage the National Center for Criminal Forensics, which is qualified to perform forensic expertise and provide material evidence for proving criminal acts. The organizational unit of the Directorate of Police and Police Administration consists of the Directorate of Criminal Police, which includes the National Center for Criminal Forensics and the Unit for Suppression of Environmental Crime and Environmental Protection. The Unit for Suppression of Environmental Crime and Environmental Protection

1 *Official Gazette of the Republic of Serbia No.* 72/11, 101/11, 121/12, 32/13, 45/13, 55/14, 35/19, 27/21 i 62/21

monitors, analyzes and reports on the state, movement and forms of economic crime in the field of ecology and environmental protection. Directs, coordinates and controls the line of work of the criminal police in regional police administrations in the field of environmental crime. It provides professional assistance and is directly involved in solving the most serious and complex crimes. Inspects and controls the implementation of work plans and reports on the work of organizational units of the criminal police in police administrations with the aim of suppressing crime in the field of ecology.[1]

The application of environmental regulations is an important factor in environmental protection and reduction of environmental damage, and this is achieved through the work of competent authorities. The role of the police in environmental protection depends on specific circumstances, but the police can be considered a potentially important factor in controlling compliance with regulations in the field of environmental protection, because there are usually a much larger number of authorized officials employed by the police than environmental protection inspectors in a certain area. However, the police have numerous tasks within their scope of work, in the sense of preventive and repressive activity in connection with criminal acts in a society, and compliance with environmental regulations is not a priority in the work of the police in principle, as long as the elements of the act are not acquired in that violation of a punishable offense under the penal regulations of a country (Lukic & Pisaric, 2012: 231).

The inspector responsible for the environment may, within the limits of his authority, file criminal charges with the competent authority if a criminal offence was committed. Criminal offences in the domain of the environmental protection are defined in Chapter XXIV of the Criminal Code.[2] The Criminal Code of the Republic of Serbia recognizes the environment as a protective object, so this law prescribes eighteen criminal acts, as well as criminal sanctions for the execution of these criminal acts, ranging from fines to imprisonment.

### 2.1 Access to Justice Within Aarhus Convention

The Aarhus Convention was concluded on June 25, 1998 at the fourth ministerial conference "Environment for Europe" (in the city of Aarhus, Denmark) within the activities of the United Nations Economic Commission for Europe, and entered into force on October 30, 2001. The Aarhus Convention establishes specific obligations of member states concerning three groups of issues: access to environmental information, public participation in environmental decision-making, and access to justice in environmental matters, which constitute the three pillars of

[1] Ministry of Internal Affairs, Informator o radu, the Unit for the Suppression of Environmental Crime and Environmental Protection, https://informator.poverenik.rs/informator?org=v2yHFESmGTAMAfXF5&ch=B7e85r4rMtMRMyzb7, 17.09.2023.

[2] *Official Gazette of the Republic of Serbia No.* 85/05, 88/05, 107/05, 72/09, 111/09, 121/12, 104/13, 108/14, 94/16 and 35/19

the Aarhus Convention. The Republic of Serbia ratified the Aarhus Convention in 2009. godine and acceded to the Aarhus Convention on July 31st, 2009.

## 3. Access to Justice Cases Related to Environmental Criminality and Environmental Forensics

### 3.1 The case of hazardous waste in Pancevo

The police discovered that there was a large amount of hazardous waste at three locations in the city of Pancevo, and the judge issued an order to search the apartment and other premises at all three locations. It turned out that the locations as well as the houses or other premises at those locations belonged to the owner of the company who had the necessary permits for waste treatment but not for storing hazardous waste at the locations where it was found, nor could anyone present at the investigation point to the origin of the waste that was found, as well as how long it was there because no documentation existed for this waste.

An investigation was carried out by the police and the public prosecutor and the investigation was attended by experts from the city's public health institute who sampled the substances found at these locations. Considering the complexity of the investigation, as well as a large amount of waste found, environmental protection inspectors were also present and they suggested which substances to look for and also assisted in the detection of potentially hazardous waste. After the sampling had taken place, the prosecutor ordered an expert examination of the substances found at the locations. Based on the data provided by the environmental protection inspectors who acted as representatives of the Ministry of Environmental Protection, it was established that the suspect had a permit to collect and transport hazardous waste and also to treat hazardous waste in a mobile facility on the territory of the Republic of Serbia, issued by the competent Ministry but he did not have a permit to store hazardous waste at the locations where the waste was found, nor was he allowed to treat that waste at these locations, considering that there was no permit for the storage of hazardous waste at these locations. The expert examination found that the defendant stored about 77,100 kg and 7,300 liters of hazardous waste at all three locations. After the completion of the investigation and the collected evidence, a criminal complaint was submitted to the Basic Public Prosecutor's Office in Pancevo, after receiving it and observation by the prosecutor, the suspected owner of the company whose waste was found in this area was invited to present his defense before the prosecutor, i.e. to be heard in his capacity the suspect. After the investigation had been completed and the evidence collected, an indictment was submitted to the Primary Court against the defendant for the criminal offense of transporting dangerous substances to Serbia and illegal processing, disposal, and storage of dangerous substances as per Article 266 paragraph 1 of the Criminal Code. The proceedings concluded with a first-instance verdict in which the defendant was found guilty of the criminal offense charged against him and was sentenced to two years in prison and a fine of 500,000.00

dinars, and he was ordered to confiscate his property of found waste and in the sense of Art. 87 paragraph 3 of the Criminal Code, the court ordered the destruction of this waste. The prosecution appealed this verdict because it requested a stricter prison sentence, i.e. a four-year sentence, and the defendant also filed an appeal through the defense attorney, requesting an acquittal. The High Court issued a verdict that changed the decision of the first-instance court only concerning the sentence of the way that the convicted person was sentenced to a prison sentence of one year and a fine of RSD 500,000.00. The time spent in custody was included in the prison sentence (Vuckovic et al., 2022: 56-60).

### 3.2 The case of Mali Pek River pollution

In March 2021, there was a public outcry over the pollution of the Mali Pek River, which appeared murky, red, coppery, and green due to the activities of the Serbia Zijin Copper Company. After the complaints of a large number of citizens, the civil society organization „Regulatory Institute for Renewable Energy and the Environment" (RERI) hired the Institute for Mining and Metallurgy Bor, which carried out the sampling of silt from the Mali Pek River. The sampling results showed that the sludge was extremely polluted due to high concentrations of pollutants: copper was 17 times higher than the recommended amount, arsenic was 3.5 times higher than the recommended amount, as well as the lead was almost 2 times higher than recommended. Also, to determine the pollution of Mali Pek, RERI invited the Institute for Public Health Timok, which, upon request, provided environmental expertise and took samples of surface water and wastewater. Sampling was carried out at 3 locations with the aim of proving that the pollution can only originate from the illegal activities of the Serbia Zijin Copper company. The results of surface water and wastewater tests downstream from the mine showed multiple exceeding-of-limit values of polluting substances. Due to all of the above, RERI filed criminal charges in May 2021 due to the existence of a well-founded suspicion that as a result of illegal operations by the company Zijin Copper, environmental pollution occurred as per Article 260, paragraph 1 of the Criminal Code of the Republic of Serbia, and proposed to the prosecutor's office to initiate proceedings against the suspects as soon as possible. Acting on RERI's criminal charges, and based on the evidence and reports/findings it submitted, the Public Prosecutor's Office in Negotin issued an order in April 2022 to postpone the criminal prosecution against Zijin Copper, as well as the responsible person Jian Ximing -a, due to the criminal offense of environmental pollution and ordered them to pay the amount of RSD 1,000,000.00 for humanitarian or other public purposes. Specifically as per Article 283, paragraph 1 of the Code of Criminal Procedure, the public prosecutor can postpone criminal prosecution for criminal offenses for which a fine or a prison sentence of up to 5 years is prescribed, if the suspect accepts one of the obligations prescribed by the same law, such as a monetary payment for humanitarian or other public purposes.

If the suspects do not pay the specified amount by the deadline, the prosecutor's office will initiate criminal prosecution.[1]

## 4. Problems, Challenges, and Dilemma in the Implementation of Access to Justice in the Field of Environmental Criminality

According to data from the judicial statistics in the Republic of Serbia, we have a very small number of reported criminal acts against the environment and a very small number of indictments against the perpetrators of those acts at the national level. During 2020, the criminal offense of forest theft dominates the structure of reported crimes, while the number of reports against perpetrators of the criminal offense of environmental pollution is very small (a total of 20 reports and only 13 against known criminals). It is worrisome that only 379 cases were indicted, of which the largest number (302) was in cases against perpetrators of the criminal offense of forest theft (Kostic, 2023).

For criminal offense against the environment in Serbia, fines, conditional sentences, and much less often prison sentences, or some of the security measures that can be a particularly useful form of punishing legal entities, such as banning certain registered activities or jobs, confiscation of objects and public publication of the judgment (Gajinov, 2011: 80).

When conducting proceedings for environmental crimes, our judicial authorities today face the problem of proving the guilt of polluters through expert testimony (Vig & Gajinov, 2011: 80) as well as difficulties in gathering evidence during investigative and criminal proceedings (Stopic et al., 2009: 55).

Also, statistical data compared to daily media reports and the activities of environmental associations confirm that the essential problems in the process of successfully suppressing environmental crime are first of all late prevention, that is, reacting only when the problem is found in the courtroom. Trials last several years, there is a problem in the frequent lack of evidence, expensive and complicated expert reports, which are rarely conducted on the spot, and lack of objectivity, and insufficient expertise of the persons conducting these procedures, as well as the need for radical institutional reforms. All of these are the reasons that indicate why there is a small number of reports for criminal offenses against the environment, as well as a small number of cases that have been completed and where a conviction has been pronounced (Gajinov & Vig, 2012: 315).

The main problem in the prosecution of either criminal acts or economic offenses in the field of environmental protection is in the insufficiently clearly defined legislation in the field of environmental protection, in the insufficiently clear delimitation of the powers of all actors who are responsible for protecting the environment (inspection authorities at all levels such as and the role of the local

[1] According to RERI's criminal complaint, Zijin Copper and the company's director were fined one million dinars for polluting the Mali Pek River, *https://reri.org.rs/po-krivicnoj-prijavi-reri-ja-zijin-copper-i-direktor-kompanije-kaznjeni-sa-milion-dinara-zbog-zagadjenja-reke-mali-pek/,* 29.09.2023.

communal militia). Uniting the work of all stakeholders must become a priority in work, in order to achieve the goal of a healthy environment, i.e. protection of human rights, as well as consideration of the position of civil associations and initiatives, because there is a need to give greater rights and importance considering that they are the protectors of collective interests, namely those ecological associations whose only basis and role is the protection of the general - public interest in the protection environment and in criminal proceedings (Association of Public Prosecutors and Deputy Public Prosecutors of Serbia, 2021: 10).

## 5. Conclusion

Given the absence of cases of compensation for damages in accordance with Directive 2004/35EC, i.e. the failure to adopt the Law on Liability of Environmental Damage that would transpose the said directive, based on the existing cases of punishment for criminal acts in the field of environmental protection, it can be concluded that the penalties are small, do not lead to criminal protection of the environment or to the improvement of nature protection. It is necessary to introduce a regime of compensation for damage caused to the environment, that is, to implement remediation measures, that is, to remove damage caused to the environment at the financial burden of the polluters who caused them. The existing legal framework and the practice of implementing criminal environmental protection do not contribute to adequate environmental protection because the fines are low and it is in the polluters' interest to pay them and continue with further endangering the environment.

In addition to the tightening of sanctions for environmental crimes, a compensation regime should be established following Directive 2004/35EC, that is, the Law on Liability of Environmental Damage should be adopted, in which the costs of eliminating or preventing the occurrence of environmental damage would be borne by polluters.

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Forging the Future: Pioneering Approaches in Business, Management and Economics Engineering to Overcome Emerging Global Challenges - 2024

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# THE ECOCRATIC TURN KEEPING OR LOSING THE CONTROL OF M-E-O

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***Abstract***

*Treating components in the current environmental catastrophe, we must incorporate AI analysis and big data-based decision systems into diagnosis and treatment, as well as the new normality molding "environmentally friendly" human behavior. The Transhumanist ideology is an emerging perspective of the post-postmodern epoch of the Anthropocene. However, based on cultural anthropological considerations, transhumanism might be seen as an essential feature of human ontology. The term „Transhumanism" must be corrected based on the human ecological Man-Environment-Organism (M-E-O) co-ontological model, which demonstrates that the borders of adapting human beings are continually extended by technological, memetic and social means beyond their own physical „surface". These extensions serve human control during biocultural adaptation processes in micro-, meso- and macro scales of human ecology. The paper offers an insight to revolutionary shifts of M-E-O based on handling information and energy transformations determining subsistence systems. As infocratic power implying monetocracy based on fiat money, mediacracy and juristocracy influenced by corporatocracy led tho severe imbalance of earthly ecosystems, crossing planetary boundaries, human society necessitates a move from present infocratic rule over society to an ecocratic one. We must optimize this change while preserving control on the human side.*

***Key words:*** *MEO, ARES, and EROS economies, control, infocratic and ecocratic eras, green transition, 4IR, transhumanism and posthumanism.*

## 1. M-E-O: Has transhumanism been with us since the beginning?

The human being is contextual, going by the labels Homo Sapiens, Homo Faber, Homo Economicus, and Zoon Politicon. This contextuality is central to the co-

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ontological limitations of human ecology, where humans hybridize with the technosphere, memosphere, and sociosphere, thereby promoting a sense of control over Nature. This 'Promethean' approach includes an expanding sense of human superiority and exceptionality fueled by the rise of rationality, techno-optimism, and control. The deist detachment of the Creator from his Creation, along with the Watchmaker's physical theology, resulted in a new mental representation of Totaliter Aliter, the Distant Lord, and with a modern sense of restoring control over human life based on rational human thought and action, and scientific skepticism. This was fueled by the growing importance of hybridization with developing industrial machinery, monetary technologies (usury), and democratization of written and printed knowledge (Gutenberg galaxy) in the context of the Latourian Actor-Network Theory, where printing technology reshaped cognitive style, religious rituals, and social structure, according to Marshall McLuhan. The same political transformation occurred, from sacred legitimation of royal power and feudal hierarchy (sacred social order) to the dynamic juristocratic power of social contracts of the ever-changing and transforming social forces. As the demand for human control over the natural environment combines human agency with technological, memetic, and social control tools, transhumanism expands the boundaries of human beings beyond their bodily borders towards outer techno-, memo-, and social frontiers from the start. The contextual aspects of many anthropologies reflect this co-ontological viewpoint.

Cyborg anthropology focuses on the hybridization of technology and humans. The symbolic, interpretative anthropology likewise has a hybridized perspective of human beings as a person is linked up in a succession of symbolic or mythological representations, where "man is an animal suspended in webs of significance he has spun" that help to generate and retain meaning. Radcliffe-Brown's structural functionalism and Durkheim's social theory emphasized the primacy of social systems over individual needs. Edmund Leach was bridging the gap between memetic and social constructivist techniques. Several anthropological traditions, such as neoevolutionary anthropology by Leslie White and Julian Steward, cultural materialism by Marvin Harris, and ecological anthropology by Andrew Vayda and Roy Rappoport, have expanded the hybrid of human beings and their social, natural, memetic, and technological surroundings.

White's neoevolutionary approach is based on an sociocultural adaptation model with control by energy transformation in the focus. He uses a three-dimensional cultural model similar to the technosphere, memetic info spherical, and sociospatial M-E-O model, where the culture implies Technological, Sociological, and Ideological components during adaptation to Natural challenges and stressors. In this framework, technology attempts to tackle difficulties related to survival, entailing gathering enough energy and repurposing it for human purposes. This way, societies that capture and use energy more effectively have a competitive advantage over other societies, and the more effective energy transformers have gone further in terms of evolution. In this system, E symbolizes the quantity of energy harvested per capita per year, T is the efficiency of the equipment employed

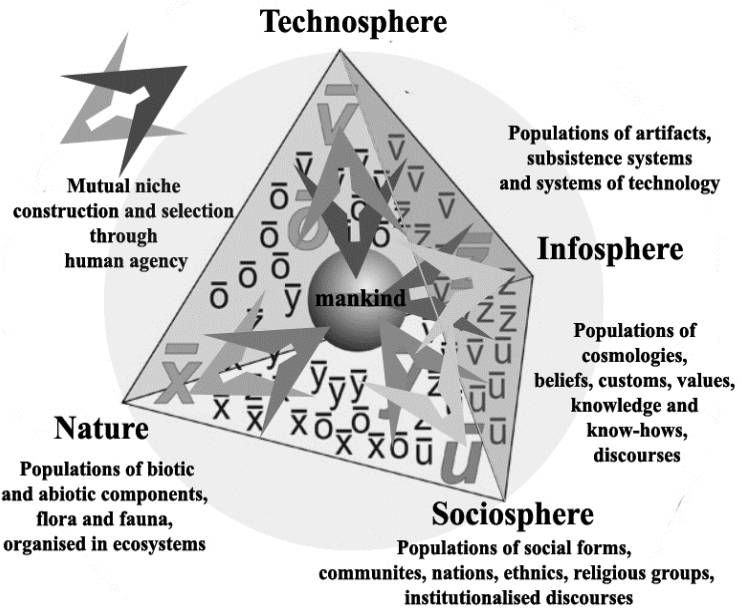
to extract the energy, and C is the level of cultural progress. Presenting this frame of measurement, White claimed that having effective control over energy is the primary cause of cultural evolution. This logic of socio-techno-info effectivity of a culture can be expressed by the formula: E x T = C. This formula points to the importance of control. Looking back at the history of M-E-O, we can see a demographic, techno-memetic acceleration reshaping cosmologies and social systems as permanent modifications occur; in this way, transhumanist transformations have dynamized the history of M-E-O since the invention of fire and the hand axe.

Julian Steward added the behavioral dimension to this technology-based framework, accepting the primary role of technology and economics but emphasizing the co-determining role of political systems, philosophies, and religion. He pointed to the critical relationship between subsistence techniques and natural resources, the behavior patterns involved in a specific subsistence strategy, and explored how these behavior patterns influence other elements of society. The approach of Steward and White is close to the ecodynamic model of Kenneth Boulding and the Latourian Actor-Network theory creating a basdisand is summed in our M-E-O model.

The Latourian 'amodern' turn makes a further step toward the criticism of Homo Economicus, as he denies the western concept of domination of the Nature as a challenging „Enemy", something to be dominated. This way, permanently changing ecodynamic relationships are reshaping changing power and control positions in each sphere, Nature, Technosphere, the memetic Infosphere, and the Social systems at the macro-, mezo- and microsocial levels.

The changing eco-relationships include domination and predating, parasitism and saprophytic features, and symbiotic mutualism.

| **Technocracy** | **Infocracy** |
|---|---|
| From 1789 AD to 1971 AD, | From 1971 AD until 2020 AD. |
| I-II-III industrial revolutions | 4IR |
| Dominance of Technosphere (fossile-based), | Dominance of Infosphere |
| Strong demographic growth | (monetocracy, mediacracy, |
| Social reference /class, race, consumer/ | juristocracy) |
| secularism, rationalism | Unequal demographic growth. |
| Fossile allopoetic system, | Technological-economic reference, with networked infocratic power fuelled by fiat money, alchemic economy, |




| Naturocracy | Sociocracy |
|---|---|
| From 400 000 y.- 12 000 y. BC | 5000 y. BC to 1789 y. AD. |
| Revolution of paleolithic | Neolititic agricultural revolutions |
| use of tools and fire | (grain, maize, rice), domestication |
| Domination by Nature, | local feudal sociocratic domination, |
| No demographic growth, | modest demographic increase. |
| High spiritual and religious reference. | Mechanical (hydroelevation) technology behind |
| Solar ecological system | Solar autopoiethic system |

*Figure 1. Four-dimensional, ecodinamically interacting model of human extensions. (M-E-O)*

### 1.1 Questions of eco-dynamism and the control

Human control over M-E-O can be enforced through access to natural resources, energy pools, tools, a population of instruments, or complex industrial systems of machines; by memetic resources, education, language and symbols, cultural systems of cosmology, traditions, know-how, and social superstructures; by family, circle of relatives and friends, civil engagement, class, and national solidarity.

The opposite is also necessary to note: deprivation of natural resources, be it agricultural in Nature or socioeconomical; drought, salinization of soil, severe climatic changes, destruction of technological conditions in warfare or flood, earthquake or tsunami, loss of cultural knowledge as a result of acculturation, colonialization or social exclusion from the community (voodoo death) solely or together lead to loss of control, personal and community tragedies, and, in some

cases, loss of identity, sovereignty, and autonomy. These events might all be viewed as perturbations of technological, memetic, social, and natural extensions of the extended human border, a transhuman extension of power and control.

If gaining control by extending human borders is transhuman, then losing and transposing control through technospherial hybridization into the technospherical and memetic parts of these hybrids, arranged by genomic intervention, big data-dependent AI decision-making or AI-dependent military robots must be classified as posthuman phenomena. Political dynamics, the equilibrium of democratic power structures, the interplay of leadership and followership, the dissemination of information, and the exercise of agency could potentially mitigate power imbalances, feelings of subjugation, and the erosion of autonomy.

## 2. ARES versus EROS: control, domination, and accumulation as issues of power

The technological, memetic, social, and natural extensions of human boundaries represent a transhuman expansion of authority and influence that is unequal and hierarchized in society. ARES symbolizes concentrated power, fight, war, predation, and dominance and offers an acronym for **A**ccumulation and concentration of profit and power, **R**isk, **E**nvironmental degradation, **and S**upremativ dominance.

EROS symbolizes symbiosis and mutualism, love, philia, agape, and include the acronym of **E**nvironmental **R**esponsibility and **O**ptimalist strategy, and Sustainability of economical activity (Lázár, 2013).

The social consequences are also antagonistic: ARES might induce Anomy, Riots, Environmental crises, Slavery and Social Suffering, while EROS might be basis of Environmental Reconstructive Organic Sustainability.

The M-E-O paradigm of ARES versus EROS is represented by the following tetrahedrons.

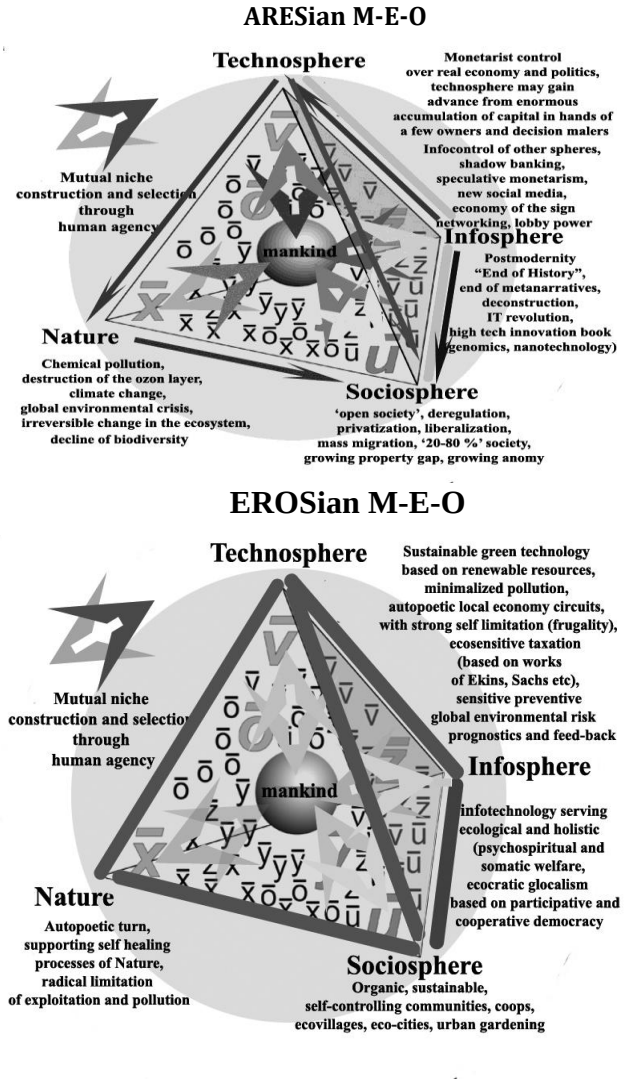



*Figure 2. ARESian and EROSian alternatives of contemporary M-E-O*

EROS paradigm expresses the mutualist organic, bionomic, or Kropotkinian evolutionist features of internal human ecological potential of M-E-O, which is based on laws of life, with the primary objective of serving life, especially human communities, and the Economic theology, embracing the economic teaching of world religions, alternative schools of economics and sustainable development science.

ARES paradigm follows a Darwinian evolutionary algorithm of survival of the fittest and the idea of the struggle of life through blind environmental selection.

Techno&infospherial dominance means the hegemonic dominance of Economics, including the accumulation and concentration of wealth, endless growth of GDP, globalization, extending competition, money as a means of speculation (casino capitalism), and — from an evolutionary point of view —creating extreme local negentropy on the top and in the center and serious negentropy on the periphery.

**Info-technospherial dominance as a passage to ecocracy.**

During the past 25 years, the technological advances and digital innovations with profound impact on ecosystem relationships reshaped our world. The accelerating pace of adoption is evident if we compare the adoption of two info-spherical innovations, Instagram and Chat GPT. After its launch, Instagram took two and a half months to reach one million subscribers in 2010, while Open AI's ChatGPT reached a million subscribers in just five days. Profound changes are observable in monetary mechanisms, and the broader digital asset industry persists with Bitcoin dominance despite blockchain scandals. 5G networks, the internet of Things, robotics, AI-based process, smart homes, smart cities, and emerging surveillance capitalism signify a rapid techno-info spherical paradigm shift. The vision of surveillance capitalism and social credit system, social and economic control mechanisms based on digital currency, centralized, epidemiological instruments of health control, and the visible efforts of transformation of present farming systems underline the suspicions regarding the centralized power dynamics of ecocratic transition.

On the other hand, means of solar technology-based energy autonomy, local food sovereignty, and feminist and social-economical considerations of ecological transition of economy offer different scenarios to overcome the burdens of nowadays volatile, uncertain, complex, and ambiguous „VUCA" world.

If the expansion of human borders in the frame of the M-E-O model signifies transhumanism, then the relinquishment and reconfiguration of control through technospherical hybridization into the technospherical and memetic dimensions of these hybrids, orchestrated by genomic intervention, along with AI decision-making reliant on big data, or military robots governed by AI, should be characterized as a posthuman phenomenon.

**M-E-O possesses transhuman and posthuman abilities.**

If the branches of agricultural revolution and the previous three waves of industrial revolutions may be understood as progressive evolution of transhuman techno-, memetic, and social hybrids, one thing is constant across them: these hybrids gained more and more power over the surrounding environment, and maintained human control.

On the other hand, the consolidation of control in successive stages of M-E-O progression coincided with the accumulation and concentration of monetary power, material commodities, information, and social legitimation based on mass influence

(propaganda, existential reliance). As a result of their technological-cultural expansion, fewer and fewer individuals wielded increasing power over the majority.

As we explored above, the acronyms ARES and EROS represent two oppositional logics that have a role in the structuring of social control. Archaic small-scale societies have a high rate of cooperation, sharing goods, and forms of substantial economies reflect a socially embedded economy with socially and social-psychologically meaningful and constructive gift-based exchange systems, social economy mechanisms (Kula ring, specific forms of economic rituals creating prestige like potlach, mutual services, barter), and a high spiritual reference.

At this level, there is limited demographic increase, and solar energy-based autopoietic, non-exhausting, non-polluting agriculture dominated until the coming of the industrial revolutions. The memetic and social systems are conservative; so-called Gemeinschaft-type societies are primarily local, traditional communities with stable traditions, customs, oral cultural transfer, transgenerational faith, trust, and loyalty, and social regulation based on high religious and moral standards (after Tönnies).

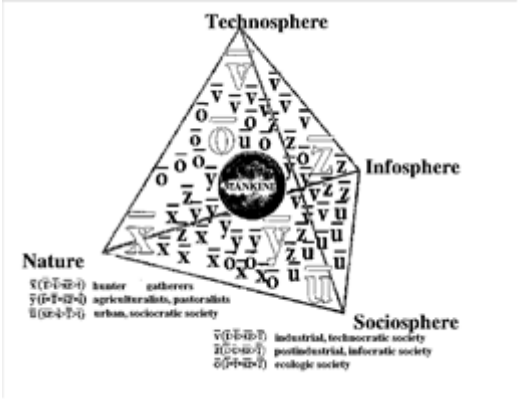
The indsutrial revolutions transformed the traditional, embedded local human ecological patterns, induces detachment and dislocation of social masses, the autopoietic solar energy- based subsistence patterns were transformed into allopoietic, fossile energy-based, exhausting-polluting socioeconomic systems, with the Tönniesian „Gesellschaft" sociocultural features. At the global scale colonialization and westernization dominated the geopolitical terrain in frames of monopolcapitalism and communist state-capitalism.

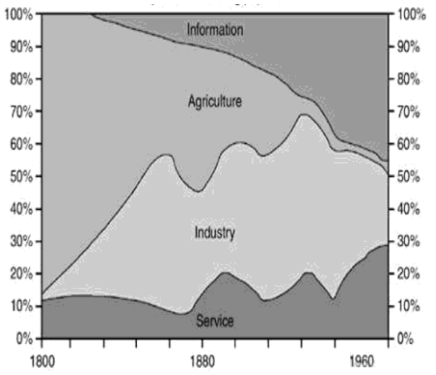
The last technocultural transition might be call an infocratic transformation. The terms: postindustrial, postmaterial, postmodern, informational or network society, VUCA world reflect a hight tech transition of appalying new electric technology of global informational flows, organisation and communication. The transformation of monetary systems, global telecommunication and global transformation of industrial production and transfer led to the monopolic accumulation of economic wealth in hands of transnational, networked corporatocracy determining global mainstream media narratives, termnoinology and heremeneutic frameworks through mediacracy, and legal constructions serving this hegemony (juristocracy).

The control shift from productive technocratic power centres toward the determining information power of networks might described by the term of infocracy. The so-called fiat money and casino capitalist transformation of monetary approaches generated a new power based supremacy which accelerated socioeconmic and Earth trend changes leading to corossin the so called Earth boundaries, serious environmental crises of Anthropocene.

**V Modern, technocratic materialist, individualist**

| | |
|---|---|
| Gesellschaft based society (Tönnies) | |
| Industrial revolution I, II. | **Z Postmodern infocratic, syncretist,** |
| Printed & analog electric communication | **(Fiat money&media&networks)** |
| Fossile and nuclear power | Network Society (Manuel Castells) |
| based, exhausting&polluting allopoietic | Digital communication |
| E x T = C system | III.IR Infotechnology revolution |
| | High tech based, infotechnology dominated highly polluting@exhausting allopoietic E x T = C system (fiat money, casino capitalism, alchemic economy) |




X&Y&U **Premodern magico-religious sociocratic, collectivist** *'Gemeninschaft' based info-social system (oral, written& ritual communication)* Solar-energy is the basis of non-polluting, no-exhausting autopoietic E x T = C system

*Figure 3. Typology of economic revolutions of M-E-O and the population changes*

The demographic transformation of the twentieth century indicates a major M-E-O shift from the primarily agrarian nineteenth century to the infocratic end of the twentieth century. Technologies and their pervasive impact on our lives as individuals and civilizations at micro-, meso- and macrosocial levels, together with the impending existential threat posed by climate change in the Anthropocene, have established a new normal in the infocratic, postindustrial, consumerist society.

The situation is more serious, as the sustainable, non-polluting, non-exhausting, solar-based auto-poietic solar energy-based subsistence systems were fading away, and in westernized countries, only 5-7% of the population remained in this sector, but in a more industrialized manner, as shown above. The infocratic turn brought about 70% of the population to information and service employment at the end of the Millennium in the "advanced" societies.

The following timeline demonstrates the devastating impact of the so-called Anthropocene on the Earth's biological system, necessitating rapid modifications and a drastic ecocratic shift.

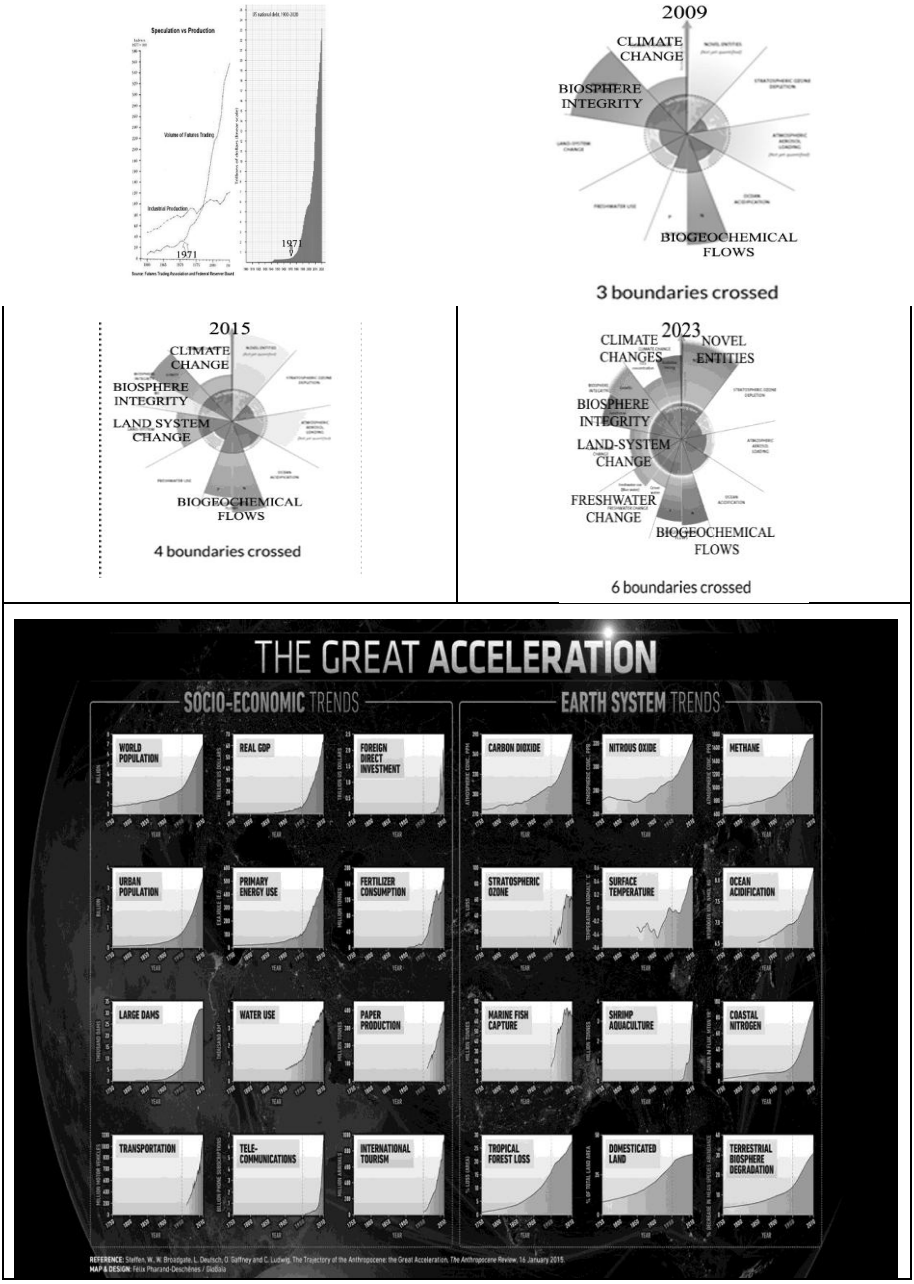



*Figure 4-5. Consequences of infocratic dominance of fiat money, growing state debts, and the crossed planetary boundaries with the great acceleration of socio-economic and Earth-system trends*

Industrial revolutions created allopoietic, polluting, exhausting economies powered by more intensive transformation of fossil, electronic, or nuclear energy, and they could be referred to as Gesellschaft societies by Tönnies, which are shaped by centralization, standardization, bureaucratization, legal regulation, contracts, and written media influence. As neoevolutionary anthropologists Leslie White and Julian Stewards have demonstrated, these high-energy transformative cultures take control of Nature and other autopoietic societies. The growing population, complexity, integration of local cultures, ethnicities, and languages, as well as bureaucratization, centralization, and industrialization, all help centralize cultural and economic control.

While the autopoietic, cooperative, subsidiary locality-based economic logic values are based on EROS-ian logic: Environmental Responsibility, Optimalism, and Sustainability (Lázár, 2013), the ARES acronym of Accumulation and concentration of profit and power, Risk, Environmental degradation, and Supremative dominance is a proper pattern of control maximization for M-E-O hybrids. When we examine the postindustrial period of the late twentieth century, we must recognize the significance of the dominating few's highly developed control maximization methods over the remaining 7-8 billion people. If environmental crises exhibit exponential dynamics, centralized, quick actions are more likely; in this case, an ecocratic turn may result in a dictatorial framework.

The exponential expansion, described above, is evident in both socioeconomic trends and indicators of Earth System Failure. The infocratic organization of M-E-O is based on four power pillars: accumulation and concentration of global wealth, corporatocracy (Shaw 2008), mediacracy (Kevin P. 1974), and juristocracy (Pokol 2021). According to Manuel Castells, the "spirit of informationalism" is a culture of "creative destruction" that accelerates the speed of the optoelectronic circuits that process its signals. In the era of globalization, capitalism is characterized by near-instantaneous flow, creating a new spatial dimension, "the space of flows." Castells defines the new spatial form of the megalopolis as having the contradictory quality of being "globally connected and locally disconnected." This infocratic epoch could be viewed as a transition period between M-E-O's transhuman and posthuman organizations.

**The M-E-O transition from infocratic to ecocratic epoch**

The demographic transformation of the twentieth century indicates a major M-E-O shift from the primarily agrarian nineteenth century to the infocratic end of the twentieth century.

Technologies and their pervasive impact on our lives as individuals and civilizations, together with the impending existential threat posed by climate change in the Anthropocene, have established a new normal in the infocratic, postindustrial, consumerist society.

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this sector, but in a more industrialized manner, as shown above. The infocratic turn brought about 70% of the population to information and service employment at the end of the Millennium in the "advanced" societies.

If environmental crises exhibit exponential dynamics, centralized, quick actions are more likely; in this case, an ecocratic turn may result in a dictatorial framework. Although the EROS paradigm promotes environmentally friendly values and behaviors, ARESian structures have the ability to incorporate EROSian ideals. The EROS (Environmental Reconstructive Organic Sustainability) acronym conveys a lot about the EROSian offer. The EROS structure's ideologies, economic ethics, and value systems include economics as a moral science, concepts of substantial and social economics or the so-called ESG norms are incompatible with risk producing limitless profit accumulation, local growth of extreme negentropy and concentration of the wealth in the hands of a few with consecutive peripheral socioeconomic entropy.

When we compare the bionomical logic of EROS structures to the economic logic of ARESian supremacy, we discover more inconsistencies. Bionomia is an economic theory based on life's principles, with the primary goal of supporting life and human communities. Economic theology includes the economic teachings of global religions, alternative schools of economics, and sustainable development science. Economism is about externalities, growth, GDP, globalization, extending competition, money as a means of speculation, profit-maximizing corporations, and specialization, whereas Bionomia is about internalities, peaceful balance, GDP plus ecological footprint, localization, extending cooperation, local money as a means of exchange, truly responsible enterprise, and meaningful work (Tóth, 2014).

We can create a tipological comparison based on business ethic consideration and categories, examples, too.

*Table 1. Tipologies of ARESian and EROSian economies*

| **ARES economy** | **EROS economy** |
|---|---|
| Extreme accumulation and concentration of capital | Economics as moral science, |
| monetocracy<br>(bank system based networks, hedge founds) | local money systems, |
| Techno-info Network power, | Social economics |
| Washington consensus: deregulation, liberalization, privatization | Schumacherian economy, |
| dromocracy, | Buddhist economy, |
| mediacracy, political economy of sign, | Economic Interaction Dominated Model Systems' (Byron) |
| conquest of cultural capital and recreation of habitus, | Frugality, voluntary simplicity |
| Destruction of natural, social and psychological environment | Coops versus corps |
| Transnational corporation networks, | Sustainocracy versus dromocracy |
| Corporatocracy | Bionomia |

| | |
|---|---|
| Juristocracy | Economic theology |

The machinery of the ecocratic turn is predicted to include the technology of the Fourth Industrial Revolution (Byabazaire, 2020). The vision of surveillance capitalism and social credit systems, social and economic control mechanisms based on digital currency, centralized epidemiological instruments of health control, and visible efforts to transform current farming systems all raise concerns about the centralized power dynamics of ecocratic transition.

We can compare the above-mentioned transformations with the critical postulates of Michael Haupt regarding the emerging ecocratic transition, as follows:

- **Postulate 1**: Civilization — as it has progressed since the Agricultural Revolution — has overshot the carrying capacity of the planet. As a result of — and because of the globalized Nature of the human species — we are in late stage civilizational collapse. If our species is to survive, a systemic reset of our human systems is required.
- **Postulate 2**: Considering how fragile our human systems are, it is natural that the 2020 Coronavirus pandemic triggered a series of system resets (colloquially referred to as "the new normal" in mainstream media).
- **Postulate 3**: There is a tension between two significant factions to birth their widely differing versions of a systemic reset. One is the Fourth Industrial Revolution (4IR) — espoused by WEF, technologists and multi-national corporates — and the other is the Global Peoples Revolution (GPR) — championed by numerous activist and grassroots movements.
- **Postulate 4**: The 4IR systemic reset is further ahead and far more organized than a GPR systemic reset. If successful, a 4IR reset will replicate many of the design flaws of our current human system.

The constraints generated by bureaucratic and juristocratic application of Green Transition means also serious challenge to motor car industry, milk and beef producing farmers, fossile and nuclear power based industrial segment and wide range of employees and consumers, or great parts of national economies. Robotization and AI-based high tech automatization push tens of millions out of the labour market.

Harnessing the innovations of the Fourth Industrial Revolution. Redesigning skills and jobs for a digital era.
**ROBOTICS**
**ARTEFICIAL INTELLIGENCE – BIG DATA** – AUGMENTED REALITY – CLOUD COMPUTING – KNOWLEDGE WORK AUTOMATION - **INTERNET OF THINGS** - 3D PRINTING – **BIOTECHNOLOGY** (nanotechnology, GMO) – RENEWABLE ENERGY SYSTEMS WITH ENVIRONMENT-FRIENDLY ENERGY CAPTURE, STORAGE, AND TRANSMISSION- **SYSTEMS INTEGRATION** - AUTONOMOUS SYSTEM – **NETWORK SECURITY** – **SURVEILLANCE CAPITALISM**

*Figure 6. Characteristics and components of 4IR technology sources.*

The elements of the 4IR, written in bold, imply technological, "suprahuman" control, but the 4IR might also have empowering support for grassroots enterprises using AI computers that can "think" like humans, offering cheap substitution of expensive professional human agency and service. The AI can recognize complex patterns, process information, draw conclusions, and make recommendations. The seemingly environment-friendly visions might include enhanced control over our everyday life, like 15-minute cities (The OXFORD example) with limitations of free use of cars, WFH (work from home) with its long-lasting effects on business and society, delivery from the 'cloud market' (ghost kitchens, restaurant-quality food deliveries ). The environment-friendly business might mean the use of an individual carbon footprint tracker, where the tracker can monitor — as J.Michael Evans proposed at the Davos meeting of WEF — where consumers "traveling, how they are traveling, what are they are eating and what are they consuming on the platform," and use of tracker chips might allow fashion brands to resell their clothes with continuous gains of profit. Soshana Zuboff explored the risks of permanent digital surveillance, and the so-called social credit system enabled by high-tech digital systems is not a future vision but the present practice in China.

On the other hand, the faster computers with greater capacity (quantum computers, new generation of chips) enable Web3 to serve a decentralized world, putting ownership into the hands of the community. Web3 comprises blockchain technology, cryptocurrencies, and token-based economics. The solar technology-based energy autonomy, local food sovereignty, and feminist and social-economic concerns of ecological transition economy provide several alternatives for overcoming the constraints of today's turbulent, uncertain, complicated, and ambiguous „VUCA" environment.

## Conclusions

Given these challenges, we must reconsider the meanings of transhumanist and posthumanist terminology (Farisco2013, Merzlyakov 2021). We can use the terms trans- and post- in a diachronic disciplinal sense because these ideas emerged after the normative universalist humanism, a concept of the universal, decontextualized, and desacralized human being of developing industrialized modernity of the "Gesellschaft" epoch .On the other hand we understand human agency, and the adaptive techno-, memeticv and social extensions of human being as an essentially transhuman feature. In this case the locus of human control makes the difference between transhumanist and posthumanist conditions, where the transhumanist extensions keep the control on the human side, while posthumanism means delegating the control to AI-based high tech decisions systems and the production to robotized automatized non-human technology offered by the 4IR.

The Latourian statement "we have never been modern" implies in our M-E-O model that we were all transhuman from the start, by associating the term with expanded human borders and technological, memetical and social extensions and putting human control at the center of the M-E-O notion. We are endangered to become posthuman once when we lose human control over our M-E-O extensions. The most significant challenge is how we can maintain human control in the emerging M-E-O machinery of posthuman technology, which includes AI, big data-based decision systems, robotics, and genomics along the different routes of ecocratic corporatocracy and/or cooperative ecocracy.

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