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An Overview of the Literature on Women’s Entrepreneurship in Kosovo

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Abstract: In recent years, female entrepreneurship in Kosovo has garnered significant attention, particularly in the unique context of post-war recovery and economic transition. This paper provides a comprehensive overview of the literature on women's entrepreneurship in Kosovo, focusing on the specific challenges and opportunities they face. Among the key obstacles identified are limited access to finance, insufficient institutional support, and the influence of cultural norms and gender stereotypes. However, the literature also highlights the positive role of technology and professional networking in enhancing the resilience and success of women-led businesses. Women who make use of these tools demonstrate a greater capacity for business survival and expansion. Furthermore, recent changes in supportive policies have started to offer more opportunities for women in the entrepreneurial sector. These efforts aim to strengthen women's access to finance and improve training and networking opportunities, thereby promoting the sustainable growth of female entrepreneurship. The study suggests that improving access to finance and expanding institutional support programs could foster sustainable growth in female entrepreneurship, contributing positively to Kosovo's economic development.

Keywords: female entrepreneurship, access to finance, institutional support, technology in business, gender inequality

1 Introduction

Women's entrepreneurship is a phenomenon that has been gaining increasing attention globally, particularly in countries undergoing phases of economic

transition and post-conflict development. In Kosovo, women have played a pivotal role in the country's economic reconstruction following the war of 1998–1999. While both men and women have contributed to the development of the private sector, women often face numerous challenges that distinguish their entrepreneurial journeys from those of their male counterparts. These challenges include gender inequality, limited access to finance, inadequate institutional support, and the influence of cultural norms and gender stereotypes (Kamberi & Mustafa, 2022).

In recent decades, efforts have been made to better understand the dynamics of women's entrepreneurship in Kosovo. Existing literature highlights the need for more inclusive public policies that address these inequalities and support women's entrepreneurship as a powerful driver of economic development. According to the OECD (2022), despite international and local efforts to improve the situation, women in Kosovo still face significant barriers compared to men in accessing the labour market and securing the necessary finances to establish businesses.

One of the most significant aspects explored in the literature is the contribution of women entrepreneurs to Kosovo's economic development. Women have demonstrated exceptional adaptability in tailoring their business strategies to address economic, social, and cultural challenges. For instance, in the services and trade sectors, women have established businesses that not only survive in a competitive market but also contribute substantially to the well-being of their families and communities (World Bank, 2021).

Another critical aspect is the use of informal and community networks by women to cope with the daily challenges of business management. Many women entrepreneurs in Kosovo rely on family and friends for financial and moral support, while others have developed broader professional networks to achieve greater success (Spicer et al., 2020). These networks often provide women with opportunities to share experiences and build valuable partnerships, which enhance the sustainability of their businesses.

Only around 18-20% of women in Kosovo are active in the labour market, a figure that remains among the lowest in the region and reflects the cultural, economic, and social challenges women face in engaging with the economic sector.

¹According to the Kosovo Agency of Statistics and the OECD report for 2021, the percentage of businesses led by women is approximately 10-12%. This relatively low figure highlights a significant gender gap in entrepreneurship compared to men.²

The Swiss Entrepreneurship Program (Swiss EP) has identified specific challenges faced by women entrepreneurs in Kosovo, such as limited institutional support and restricted access to investments. To address these challenges, Swiss EP has created supportive communities like Women Entrepreneurs Kosovo (WEK),

¹ World Bank. (2018). Promoting Women's Employment in Kosovo.

² UNDP. (2022). Screening Women's Status in the Western Balkans Economy.

helping women entrepreneurs share experiences and establish strong collaborative networks. Additionally, the lack of tailored investment instruments has been a significant barrier for women-led businesses. To mitigate this, Swiss EP has supported the creation of a women-focused angel investor group, providing dedicated training and education for women interested in investing in other businesses.³

Despite progress, challenges remain numerous for women aspiring to become entrepreneurs in Kosovo. One of the main obstacles is limited access to finance. Studies show that women in Kosovo face significant difficulties in obtaining loans or other formal financial resources due to a lack of collateral and potential gender discrimination within the banking system (OECD, 2021). According to the World Bank (2021), only 18% of women in Kosovo are engaged in the labour market, a low percentage also reflected in the proportion of women entrepreneurs.

Another barrier for women in Kosovo is the lack of institutional and political support. According to Ramadani et al. (2015), public policies often fail to consider the specific needs of women entrepreneurs and predominantly focus on supporting businesses led by men. This gender gap in economic development policies makes it difficult for women to benefit from equal opportunities for finance and professional training.

A positive aspect is the role of technology and innovation in enhancing the success of women entrepreneurs. Technology has been a transformative tool for women seeking to expand their businesses beyond local borders and enter international markets. The use of digital platforms such as social media and e-commerce sites has enabled women to reach wider audiences and improve their business operations (Elliott & Mahmoud, 2021). For example, entrepreneurs in the craft and services sectors have leveraged online platforms to promote their products and expand their markets beyond Kosovo's borders.

Technology has also enabled women to manage their businesses more flexibly and respond swiftly to changes in the labour market. For instance, during the COVID-19 pandemic, women entrepreneurs who leveraged technology to enhance client interaction and reorganize their business operations managed to survive and even grow in a highly challenging economic environment (Aukena et al., 2021). The literature also suggests that public policies and support programs play a critical role in improving opportunities for women entrepreneurs. **UN Women (2021)** highlights the importance of developing specialized programs for women, including professional training and networking opportunities. These programs strengthen managerial skills and provide essential resources to overcome the challenges women face in establishing and maintaining their businesses.

³ Swiss Entrepreneurship Program. (2023). Continuous Support for Women Entrepreneurs in Kosovo. *Swiss EP*

According to the **EBRD (2021)**, financial institutions and international organizations have started creating tailored programs to assist women entrepreneurs in Kosovo, offering easier access to finance and establishing support networks that enable women to capitalize on new economic opportunities.

The aim of this study is to review the literature on women's entrepreneurship in Kosovo, with a particular focus on the challenges and opportunities faced by women in business development. The review will also examine government policies related to support for women entrepreneurs. This will provide a deeper understanding of the context and barriers encountered by women in this field.

Objectives of the Study

To identify the impact of institutional and public policies on the development of women's entrepreneurship in Kosovo.

To evaluate the financial challenges and access to resources faced by women entrepreneurs in Kosovo.

To assess the role of technology, social networks, family, and professional networks in the success of women-led enterprises.

Research Question

How do institutional, political, social, and family support influence the development of women's entrepreneurship in Kosovo?

Supporting Questions

What are the main obstacles women face in accessing finance and capital in Kosovo?

This study aims to explore the challenges and opportunities encountered by women entrepreneurs in Kosovo. The gap in Kosovo's literature highlights the need for a study that reviews reports, policies, and local literature to better evaluate women's entrepreneurship in Kosovo's economic and social context.

2 Literature Review

In Kosovo and the Western Balkans, the challenges faced by women in entrepreneurship are intertwined with complex socio-economic contexts, including the aftermath of war and economic transition. At the same time, international studies have highlighted the global challenges women entrepreneurs encounter, such as the lack of gender equality and institutional support.

One of the most significant challenges identified in recent literature is the limited access to finance for women entrepreneurs. **Harvard Business Review (2018)** and **OECD (2021)** emphasize that women in transition economies, including Kosovo and the Western Balkans, face significant difficulties in securing loans and funding for their businesses due to cultural norms and gender discrimination. Similarly, **Ramadani et al. (2015)** highlight that the lack of collateral often negatively impacts women's ability to access credit, hindering the growth of their businesses.

Access to finance remains one of the largest obstacles for women entrepreneurs in Kosovo. **Gashi (2021)** notes that following the war, Kosovo's economy has undergone a challenging transition, where access to finance remains a major hurdle for women seeking to start or expand their businesses. This lack of access to credit and financial resources is closely linked to the absence of collateral and the persistent gender discrimination in Kosovo's banking sector.

Other studies, such as that by the **Bank of England (2019)**, show that this is a global challenge impacting women's success in many countries, including economically advanced ones. In this context, access to financial resources is considered one of the most significant barriers to women's entrepreneurship.

Another critical aspect is institutional support for women entrepreneurs. According to a report by the **European Commission (2020)**, institutional support is a key factor for developing successful women-led enterprises. However, the report indicates that in many Eastern and Southeastern European countries, including Kosovo, government and public policy support remains limited. The **World Bank (2021)** points out that the lack of access to supportive programs for women entrepreneurs negatively affects their efforts to enter and sustain themselves in international markets.

Most women entrepreneurs operate microbusinesses and face pronounced challenges in securing finance and managing the financial aspects of their ventures. A study published in the *Journal of Enterprising Communities: People and Places in the Global Economy* provides a comprehensive view of the profiles and unique challenges of women entrepreneurs in this sector in Kosovo. The findings show that these women, who primarily operate in the trade and education sectors, are significantly affected by factors such as limited access to finance and the absence of institutional support (**Ramadani et al., 2015**).

Despite international and governmental efforts to support women entrepreneurs, institutional support in Kosovo remains limited. **UN Women (2021)** reports that women in Kosovo, particularly in rural areas, face a lack of institutional support, including limited access to training programs and grants essential for developing their businesses. Even when support is available, it often fails to meet the specific needs of women entrepreneurs, who face numerous challenges in meeting the criteria required to benefit from these programs.

In the Western Balkans, the **EBRD (2021)** underscores the importance of support programs specifically designed for women in business, offering grants and subsidized loans. Such initiatives highlight that efforts to increase women's access to funding and professional training are critical to improving the sustainability of their enterprises.

Stanford University (2021) emphasizes that women who participate in professional networks and benefit from mentoring programs are more likely to achieve business success. However, in Kosovo, access to these networks remains limited, particularly for women living in more isolated areas where professional support and networking opportunities are scarce.

Technology has been identified as one of the most powerful tools for women seeking to develop their businesses in a complex economic environment. According to a study by **University of Cambridge (2020)**, women's use of digital platforms in business has transformed how they manage and promote their products and services. The study highlights that women who utilize technology to access global markets have a clear advantage over those relying solely on local networks.

In the Western Balkans, studies by **UNDP (2020)** and **USAID (2021)** indicate that technology is particularly important for women in rural areas, where access to traditional markets is more limited. These studies reveal that women who use technology to promote and manage their businesses benefit more from innovation and achieve more sustainable success.

According to **Stanford University (2021)**, women who are part of professional networks and benefit from mentoring programs are more likely to achieve success in business. This study suggests that mentoring is particularly important in countries like Kosovo, where institutional support is limited, and informal networks play a significant role in the success of women's enterprises.

Gender inequalities and the influence of cultural norms continue to be major obstacles for women in the Western Balkans. **Harvard Kennedy School (2020)** and **OECD (2021)** indicate that women often face cultural challenges that restrict their participation in the labour market and entrepreneurship. In Kosovo, **Ramadani et al. (2015)** emphasize that gender stereotypes and traditional expectations hinder women from actively participating in the business sector, limiting their opportunities for economic development.

Gender stereotypes and traditional norms are also significant factors influencing women's participation in entrepreneurship in Kosovo. **Harvard Kennedy School (2020)** highlights that in post-conflict societies like Kosovo, traditional expectations that women focus on family care rather than professional careers continue to impact their ability to enter and succeed in the business market. This cultural influence creates a major barrier for women aspiring to entrepreneurship, making it difficult for them to secure the necessary financial and institutional support.

3 Methodology

This study employs a secondary research approach, relying on existing literature and published data to analyze the economic survival and creation of enterprises by women in Kosovo. The primary sources for this study include a comprehensive review of scholarly literature, reports from international organizations such as the OECD, World Bank, and UN Women, as well as articles from renowned academic journals on topics related to entrepreneurship and gender equality. This method is

valuable for highlighting the current context of challenges and opportunities for women in entrepreneurship.

Through an analysis of existing literature, this study aims to identify the main trends and challenges faced by women entrepreneurs in Kosovo. These include limited access to finance, lack of institutional support, and the impact of technology on the innovation of their businesses. By utilizing a secondary approach, the study has enabled the collection and analysis of data from previous studies that have examined these issues in depth, providing a more comprehensive overview of the situation.

Furthermore, the study draws on recent reports and statistical data from well-established international organizations to evaluate the effectiveness of public policies and institutional support for women in entrepreneurship. These reports include data on women's participation in the labor market, access to credit, and the support provided by government and international programs for the development of women-led enterprises in Kosovo.

4 Findings

According to data from secondary sources, the percentage of women entrepreneurs with access to finance remains low compared to men, highlighting the need for policies aimed at improving this access. Institutional support, through grants and training programs, also plays a crucial role in enhancing the sustainability of women-owned businesses. Another significant factor is the use of technology, which aids women in expanding their businesses and improving operational efficiency. Graphical representations of this data illustrate the importance of access to finance, institutional support, and technology in improving the performance of women-led enterprises in Kosovo.

Percentage of women entrepreneurs with access to finance (compared to men):

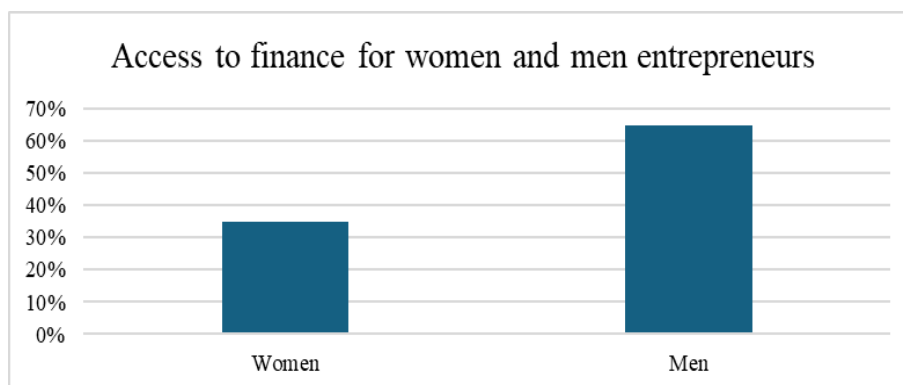


Figure 1: Access to Finance for Female and Male Entrepreneurs

The gender gap in access to finance for women entrepreneurs in Kosovo represents a significant disparity compared to men. According to The Global Findex Database 2021, only 35% of women entrepreneurs have equal access to finance, compared to 65% of men, highlighting the structural and cultural barriers affecting women's financial empowerment (World Bank, 2021).

This report, which reflects global data on financial inclusion and resilience during the COVID-19 era, emphasizes that this pronounced gender gap is not merely a matter of resource scarcity but is also tied to limited access to financial resources for women. These include challenges such as insufficient collateral and biased treatment from financial institutions.⁴

⁴ World Bank. (2021). The Global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19. World Bank. Retrieved from <https://www.worldbank.org/en/publication/globalfindex>

The Impact of Institutional Support:

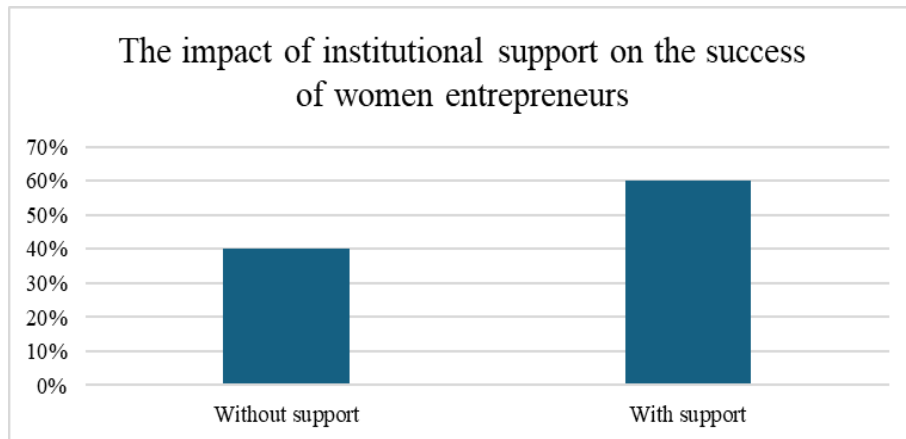


Figure 2: The Impact of Institutional Support on the Success of Female Entrepreneurs

Regarding the use of technology, the literature indicates that women entrepreneurs' adoption of digital platforms has positively influenced the promotion and development of their businesses. This figure illustrates the success rate of women entrepreneurs who receive institutional support compared to those who do not. The percentage of women with limited support who achieve success is only 40%, compared to 60% for those benefiting from institutional support through training programs, grants, and loans. This result highlights a strong correlation between institutional support and the success of women-led enterprises (GAP Institute, 2021).⁵

⁵ GAP Institute. (2021). Women in Entrepreneurship: Challenges and Opportunities in Kosovo. GAP Institute. Retrieved from <https://www.institutigap.org>

Use of Technology by Female Entrepreneurs in Business Promotion:

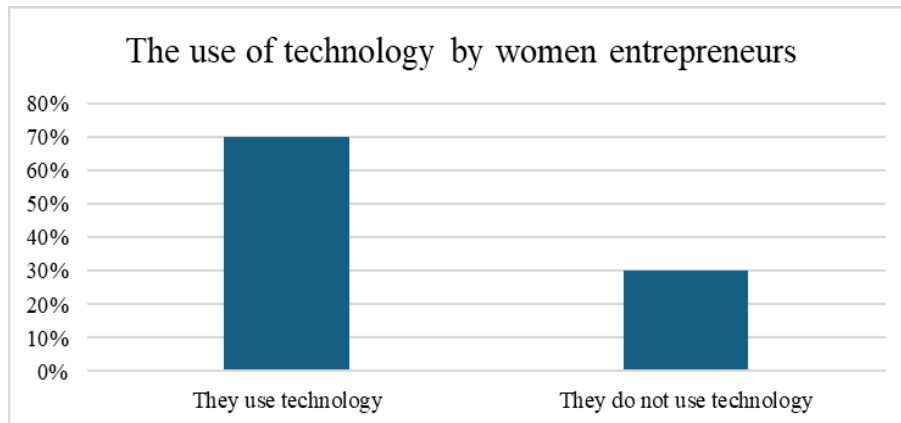


Figure 3: Use of Technology by Female Entrepreneurs

The use of technology by women entrepreneurs has emerged as a decisive factor in promoting and expanding their businesses. This figure illustrates that a significant 70% of women entrepreneurs utilize technology to promote and develop their enterprises, while only 30% do not, potentially impacting their market performance. The findings highlight the importance of technology, alongside access to finance and institutional support, in fostering the success and sustainability of women-led businesses in Kosovo (Kosovo Agency of Statistics, 2022).⁶

Figure 1: illustrates that only 35% of women entrepreneurs in Kosovo have access to finance, compared to 65% of men. This significant gender gap in financial access is a primary reason many women face substantial difficulties in developing their businesses. Limited access to bank loans and other funding sources often forces women to rely on informal resources, which are frequently insufficient to meet the financial needs for business expansion. This situation hampers their ability to compete equally in the open market and to ensure the long-term survival of their enterprises. Using this graphic in the study helps to illustrate the challenges women face in accessing critical resources for business development and underscores the need for further reforms in the financial sector and support institutions.

⁶ Kosovo Agency of Statistics. (2022). The Use of Technology by Women Entrepreneurs in Kosovo. Kosovo Agency of Statistics. Retrieved from <https://ask.rks-gov.net>

Figure 2: highlights the essential role of institutional support in promoting the success of women entrepreneurs, particularly in the context of Kosovo, where women face numerous challenges in developing their businesses. This support encompasses a wide range of services and resources, including training programs, grants, loans, and advisory services, which are critical in helping women establish and manage their enterprises.

Figure 3: demonstrates the significant role of technology in promoting women-owned businesses. Women who leverage digital technology for marketing, resource management, and operational efficiency are more likely to reach a broader audience and enhance the sustainability of their enterprises. Technologies such as e-commerce platforms, social media, and project management tools are particularly beneficial for women entrepreneurs in Kosovo, enabling them to compete in an increasingly digitalized market.

Conclusions

The review of literature on women's entrepreneurship in Kosovo, particularly on the economic survival and business creation by women, leads to the conclusion that women face significant challenges in developing and maintaining the sustainability of their businesses.

One of the primary obstacles is limited access to finance, which prevents women from securing the necessary capital to establish and expand their enterprises, thereby creating a gap compared to men (**Harvard Business Review, 2018; OECD, 2021; Ramadani et al., 2015**).

Institutional support is another critical factor for the success of women-led businesses. Women who participate in training and support programs are more likely to develop successful businesses; however, the literature (**European Commission, 2020; World Bank, 2021**) indicates that such support remains limited and often fails to adequately address the needs of women, particularly those living in rural areas.

Additionally, the use of technology emerges as an effective strategy for women entrepreneurs to overcome market challenges and expand their businesses beyond local boundaries. According to the literature (**University of Cambridge, 2020; UNDP, 2020; USAID, 2021**), technology and digital platforms have improved women's access to international markets, increasing the impact and sustainability of their businesses.

In conclusion, to improve the survival and success of women-led enterprises in Kosovo, it is essential to:

Enhance access to finance for women through tailored credit programs and financial support (**World Bank, 2021; OECD, 2021**).

Expand the range of training and support programs for women entrepreneurs, including the development of managerial and operational skills (**European Commission, 2020; UN Women, 2021**).

Promote the use of technology to facilitate business growth and provide broader market access (**University of Cambridge, 2020; Stanford University, 2021**).

The implementation of these measures is vital to creating a supportive environment for women entrepreneurs and contributing to Kosovo's economic development.

Recommendations

It is essential to establish dedicated credit programs for women entrepreneurs, tailored to their specific needs and designed to avoid requiring high collateral. To address challenges related to financing, banks and financial institutions should develop financial products that promote equal access for women and encourage entrepreneurship through subsidized or government- and internationally-supported funds. These subsidized funds could significantly improve women's access to finance and enhance the sustainability of their businesses by reducing the financial barriers that often pose substantial challenges.

Governments and international organizations should offer more training programs and technical support for women in business, focusing on improving managerial and operational skills. This includes developing mentorship and professional networking programs that provide sustained support to women as they grow their enterprises. Through mentorship and professional networks, women entrepreneurs can benefit from the experiences of other professionals, building a solid foundation for ongoing success.

It is recommended to establish networking platforms for women entrepreneurs in Kosovo, where they can share experiences, ideas, and resources. Mentorship from field professionals should become a mandatory component of entrepreneurship development programs to ensure women receive direct support from experienced individuals. Such platforms would improve women's access to knowledge and best practices in entrepreneurship, helping to overcome barriers often arising from a lack of access to professional networks.

Technology has emerged as a crucial tool for expanding women-led businesses. Therefore, training and resources should be provided to help women utilize digital platforms to promote and manage their enterprises. Moreover, subsidies for technology and support for digital transformation should be made available to ensure women have equal opportunities to adapt to global market developments. By making these training programs accessible and adaptable for all, including women in rural areas, the competitiveness of women-led businesses would significantly increase.

Governmental and non-governmental institutions should launch campaigns to combat gender stereotypes and promote gender equality in the labor market and

entrepreneurship. Public policies should encourage women's inclusion in the economic sector by fostering a supportive environment for women entrepreneurs, particularly in rural areas. These campaigns would contribute to reducing cultural barriers and improving the environment for active participation of women in the country's economy.

The government should develop clear policies aimed at improving the position of women in entrepreneurship. These policies should include financial support, professional training, and greater involvement in economic development to ensure women have equal opportunities to succeed as men in the business sector. By creating sustainable policies that reflect women's needs, support for women's entrepreneurship would improve, contributing to broader economic and social development in Kosovo.

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Organised Innovation Spaces' link to Sustainability

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Abstract: This research is part of my PhD research about examining the link of Future Science Parks to sustainability, in which this study focuses on what activities Science and Technology Parks (STP) undertake to manage sustainability on-park and off-park across economic, social, and environmental dimensions, either independently or in collaboration with stakeholders. The objective is to integrate literature from several theoretical fields—including Science Parks, regional development, the relationships among triple helix actors, and sustainability—to construct an analytical framework that supports new theoretical perspectives. My pre-assumption is that STPs, with a broader term, Organised Innovation Spaces (OIS) can contribute significantly to achieving Inclusive and Sustainable Industrial Development (ISID) of 2030 Agenda by promoting innovation-driven economic growth. The methodology applied is a semi-systematic literature review, by which I examine each kind of OIS' potential link to the region's sustainability, on one hand, and semi-structured interviews as part of a qualitative research, to discover the Hungarian STPs' stakeholders and their benefit of as well as impact on the Park's sustainability. The results regarding the external view of sustainability were the following: OIS contributes to the economic wealth of its tenants as well as the region, and combats unemployment, raises the level of education in the region, these were proven by research. Innovation-management being in close correlation with the sustainable management of companies, was also discovered. The quintuple helix model incorporates the environmental layer, too, enabling the OIS operating in this model to contribute to the ecofriendly operation of the region significantly. As this model is quite young, no evidence was discovered about its true operation and impact. Focusing on the internal view of sustainability, the Hungarian STPs affiliated with Óbuda University (OU) viewed the industrial segment as their most important stakeholder. The expectations of various participants of this segment, can be narrowed down to three areas: infrastructure, talent, networking. The limitations of this research This could be researched further.

Keywords: Science and Technology Park. Innovation management. Sustainability. Regional development.

1 Introduction

The United Nations (UN) Development announced Agenda 2030 for Sustainable Development, in 2015 at UN Headquarters, due to the immense social, environmental, and economic challenges we face on global level (UN 2030 Agenda website). The goal was to stimulate action in next 15 years along ‘5P’: People, Planet, Prosperity, Peace, and Partnership. Three weeks ago in mid-November 2024, in Baku, the United Nations (UN) Climate Change Conference took place, with ambiguous results. As UN Climate Change Executive Secretary, Simon Stiell announced the new finance goal “as in insurance policy for humanity”, he also confessed that they need to “redouble their efforts on the road to Belém” (UN Climate Change Conference Baku website).

Despite the institutional push to encourage sustainable actions, which would necessitate systematic innovation management, science and innovation investments experienced a significant downturn of 5.3% in 2023 vs. 2022, following a boom between 2020 and 2022 (Global Innovation Index website). While technological progress and technology adoption increased, the socioeconomic impact was negative with the global warming increasing by 1.17 degree Celsius. There is room for improvement in this area, which prompted the idea to investigate the innovation clusters more closely to discover any discrepancies or even opportunities how the national and global innovation ecosystems could work better. In parallel, the studies focusing on sustainability got abundant recently, though the area of linking sustainability with innovation-management, and more specifically, with OIS and STP, looks under-researched, yet.

The Horizon Europe Regulation defined the innovation ecosystem as bringing together ‘actors or entities whose functional goal is to enable technology development and innovation; it encompasses relations between material resources (...), institutional entities (...) and national, regional, and local policymaking and funding entities’. Organised Innovation Spaces (OISs, Sanz et al. 2023) are the physical manifestations of innovation ecosystems, bringing together a ‘critical mass of innovation actors ... enabling the whole to become more than the sum of its parts’. Science and Technology Park is a form of OIS which have emerged as recent phenomenon in Hungary since 2019, currently in planning phase.

STPs play a crucial role in fostering innovation, regional development, and economic growth, serving as hubs where industry, academia, and government intersect. These parks have evolved from basic business incubation models operating in triple helix model to more complex structures that embrace the quadruple or quintuple helix model, which incorporate human-centered innovation alongside traditional pillars of science, industry, and policy (Burke & Grass, 2019).

There is a certain 40-year-backlog of Hungarian STPs compared to their European peers. Contributing to the ongoing research on STPs, the aim of this study is to enhance the understanding of how each OIS can link to sustainability to learn the context of Science and Technology Parks, and to understand the stakeholders' influence on STP's sustainability by empirical studies. Ultimately, providing policy recommendations for STP management and stakeholders.

2 Literature review

The concept STP is one of the Geographies of Innovation (GI – Galán-Murros et al. 2021.), Areas of Innovation (AOI – Van Dinteren and Jansen, 2021.), Organised Innovation Space (OIS – Sanz et al. 2023.) or Entrepreneurial Ecosystem (EE – Aveline et al., 2022). The diversity in naming indicates various angles and stakeholder-groups by which knowledge transfer can be managed in a certain physical space. Originally, STP was a real estate concept and by time, it evolved to a network and community concept.

Geographies of Innovation were defined as vehicles to drive economic development (Galán-Murros et al., 2021), social development coming as additional benefit. The success of GI is highly dependent on the regulatory context. The author group suggests that policymakers should collaborate in a way to harmonize regional, nationwide, and European policies both horizontally and vertically, in order not to hinder, but jointly support the GI to thrive.

Van Dinteren and Jansen (2021) clustered the Area of Innovation into three groups: science park, which creates a business environment for innovation-oriented companies, knowledge institutions and support services; industrial co-innovation park, which is science park without knowledge institution; and innovation district, being the mix of functions, usually in and around cities. In terms of its location, it is usually scattered through or in the city, born out of STP or lead universities.

Sanz et al. (2023) used the term Organised Innovation Space and differentiated six forms: Science and Technology Parks, Innovation Districts (ID), Industrial Innovation Campuses, Areas of Innovation (as mentioned above), Incubators and Living Labs (LLs), analysing their scale and location, management structure, industrial focus, and target group.

Science Park (SP) is one of the forms of AOI, meaning a smaller, more concentrated physical form of innovation cluster, usually involving unique buildings, laboratories, clean rooms, depending on the specific industries it invites. SP and STP represent the oldest concept of AOI, in case of STP, the triple helix model (Etzkowitz, 2003) was born – the cooperation of universities, high-tech

companies and an organization helping start-ups. 'Industry operates ... as the locus of production; government as the source of contractual relations that guarantee stable interactions and exchange; the university as a source of new knowledge and technology...' (Etzkowitz, 2003).

In addition to on-park tenants, there are several informal institutions that have a major influence on entrepreneurial dynamics (Aveline et al. 2022) within the quadruple and quintuple helix spheres. The quadruple model includes the civil society, enabling lead users to provide inputs to the innovation management process. The quintuple model adding the environmental sphere, answering the recently urging challenges of sustainable management. In these new helix models, the stakeholders' interplay with each other through Entrepreneurial Ecosystems (EEs) through socio-technological transformations.

The first STP in 1950 in USA, the Silicon Valley's success is attributed not only to technological innovation but also to its collaborative culture and community networks (Wadhwa, 2013). However, replicating this model in different regions poses challenges, as successful STPs must consider local conditions and stakeholder needs. In many cases, governments are reluctant to commit resources to developing such areas, as they fail to understand the long-term benefits (Galán-Murros et al. 2021) Albahari et al. (2018) found that firms in both newer and established STPs exhibit better innovative performance, particularly in larger parks and regions with less advanced technology sectors. Despite this understanding, gaps remain regarding how various models impact on- and off-park sustainability across different contexts.

When examining the economic sustainability of STPs, researchers have focused on the benefits to tenants and contributions to regional economic growth, with Tajpour et al. (to be published in 2025) suggesting a positive correlation between innovation management practices and the sustainability of Small and Medium Enterprises (SMEs) within STPs, where entrepreneurship acts as a mediating factor.

The social dimension of STP sustainability emphasizes the Parks' impact on regional development (Etzkowitz and Klofsten, 2005). Successful STPs in developed regions illustrate how they can support broader regional goals, yet little research has focused on their role in social development in countries with limited innovation resources (Mondal et al. 2023). In Hungary, where a significant portion of the population resides in the capital, firms, let alone STPs not residing in Budapest may face unique challenges and opportunities in terms of talent attraction (Cadorin et al., 2019).

The environmental aspect of STP sustainability is increasingly important as these Parks adopt sustainable practices. Recent studies highlight climate risk as a driver of green innovation, motivating companies to pursue digital transformation and green technologies (Xiaohang et al., 2024). Corporate governance factors,

including venture capital and legal frameworks, are critical in fostering an innovative culture that prioritizes sustainability (Cai, 2014; Amore & Bennesen, 2016). However, there is a notable gap in research regarding how STPs manage environmental sustainability, presenting an opportunity to explore their role as testing grounds for sustainable innovation strategies (Borrero and Yousafzai, 2024)

3 Methods

This research integrates literature from several theoretical fields—including Science Parks, regional development, the relationships among triple helix actors, and sustainability—to construct an analytical framework that supports new theoretical perspectives. My PhD project is divided into five stages: literature review (Workgroup 1), qualitative research (Workgroup 2), case studies (Workgroup 3), and quantitative studies (Workgroup 4), conclusions and compilation of articles published (Workgroup 5). Workgroup 1 and the first part of the Workgroup 2 are compiled in this conference paper.

For literature review, SCOPUS scientific database was used, having searched for the past 30 years with the following CCL:

(TITLE-ABS-KEY ("science park") AND TITLE-ABS-KEY ("technology park") AND TITLE-ABS-KEY (sustainability*) OR TITLE-ABS-KEY (knowledge AND transfer*) OR TITLE-ABS-KEY (social AND science*) OR TITLE-ABS-KEY (innovat*)) AND PUBYEAR > 1993 AND PUBYEAR < 2024

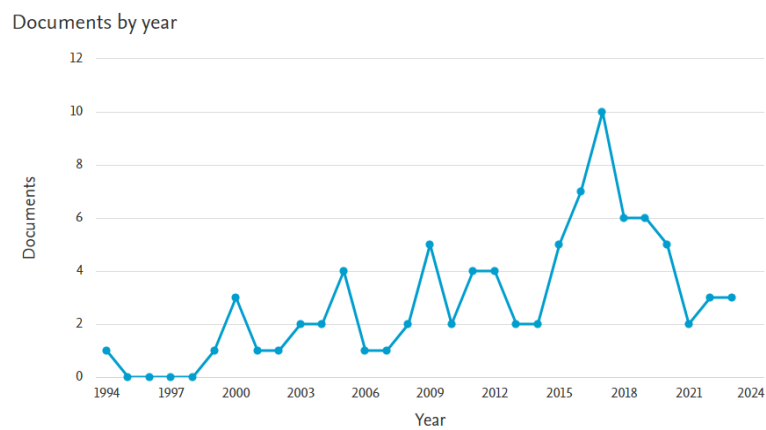


Figure 1. SCOPUS database search result on the documents, viewed by year.

To review the literature, I focused on the following questions:

- Q1 What's the 'Science and Innovation Park linking to Sustainability' literature like?
- Q2 Which are the most cited studies in the area examined?
- Q3 Which researchers published the most in this subject?
- Q4 Which journals studied this topic the most?
- Q5 Which were the keywords applied the most often?
- Q6 What's the ratio of research focusing on corporations, SMEs, start-ups, universities, governmental institutions, regional and/or innovation clusters?

Workgroup 2 is qualitative research, the first interviews being summarized in this paper, in particular interviews with Hungarian STPs affiliated with Óbuda University (OU) professional leaders and executive managers, namely the Zsámbék Future Industry Science and Technology Park (Zsámbéki Jövőipari Tudományos és Innovációs Park, ZSTIP) and the Székesfehérvár Science and Innovation Park (Székesfehérvári Tudományos és Innovációs Park, SZTIP). The objective was to describe the Hungarian STPs in terms of location, size, industrial focus, management structure, affiliation, current stage of development and their short-, mid- and long-term plan strategy. In addition, to understand how they perceive the regulatory environment, and to map their stakeholders both on-park and off-park, evaluate their impact on the sustainable management. The interviewees were requested to evaluate STP by SWOT analysis (Strengths, Weaknesses, Opportunities, Threats). Detailed questionnaire included in Annex.

4 Results

Firstly, below are the answers to the questions for SCOPUS literature review.

A1. There were 85 results in SCOPUS database, in which articles, book chapters and conference papers were equally included. The outcome demonstrated that the subject is thoroughly studied on international scale, though the volume of papers varied over time, as following a surge in 2018, it has decreased recently to the number published 20 years ago.

A2. The articles with the most citations were all focusing on a particular STP – in Turkey, China and Australia, countries trailblazing along Global Innovation Index, as well.

A3. The authors having published the most in past 5 years, so probably the ones who are the most obsessed in this topic and prompt discussions, are as follows:

Documents by author

Compare the document counts for up to 15 authors.

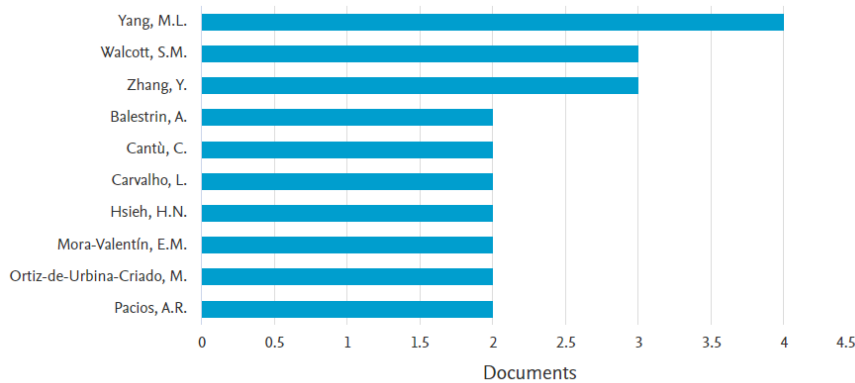


Figure 2. SCOPUS database search result of documents viewed by authors cited the most.

A4. The journals publishing the most about this subject, therefore worth watching out for, are the followings: Journal of Technology Transfer (ISSN:0892-9912), International Journal of Entrepreneurship and Innovation Management (ISSN:1368-275X, E-ISSN:1741-5098), Technological Forecasting and Social Change (ISSN:0040-1625).

A5. Innovation, Science and Technology Parks and its variations were by far the most frequently applied keywords.

A6. The sub-domain examined to the highest extent was the regional and/or innovation cluster, besides, the stakeholder of corporations, whereas all further sub-domains were only focused on by minor number of articles.

To sum up, the past 30 years' relevant literature presents that Science and Innovation Parks have become essential physical objects of regional innovation clusters, what's more, intermediary places that support innovation, thus economic growth, and to contribute to this dimension of sustainability.

Below I have summarized the Organised Innovation Spaces' description, scale and location, management, target users and services, let alone their link to helix models. The Innovation Districts, Areas of Innovation or Living Labs can be labelled as not only triple, but quadruple and quintuple models, integrating the citizens and the environmental sphere into the innovation cycle. Therefore they have even higher potential to contribute not only to the economic, but also to the social and environmental dimension of regional sustainability.

OIS	Description	Scale, location	Management	Target users and services	Helix model	Link to sustainability	Challenges to Sustainability
Science and Technology Parks	Research-based innovation With clear sectoral focus Providing various internal & external services for their users	100K – 1M sq.m. Urban	Intensive Comprehensive	Technology and innovation-based firms; all stages of maturity; all sizes Research centres	3 Triple helix	Economic Indirectly social	Lacking a true social dimension Failing to engage in a sustainable ecosystem
Industrial Co-innovation Campuses	To overcome losing company-power of action and innovative capacity, they place small units outside the co. Link between host firm and the partner firms on co-site	15-20 hectares Peri-urban			Non Applicable (NA)	Environmental Economic	Lacking a social dimension
Innovation Districts	Recent phenomenon Designated existing urban area w/ strong mix of institutions, companies, startups No sectoral focus Open structure	50-200 hectares Urban	Semi-comprehensive	Industry of all sizes Research centres Local governments Final users Citizens / students	3 Triple or 4 Quadruple helix	Social Economic	Lacking an environmental focus
Areas of Innovation (Innovation Corridor)	Place designed to attract entrepreneurial-minded people, talent, knowledge-intensive businesses, investments Ecosystems in their own right	Scattered throughout the city / region Peri/Urban	Non-comprehensive	Industry of all sizes Research centres Local governments	4 Quadruple or 5 Quintuple helix	Economic Social	Economic growth versus environmentally sustainable growth – how to overcome the paradox?
Incubators and Accelerators	Providing support to start-ups to improve the probability of survival To create and capture value from them	Measured by number of tenants. No average. Urban.	Comprehensive	Start-ups, scale-ups Research centres Citizens / students	NA	Economic Social	Lacking an environmental focus
Living Labs	The latest OIS The most inclusive w/ active user participation in co-creation. Presence of real-life conditions to enable controlled experimentation environment. ee. Testbeds.	Scale not characteristic. Peri/Urban / Rural	Semi/Non-comprehensive	Industry of all sizes Research centres Local governments Final users Citizens / students	4 Quadruple helix	Social Economic Environmental	Secure the ownership of innovation (IP)

Figure 3. OIS categorization and descriptions done by Sanz et al. (2023), completed with my assumptions about each OIS link to sustainability and potential challenges.

Secondly, based on the interviews, the stakeholder map of Hungarian Science and Innovation Parks can be segmented into the triple helix model participants: governmental institutions, industry participants, and high-education institutions. The STPs are still in the planning phase of their development, and their sustainable management was mentioned as the key goal of the organization. It is the industry which was mentioned as the most important target group of STPs when it comes to sustainability.

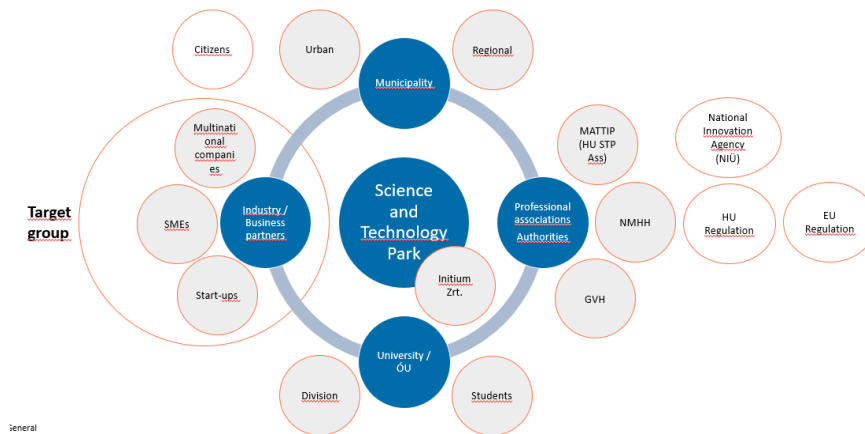


Figure 4. Stakeholder map of Hungarian STPs – my compilation, applying the Triple Helix Model.

The bigger the company, the higher their consciousness of innovation-management, however, the lower is their risk-taking potential. By decreasing the size of the company and locating the decision-taking board from abroad to Hungary, their resilience in terms of risk-taking could be higher, nevertheless, their financial stability and the ability to invest, plunges.

Industry partner	Management	Financials	Competences	Innovation management	Motivation re. STP
Multinational companies	<ul style="list-style-type: none"> • Branch in Hungary, Centre of operations abroad • ++ Annual strategic planning w/ monthly targets, operational business plan • -- Limited local empowerment 	<ul style="list-style-type: none"> • +++ Strong financial background • -- Due to limited local empowerment, limited investment opportunity • --- Short Return On Investment expectation (1Y) 	<ul style="list-style-type: none"> • +++ High level of competence • ++ Mid-level digital maturity in competence • ++ Mid-level digital maturity in infrastructure 	<ul style="list-style-type: none"> • ++ Understanding of innovation • ++ Research department to uncover trends, consumer needs • -- Limited risk-taking • ? Depending on local branch' focus • Direction: process, ecosystem 	<ul style="list-style-type: none"> • Attain high-tech infrastructure w/ capital investment • Gain flexibility • Pool of project managers, experts of latest technology • Potential to become regional competence centre, gain more empowerment
SMEs	<ul style="list-style-type: none"> □ +++ Local management □ ++ Relative quick decision-making □ ? Strategic planning 	<ul style="list-style-type: none"> □ + Focusing on balanced cost vs income, EBITDA to ensure stability □ +/- CAPEX-scarce 	<ul style="list-style-type: none"> □ +/- Various level of competence □ -- Mid-low level of digital maturity both in competence and infrastructure 	<ul style="list-style-type: none"> □ + due to market-push □ + more open to risk vs multinationals □ Direction: product, per market-need 	<ul style="list-style-type: none"> □ Access to high-tech infrastructure w/o investment – risk-evasion □ Access to talent □ Gain flexibility □ New assignments
Start-ups	<ul style="list-style-type: none"> ○ +++ Local management ○ +++ Very quick decision-making 	<ul style="list-style-type: none"> ○ --- Looking for venture capital investment to enable growth & scale-up 	<ul style="list-style-type: none"> ○ +/- Various competence ○ +++ High-level of digital maturity ○ ? Digital infrastructure 	<ul style="list-style-type: none"> ○ ++ Pioneer to develop and manage innovation ○ +++ High risk-taking ○ Direction: product, technology solution 	<ul style="list-style-type: none"> ○ Office, management, working infrast. ○ New assignments ○ Relationship-building

Figure 5. The Industry partners described by management, financials, competences, attitude to innovation management and potential motivation to move to STP. My own compilation based on interviews with Hungarian STP-executives.

I could identify three key expectations of the industry towards STPs – getting access to infrastructure and to talent in flexible way, and the opportunity for networking. Infrastructure refers to either high-technology laboratories, facilities, more relevant for corporations doing production, or office spaces and adjacent facilities, the latter being interesting for SMEs or start-ups that are just about to expand. In the category of talent, experts and researchers deeply absorbed in any deep-tech area or project managers easily assigned and mobilized were all mentioned. Networking was listed as expectation number three, as STPs have the special feature to employ community managers who facilitate the connections between on-park partners, motivating the birth of innovative ideas as well as new products and businesses. As innovation is basically about value and change (Galán-Murros, 2021, Sanz et al., 2023), thus this feature of STP is crucial for the success of both the tenants and the Park itself.

5 Discussion

With this paper I intended to initiate further discussion about the link of internal and external aspect of sustainability to future STPs. The limitations of this research come from the fact that not all the most cited studies were accessible in full volume, in addition, some entailed case studies in certain countries, which might not be characteristic on wider horizon. Further on, the term ‘sustainability’ could be defined in more detail, gaining insight into specific region’s current level and notion of sustainability, how it can be measured, which points to improve, and whether STP has the potential to contribute to the region’s advancement. The empirical research was limited, due to time constraints, so further interviews could

be done with more STP-executives, involving also on- and off-park stakeholders, to understand the impact of each to the sustainable management of the Park.

Conclusion

The past 30 years' relevant literature presented that Science and Innovation Parks have become essential physical objects of regional innovation clusters, what's more, intermediary places that support innovation, thus economic growth, and to contribute to this dimension of sustainability.

OISs have the potential to link to sustainability along various dimensions. Economic sustainability is naturally linked to OIS, being the engine of economy by facilitating intensive innovation-mechanism. Social sustainability is prevalent only in recent phenomena – Living Labs and Innovation Districts. The environmental sustainability is lagging behind – I could only discover this potential link in Living Labs.

The internal sustainability opportunity of Hungarian STPs largely depends on their stakeholder-management. The industry partners were identified as their target group number one. The top needs of business tenants were the flexible, high-tech & office infrastructure, accessible talent pool and networking.

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I could not have undertaken this journey without Mr. György Eigner, PhD, my co-supervisor who announced the topic of sustainable STP management at OU Innovation Management Doctoral School and having connected me with OU-affiliated STP-executives to do the interviews.

Annex

Questionnaire applied in interviews:

1. Please introduce yourself.
What's your position in STP? Since how long have you been employed by STP? What's your role and responsibility?
2. Present me the STP, please, mentioning also the circumstances of the birth of Park, location and scale, the current stage of development and next steps, industrial focus (if any), the partners, and the initiatives to make the Park sustainable.

3. Evaluate the regulatory environment in relation to STP sustainability, mentioning the regulations in favour of and the ones hindering the sustainability of Park.
4. Present the STP strategy in short-, mid-, long-term (1-3-5-10 years), the management structure of Park, the stakeholders on- and off-park, positioning the Park within the region's innovation ecosystem. What's your plan to enable the Park to become sustainable, what are the factors that could support it or what are those impacting the other way round?
5. Evaluate the Park's stakeholders' impact on the sustainable management of Park, differentiating those who have the biggest impact, who have neutral impact and who have minimal impact, and also add your reasoning.
6. Tell me your opinion about the performance of STP, mentioning the strengths, the weaknesses, the key opportunities and the threats.
7. List the current partners and stakeholders of the Park, with special attention to those partners with whom you would recommend to do an interview with.

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Assessing the Role of Social and Traditional Media in Rural Development: Insights from Albania

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Abstract: Rural development in Albania faces several challenges, including high emigration, limited digital infrastructure, and economic constraints. Traditional and social media are essential in addressing these issues, supporting information dissemination, economic empowerment, and community engagement. Traditional media, especially radio and television, remains crucial in regions with limited internet access, providing reliable information on government policies, subsidies, and agricultural practices. Meanwhile, social media platforms such as Facebook and Instagram offer rural entrepreneurs opportunities to promote agritourism, expand market reach, and share knowledge, especially among younger populations. This study examines the combined impact of traditional and social media on rural development in Albania by comparing their roles, effectiveness, and limitations. Findings suggest that traditional and social media are complementary tools, each addressing community needs and development goals. While traditional media supports structured communication in areas with limited digital literacy, social media enables interactive engagement, facilitating market access and economic diversification. This dual approach offers valuable insights for policymakers aiming to strengthen Albania's rural development strategies by integrating both media forms to maximize their potential impact.

Keywords: rural development, Albania, social media, traditional media, community engagement, economic empowerment, information dissemination

1 Introduction

Rural development plays a vital role in promoting economic growth, social stability, and sustainability, particularly in countries like Albania, where rural communities face various infrastructural and economic challenges. These issues include high levels of emigration (Kokkali, 2024), limited internet connectivity and trust in the digital realm (Bencsik et al., 2022; Kokthi et al., 2023), and reliance on traditional agricultural practices. Effective communication strategies are essential to support economic diversification, improve agricultural productivity, and engage local communities in sustainable development.

Communication for development has evolved through different paradigms, each reflecting a distinct approach to fostering social and economic progress (Servaes & Malikhao, 2020). The transformative role of technology, particularly mobile and digital tools, is evident in rural development across various regions (Aker & Mbiti, 2010). However, the adoption of digital technologies in rural Albania is often hindered by low levels of trust in new technologies and the associated risks. As noted by Bencsik, Hargitai, and Kulachinskaya (2022), trust in technology plays a crucial role in how communities embrace digital tools, with risk perceptions often limiting engagement. In Albania, communication strategies must address obstacles such as limited internet access, high technology costs, and low digital literacy in certain areas (Institute for Democracy and Mediation [IDM], 2019). Public service media have been highlighted as a valuable resource for informing and engaging rural communities (Bino & Kadia, 2017). Additionally, Tomorri et al. (2024) underline the potential of digital advancements to improve agricultural practices and increase productivity, while Mulliri et al. (2021) stress the importance of digital tools in enhancing farming efficiency and market access. Plasari and Boshnjaku (2023) reinforce these findings by demonstrating how e-agriculture can contribute to sustainable practices and support rural development efforts.

Farmers in Albania rely on various sources of information to improve their agricultural practices. According to Bicoku and Subashi (2020), local sources such as agricultural extension services and peer networks are crucial for the dissemination of farming knowledge. These sources are often complemented by media outlets, including traditional radio and television programs, which provide farmers with essential information on government policies, subsidies, and agricultural techniques. Integrating digital and traditional media can help bridge

the information gap, particularly in regions where access to modern communication technologies is limited.

Integrating traditional and digital media is crucial for encouraging economic growth in rural Albania. Traditional media, such as radio and television, remain reliable sources for delivering structured, government-related information in areas with limited connectivity. At the same time, the growing use of social media facilitates market access, knowledge-sharing, and the promotion of local businesses (Viswanath, 2006; Rainie, 2020; Westlund, 2015). Social media also supports interaction between farmers and experts, fostering engagement and encouraging community involvement.

Despite these opportunities, Albanian farmers face technological and social barriers that limit their ability to use media effectively. Technological barriers, such as insufficient internet access and low digital literacy, restrict their engagement with digital platforms (Norris, 2001; Gurstein, 2003). Social challenges, including a lack of trust in new media and deeply rooted communication habits, also hinder the adoption of modern solutions (Bino & Kadia, 2017; Tomorri et al., 2024). Addressing these barriers is essential to empowering farmers and supporting their participation in the digital economy.

This study examines the complementary roles of traditional and social media in rural development, with a focus on how these platforms address challenges such as limited connectivity, literacy barriers, and access to relevant information. By exploring media use across rural regions, the research aims to contribute to the broader understanding of media dynamics in rural settings and offer practical insights for improving development strategies in Albania. The remainder of the paper is organised into sections covering the introduction, literature review, methodology, results, discussion, and conclusion and recommendations.

2 Literature Review

2.1 The Role of Media in Rural Development

Rural development seeks to improve the quality of life and economic opportunities in rural areas by modernizing agriculture, upgrading infrastructure, and increasing access to education and healthcare. Media facilitates these goals, as it disseminates information, fosters economic empowerment, and encourages community engagement (Servaes & Malikhao, 2020; Narula, 2006). Rogers' Diffusion of Innovations Theory (Rogers, 1995) underscores the media's role in rural development by explaining how information spreads, aiding rural communities in adopting new practices and technologies. In rural regions where

information is sparse, media can act as a vital bridge, connecting communities to resources and knowledge that support economic and social advancements (Viswanath, 2006; Park et al., 2019).

Traditional media—radio, television, and print—has long been an important medium for reaching rural communities with limited internet access (Das, 2022). Studies in developing countries show that traditional media show radio's essential role in disseminating agricultural advice, health information, and public welfare messages, especially where literacy barriers make audio communication more effective (Kavita, 2018). Katz and Lazarsfeld's Two-Step Flow Theory (1955) further explain traditional media's influence in rural areas, suggesting that information is often conveyed through trusted community figures, making it a reliable source for individuals in these communities.

Similar patterns are observed in Albania. Radio and television are key sources of information in areas with limited internet, helping farmers and rural inhabitants stay informed about government programs, agricultural subsidies, and public health guidelines. Traditional media is often seen as trustworthy for delivering government-related information and structured advice, providing a stable foundation for community knowledge. As Manyozo (2012) noted, traditional media's structured approach enhances decision-making processes in rural settings, where reliance on clear, authoritative information is high.

2.2 The Emergence of Social Media and Its Impact on Rural Development

The rapid growth of social media has transformed how rural communities access information, engage with markets and connect with broader audiences (Chowdhury & Odame, 2013; Marquardt et al., 2012; Rama Devi & Venugopal, 2022). Platforms such as Facebook, Instagram, and WhatsApp are increasingly used in developing countries to share real-time agricultural information, promote local businesses, and connect farmers with new markets (Gyawali, 2022; Balakrishna & Deshmukh, 2017). Uses and Gratifications Theory (Katz, Blumler & Gurevitch, 1973) is particularly relevant in explaining rural users' motivations to adopt social media, as these platforms fulfill specific needs such as immediate access to information, networking, and marketing (Aker & Mbiti, 2010).

In Albania, social media has become a key platform for agritourism and agriculture, especially among younger farmers seeking to reach wider markets (Kadiu, 2024). Social media supports Albania's growing agritourism sector by allowing rural entrepreneurs to showcase products and attract visitors, thereby creating economic opportunities that benefit rural regions (Tola, 2021, GIZ, 2023). The accessibility and interactive nature of social media enable rural inhabitants to

access information otherwise unavailable through traditional media, providing them with an additional layer of economic empowerment.

2.3 Comparing the Roles of Traditional and Social Media in Rural Development

Traditional and social media serve distinct yet complementary roles in rural development. Traditional media operates top-down, offering structured, reliable information critical for government updates, policy announcements, and educational initiatives. Das et al. (2021) and Irfan et al. (2006) found that between television and radio, television is the most used medium of journalism, supporting this study's claim. Yaseen et al. (2019) and Osondu & Ibezim (2015) found similar results regarding newspapers as farmers' least chosen medium of journalism. Social media, conversely, enables a bottom-up model that fosters interactive communication, empowering rural communities by facilitating rapid, user-driven engagement (Ashraf et al., 2018; Heeks, 2010).

In rural areas with limited digital literacy or internet access, traditional media remains the primary source for practices government subsidies and agricultural practices updates. However, in communities with internet access, social media has proven valuable for connecting rural businesses to broader markets and creating platforms for collective action. The dual use of media in Albania's rural landscape highlights the importance of integrating both types to address the varying needs of the population, as each media type supports different but equally essential aspects of rural life.

3 Methodology

The study was conducted using a quantitative research methodology. Participants included 150 rural residents, primarily farmers, from rural areas of Fier, Berat and Tirana, selected for their unique challenges and opportunities in information access and digital infrastructure. The gender distribution consisted of 89 males (59%) and 61 females (41%), reflecting a predominantly male farming population consistent with national trends. Participants covered five age groups—18-25 years (18 respondents), 26-35 years (36 respondents), 36-45 years (24 respondents), 46-55 years (39 respondents), and over 55 years (33 respondents). This age range provided a comprehensive perspective on media usage across generations, with younger participants more inclined toward social media platforms and older respondents preferring traditional media. Participants held various educational levels, from primary education to master's degrees or higher, with the majority possessing a bachelor's degree. Education level influenced media usage patterns, with higher-educated individuals more likely to use social media for information

and networking purposes, while those with less formal education tended to rely on traditional media such as radio and television for structured information. Data collection occurred over several weeks, utilising both in-person and online interviews to ensure comprehensive coverage of the target population. This approach allowed for a diverse and representative sample, providing valuable insights into the impact of traditional media and social networks on rural development, particularly from the perspective of farmers.

4 Discussion of Results

The demographic data show a predominantly older, male, and agricultural-employed population in rural Albania, which aligns with broader trends observed in the country (See Table 1). Over almost three decades, Albania has experienced a significant rural exodus driven by the search for better economic opportunities in urban centres and abroad (Kruja et al., 2024). Due to high emigration and urban migration rates, the rural population has declined from about 59% in the late 1990s to approximately 39.7% today (INSTAT, 2023). This trend is exacerbated by limited access to public services, infrastructure deficits, and reduced economic opportunities in rural areas, making agriculture and rural life less attractive, particularly for younger generations (IDM, 2019; World Bank, 2023). High emigration rates, particularly among youth, have intensified these demographic shifts. Many young Albanians migrate to nearby European countries, with Greece and Italy being the primary destinations (Gedeshi, 2002; Mancellari et al., 1996; Sanfey & Papapanagos, 2001; Staniscia & Benassi, 2018). This migration is often fueled by economic necessity, as rural Albania faces high poverty and unemployment rates, alongside limited access to modern education and healthcare. The prospect of improving living standards, seeking better job opportunities and gaining educational advantages motivates a significant portion of Albania's rural youth to emigrate, depleting the labour force in these communities (Migration Policy Institute, 2023).

Demographic Variable	Category	Percentage (%)	Preferred Media Type
Age	18-25 years	12%	Social Media (Facebook, Instagram)
	26-35 years	24%	Social Media (Facebook, Instagram)
	36-45 years	16%	Mixed (Social and Traditional Media)
	46-55 years	26%	Traditional Media (TV, Radio)
	Over 55 years	22%	Traditional Media (TV, Radio)
Gender	Male	59%	Social Media for Economic Activities (Market Access)
	Female	41%	Social Media for Community Engagement
Education Level	Primary	15%	Traditional Media (Radio, TV)
	Secondary	27%	Traditional Media, limited Social Media
	Bachelor's Degree	38%	Social Media (Facebook, Instagram)
	Master's or Higher	20%	Social Media (Professional Networking)

Table 1: Demographic and Media Usage Patterns
Source: Authors elaboration

A significant demographic shift in rural areas is the reduced household size and the fragmentation of family units, as many members relocate for work or study. As the OECD (2006) noted, rural regions increasingly face demographic and economic challenges—such as population decline, family fragmentation, and limited service access—that collectively strain community structures and hinder sustainable development. Smaller households often lack the resources to sustain farming activities and fulfil traditional community roles, further destabilizing rural

communities. The survey data highlighted distinct media usage patterns across demographics, underscoring generational and educational divides in media preferences within rural Albania. **Older respondents (46 years and above)** preferred traditional media, with television and radio cited as primary information sources on government policies, agricultural subsidies, and public health guidelines. In contrast, **younger respondents (18-35 years)** favoured social media, primarily Facebook and Instagram, to access agricultural updates, market opportunities, and community networking.

In relation to gender-based usage Trends-Male participants were more inclined to use social media for economic activities, such as promoting agritourism and accessing broader markets. In contrast, female participants tended to rely on social networks for community engagement and knowledge sharing on family and social welfare topics. These demographic and social dynamics provide a critical context for the media usage patterns observed in the survey. With an older population predominantly engaged in agriculture, traditional media—especially television—remains a key information source in rural areas. At the same time, social media is gaining traction among younger people, who seek broader market access and up-to-date agricultural information. This dual reliance on traditional and digital media highlights the contrasting needs for stable, trusted information sources and modern connectivity, shaping Albania’s rural media landscape.

Impact Area	Social Media	Frequency (n)	Mean Score	Traditional Media	Frequency (n)	Mean Score
Agricultural Practices (1)	Knowledge sharing	103	0.69	Policy and structured info	101	0.67
Market Access (2)	Expanding market reach	88	0.59	Limited economic connections	31	0.21
Community Collaboration (3)	Facilitating engagement	25	0.17	Moderate support for collaboration	46	0.31
Tourism Promotion (4)	Broad audience engagement	31	0.21	Moderate promotion	18	0.12
Advocacy for Rights (5)	Minimal role	1	0.01	Limited impact	2	0.01
Policy Subsidy & Info (0)	Limited use for policies	7	0.05	Key source for updates	22	0.15

Table 2: Comparison of Social and Traditional Media Impact Perceptions
Source: Authors elaboration

Table 2 compares the perceived impacts of **social media** and **traditional media** in various areas critical to rural development. The data includes the frequency of responses and the mean scores for each type of media across different impact areas.

1. **Agricultural Practices: Knowledge Sharing -Social Media (Mean Score 0.69)** is perceived as highly effective in sharing agricultural knowledge, such as farming techniques and innovations. This high score reflects the interactive nature of platforms like Facebook and Instagram, which enable farmers to exchange practical advice and experiences. **Traditional Media (Mean Score: 0.67)**, such as TV and radio, provides more **structured information** related to agricultural practices, including government policies and official guidelines. The close mean scores suggest that both media types are important, with social media offering

more dynamic engagement while traditional media focuses on formal dissemination.

2. Market Access: Expanding Market Reach- Social Media (Mean Score 0.59) is seen as a powerful tool for expanding **market reach**. It helps rural farmers connect with a broader audience, enabling them to promote and sell their products more effectively. The relatively high score reflects the ability of social media to facilitate direct communication between producers and consumers. **Traditional Media (Mean Score: 0.21)**, in contrast, shows a **limited role** in fostering economic connections, such as market expansion. While TV and radio may provide general information, they are less interactive and do not facilitate direct trade in the same way that social media does.

3. Community Collaboration: Facilitating Engagement- Social Media (Mean Score 0.17) is seen as having a **minimal impact** on **community collaboration**. While it allows for individual connections, its ability to foster collective action or community-building is limited in rural settings. **Traditional Media (Mean Score 0.31)** plays a more significant role in facilitating **community collaboration**, with a moderate score indicating its effectiveness in promoting community initiatives, such as regional projects or awareness campaigns, through platforms like radio and TV.

4. Tourism Promotion: Broad Audience Engagement- Social Media (Mean Score 0.21) is perceived to engage a **broad audience** for tourism promotion, but the relatively low mean score indicates that its impact is still growing. Social media has the potential to raise awareness about rural tourism but may struggle to create sustained interest or attract tourists. **Traditional Media (Mean Score: 0.12)** also plays a role in **tourism promotion**, though with a more **moderate impact**. It can engage audiences through advertisements and regional broadcasts, but its effectiveness is limited compared to social media's broader reach.

5. Advocacy for Rights: Minimal Role- Social Media (Mean Score 0.01), Both social and traditional media show a **minimal role** in advocating for rural rights, with social media scoring very low. This indicates that social media is not widely used in rural areas for rights-based advocacy, possibly due to limited access, digital literacy, or engagement with relevant issues. **Traditional Media (Mean Score: 0.01)**: Similarly, traditional media has little impact on **advocacy for rights**. This highlights a broader issue in rural areas where both media types may be underutilized for empowering rural communities in advocacy efforts.

6. Policy & Subsidy Information: Limited Use- Social Media (Mean Score 0.05) has a **limited role** in disseminating **policy and subsidy information**. While it can provide informal updates, it is not perceived as a reliable source for official information regarding subsidies or governmental policies. **Traditional Media (Mean Score: 0.15)**, however, is seen as a **key source** for receiving updates on

policies and subsidies, reflecting its role as a trusted and formal channel for important government information in rural areas.

The data collected and related literature indicate that different media preferences and existing barriers significantly impact rural development outcomes in Albania. The roles of traditional and social media in Albanian rural communities are distinct yet complementary, each offering benefits to different demographic groups. Additionally, the questionnaire data identifies specific challenges and opportunities for improvement, suggesting concrete steps toward integrated rural development. Limited access to technology and low levels of digital literacy pose substantial challenges to rural development, as highlighted by Norris (2001) and Gurstein (2003). The data confirms that restricted internet access and insufficient digital skills hinder rural residents from fully utilizing social media for economic and social benefits, especially older residents who are more reliant on traditional media and have limited exposure to digital platforms like social networks. These barriers create an opportunity to enhance digital infrastructure and develop digital literacy programs for rural communities. Investments in internet access and training on using social media for market access, professional development, and economic diversification align with rural development goals as suggested by Rainie (2020). Such initiatives could help bridge the digital divide in rural areas.

Trust is a crucial factor for rural residents, who express skepticism toward social media due to concerns about misinformation. The questionnaire data reveal that many rural residents prefer traditional media for reliable information on government policies and subsidies, viewing social media as less dependable for structured information. Educating communities on critically assessing online information could increase trust in social media. Media literacy programs and partnerships between government and social media platforms to distribute verified information would help build trust among rural residents. Such measures could encourage engagement in community development and support transparency and informed civic participation (Kaçani et al., 2024; Kokthi et al., 2021, 2023).

Conclusions and Recommendations

The findings from the questionnaire and existing literature support the conclusion that integrating traditional and social media is essential for advancing rural development in Albania. Traditional media provides reliable information on policies and subsidies, while social media facilitates economic opportunities and engages younger demographics in community activities. To overcome barriers such as limited internet access, low digital literacy, and high costs of devices, investments in infrastructure and digital training for rural residents are recommended.

Social media proves most effective in areas that benefit from interactivity and real-time communication, such as market access and knowledge sharing. It is also valuable for engaging a broad audience in tourism promotion, though its influence

remains limited in rural areas. Traditional media continues to play a crucial role in delivering structured information and policy updates, particularly regarding agricultural practices and community collaboration. Despite its limited impact on rights advocacy and tourism, it remains a reliable source for formal and authoritative content.

Investing in internet connectivity for rural areas will expand access to social media platforms, enabling economic engagement, educational access, and digital inclusion. Training in digital skills will empower residents, particularly older demographics, to utilize social media effectively, fostering economic and community development. Programs that educate rural residents on evaluating online information critically can increase trust in social media as a valuable information source. Providing affordable technology and internet services to rural communities would allow broader use of social media for market access and product promotion. Combining traditional media's reliability with social media's interactivity can create a comprehensive communication model that meets the diverse needs of rural communities.

By implementing these interventions, Albania can build a sustainable information system to support rural community development, empowering residents to leverage technology for a more prosperous and connected future.

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Practical aspects of social media marketing

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Abstract: Social media refers to online platforms and tools where users create, share and interact with content. Popular platforms such as Facebook, Instagram, Twitter (now X), TikTok and LinkedIn allow individuals and businesses to connect, communicate and build relationships. Social media marketing leverages these platforms for business goals such as brand awareness, customer engagement and lead generation. It includes strategies such as content creation, paid advertising, influencer partnerships and audience targeting to reach and engage users based on their interests and behaviours. Effective use includes consistent content, tracking and optimisation. The future of social media marketing will bring a number of innovative trends and technological developments that will transform the way companies present themselves online: artificial intelligence, metaverse, and shopping directly on platforms are built around creative and technological innovations, adapting to the rapidly changing world of consumer demands.

Keywords: social media, marketing strategy, digital marketing trends

1 Introduction

Social media marketing is a strategy whereby companies use social media platforms to increase brand awareness, reach their target audience and engage their customers. Social media marketing provides an opportunity to communicate directly, receive quick feedback and share relevant content, promotions or campaigns. Successful social media marketing involves regular content creation, audience analysis, choosing the right platforms (e.g. Facebook, Instagram, LinkedIn) and targeting ads to achieve desired results.

Content creation is also an important pillar, sharing visually appealing, interesting and relevant content such as images, videos, blog posts and infographics can help to communicate more effectively. The next step is engaging your followers: interacting with your audience through comments, reactions and messages, and responding to questions and feedback.

Paid advertising is also playing an important role in social media marketing: Facebook Ads or Instagram Ads, which can be tailored to specific demographics and interests, help you reach your target audience.

The final step of the marketing strategy is analysis and measurement: measuring the effectiveness of social media campaigns using analytical tools (e.g. reach, clicks, conversions), and then fine-tuning strategies based on these. Consistent presence and continuous monitoring of results are important for success.

2 Application of social media marketing

The dominance of visual and video content in today's digital communications is an unstoppable trend. The impact of digitalisation is complex and multidimensional, bringing about significant changes in many areas, including communication in our everyday choices, such as when we buy food and when we choose where to work. (Garai-Fodor et al., 2023; Garai-Fodor, 2022; 2023; Garai-Fodor et al., 2024).

Changes in the media and entertainment industry continue to be driven by the mixed reality of younger generations, according to the results of a survey conducted this year. Almost half of Gen Y and Z in the US say they spend more time with others on social media than in the physical world and 40% say they socialise more in video games than in the physical world (Deloitte, 2023).

Looking at the age distribution of social media use in international data, the following results are obtained. Most US social media users are aged between 27 and 42 and belong to the millennial generation. In the United States, 68.5 million Millennials use social media, making this group nearly one third (30.3%) of all US social media users.

In terms of usage, the next closest age group is Generation Z (11-26 year olds) with 56.4 million social media users, followed by Generation X (43-58 year olds) with 51.8 million users. Baby Boomers aged 59-77 are the age group with the lowest social media usage, with only 36.9 million users (Feger, 2023), (Figure 1.).

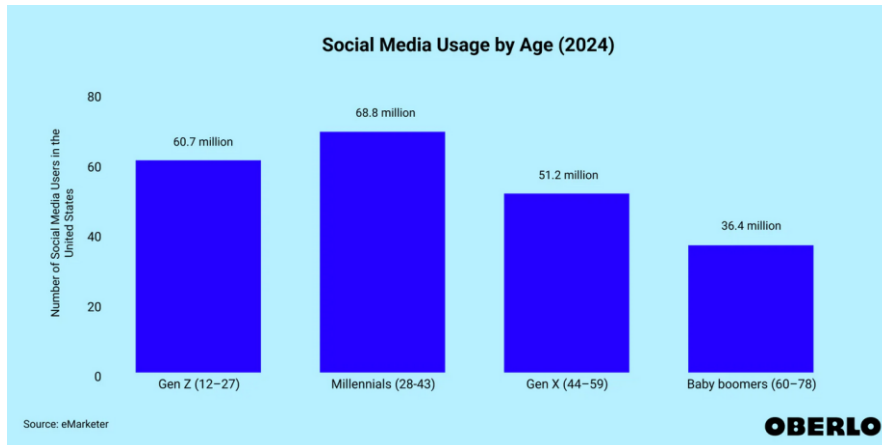


Figure 1: Social media usage by age

Source: <https://www.oberlo.com/statistics/social-media-usage-statistics-by-age>

According to the research results of NMHH (2023), the most popular social media platform in Hungary is Facebook, which is viewed daily by 31% of respondents and several times a day by 41% of respondents. Facebook is followed in order by YouTube, Instagram and TikTok (Figure 2).

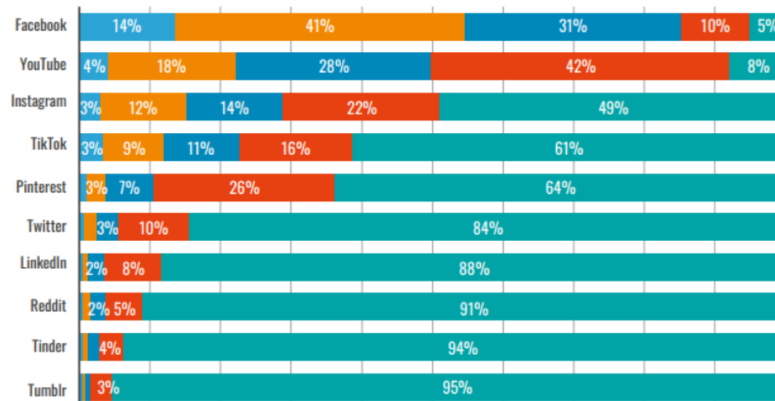


Figure 2: Most popular social networking sites

Source: https://nmhh.hu/dokumentum/242931/mediapiaci_jelentes_2023.pdf

The intensity of social media use is closely related to the feeling of FoMO, i.e. the more and more time one spends on such platforms and the more different platforms one uses, the more likely one is to be concerned about missing out on something. This is particularly significant in the case of Facebook use, where the intensity of use and general attachment to the site was strongly correlated with all

dimensions of FoMO (except for concerns about being unavailable by phone), showing the importance of Facebook in Generation Z's information and communication habits. A similar pattern was observed for Instagram, but to a lesser extent than for Facebook (Pászto-Bak, 2020).

3 The role of social media marketing

Social media consumption patterns are an indicator of users' online activities and preferences. The majority of users access social media through their smartphones, which provide quick and easy access. Videos and images are growing in popularity, especially on TikTok and Instagram Reels. Users are actively responding to content, commenting and sharing, looking for direct connections. Influencers play a big role in shaping public opinion and many people trust them to recommend products.

However, it should also be borne in mind that the importance of influencer and brand fit remains paramount to running an effective campaign (Hódi et al., 2022).

These trends are constantly evolving and companies should adapt to changing consumer needs.

Research has shown that the time spent online has increased dynamically in recent years for all generations, both globally and in our country. As a consequence of this change in media consumption, the advertising market has also undergone a fundamental transformation, with print advertising revenues declining sharply and online advertising revenues growing exponentially since the 2008 economic crisis, especially in social media (Kardos-Gál, 2021).

Iványi (2022) examined the tourism aspect of social media, pointing out that social media and consumer content management has become a separate field in the online marketing world, and is a very important part of the tourism consumer process in several steps. Consumer and corporate content in the online space can have a significant impact at many stages of the consumer process, making its proper management a strategic issue for tourism organisations.

In the context of boosting tourism, a study examined the use of social media tools by wineries in the Lake Balaton Highlands. According to the businesses surveyed, the main reasons for using social media tools are that the majority of customers are regularly present on these sites, it helps to increase brand awareness, inform customers/buyers (e.g. guests come to a wine tasting more prepared), due to the high competition in the market, other wineries use them (i.e. monitoring competitors) and it helps to improve work efficiency. The main objectives are to increase brand awareness, reach new potential customers, maintain contact with customers, increase sales and reduce costs (Horváth, 2022).

Research has also looked at the impact of content seen on social media on the choice of travel destinations. Their results show that nowadays, anyone who is present on social networking sites can be inspired by the pictures and messages posted there, even without knowing it. An interesting fact is that influencers on social media have a greater influence on people's opinions. From a tourism marketing point of view, the various social networking sites and the opinion leaders or influencers on them have become important profiles. The results show that people who are present on social media are likely to be influenced in their tourism decisions by the content and impulses they see there (Orliczki-Kovács, 2023).

Generations Y and Z are the main target group of the tourism industry. The social behaviour of these generations is different from that of their predecessors, as they have grown up in a world of digital revolution and social media, which has a major impact on their daily lives. The tourism industry has recognised the growing presence of social media influencers and the importance of trust in maintaining long-term relationships with customers. Research has shown that Generation Y and Z's trust in social media influencers has a positive impact on the first stage of their travel decisions, and that there are significant differences between Generation Y and Z in the role of social media influencers in their travel decisions (Rebeka-Anna, 2020).

Social media strategy can be used regardless of the profile of the business, for example in sports or to promote sports clubs. international research has shown that there are differences in the online marketing communication activities of club teams with different professional goals, and which development opportunities and aspects can be exploited most effectively on social media platforms. a successful online marketing strategy always involves a lot of preparation and planning, and diversification of content production on different platforms, as the consumer communities of the platforms are different (Pethő-Pfau, 2023).

Digital platforms provide businesses with a wider platform and greater freedom of action, while consumers can access information more easily and quickly, and find consumer-friendly solutions. However, all these advantages may also provide opportunities for new abuses and unfair practices based on the specificities of the digital environment. These include price and product comparison sites, intrusive banners, hidden advertising or influencer marketing that conceals the economic context. The latter is particularly the case on social networking sites, where consumers are deceived by unfair commercial practices that follow the commercial habits of a popular figure (Gellén, 2020).

Social media is also having an impact on online shopping. Online shopping is significantly influenced by various social media sites, which provide access to information and opinions from other consumers. According to the results of national researchers, companies engaged in online commerce need to develop and

implement differentiated marketing actions based on their target group. For example, in the case of products or services targeted at women, it may be appropriate to include influencers in various advertising campaigns, given that women pay more attention to social media than men when searching for and evaluating alternatives (Balogh-Kardos – Gál, 2022).

Research has also shown that social media leads to increased web traffic, but does not result in significant increases in product orders and sales revenue. However, larger social media campaigns tend to result in significantly more orders and sales revenue, and Facebook appears to be the most effective channel. It is also found that the effectiveness of social media marketing varies depending on the complexity, cost and brand status of the products (Dolega et al., 2021).

The role of artificial intelligence as a content creator is growing and companies can effectively reduce customer acquisition costs by optimising communication on social media platforms (Somosi, 2022).

In the current digital age, marketers are increasingly aware that marketing content should not only focus on the commercial aspects, but also on the social aspects or the interactions between sellers and buyers. All these activities have an impact on the quality of the relationship between the customer and the business, and managing a good customer-business relationship is a necessary strategy to achieve the marketing objective (Wibowo et al., 2020).

Conclusions

The use of social media marketing involves a number of important steps to strengthen your brand's online presence.

It is essential to define precise objectives such as increasing brand awareness, driving traffic to the website or encouraging direct sales. Subsequently, understanding the demographics, interests and behaviours of the target audience will help to create relevant content.

The next step is to choose the platforms that best suit your target audience (e.g. Instagram for young people, LinkedIn for business) and to continuously produce creative and value-added content (e.g. posts, videos, articles). Visually appealing and useful content attracts attention and increases engagement.

Social media campaigns can be amplified through a combination of paid advertising and organic posts. Ad campaigns can target the right audience, for example by targeting demographics, geography or interests.

Interaction with your target audience is essential, which means that your company actively communicates with your followers, responds to comments, questions and manages feedback.

The performance of campaigns can be tracked using various metrics such as reach, clicks, conversions and a key focus is to adjust your strategy based on this data.

Nowadays, influencer marketing is an essential part of social media marketing, i.e. working with relevant influencers who can authentically represent your brand and help you reach new audiences.

To encourage audience engagement, it is worth integrating shopping opportunities into social media platforms such as Instagram or Facebook shops.

An additional help for the marketing professional is the use of a content calendar to ensure consistent posting, taking into account the best times to match audience activity. Scheduling campaigns and regularly posting content will ensure a constant presence on the platforms.

These steps will help ensure that social media marketing is effective in building brand, increasing engagement and achieving business goals.

A well-developed social media strategy will help your company to achieve its goals effectively and measurably, while building a relationship with your target audience.

Some forward-looking social media marketing trends that can help drive an effective online marketing strategy.

Short format videos are gaining ground, with the popularity of TikTok and Instagram Reels driving demand for short, dynamic videos. Users are increasingly looking for personalised content, with unique, relevant content improving the user experience.

Among influencer marketing collaborations, microinfluencers and authentic collaborations are coming to the fore, with larger companies working with influencers with smaller but relevant followings.

Today, a major trend is the integration of shopping directly on the platforms and the use of artificial intelligence (AI) in marketing campaigns, automation, chatbots and analytics. These trends are constantly evolving according to technological innovations and user needs.

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Organizational Resilience Assessment as the Indicator of the Sustainable and Human-centric Industrial Organizations Transformation

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Abstract: Industry 4.0 brought digitalization to every aspect of the industrial manufacturing processes. Based on the rapid development, besides being accepted as major promoter of the industrial development, Industry 4.0 evoked many controversies, mainly expressed through strong opposition to the related digitalization of the processes, based on the employees' fear and lack of adequate organizational communication. Based on those circumstances, contemporary manufacturing operations are being transformed from a digital to a post-digital era, in the frame of Industry 5.0 concept. In this concept, post-digital processes are equally concerned with digitalization and with employees' opinion on their workplace's conditions and overall business success. In this research, the main focus is placed on the organizational resilience index (RI) assessment in the mining industry organizations, evaluated through the assessment of the employee's opinion on the most important influencing factors, belonging to the: technical, human, organizational and sustainability, groups. In the assessment, the employees of all organizational levels, including: machinery operators, support workers, operational, middle and top-level managers were included. Methodology for RI calculation included application of MCDA techniques, supplemented by the Fuzzy Logic and additionally boosted by artificial intelligence – through Artificial Neural Networks implementation. Obtained models enable accurate calculation of the organizational RI, and possibility to its prediction, based on the measured influential factors.

Keywords: Organizational resilience; Industry 5.0; MCDA; ANNs; modeling

1 Introduction

By integrating advanced operator I4.0&5.0 and society S5.0 standards (Choundhry et al., 2024), the SmartMiner project concept offers solutions for improving the overall level of environmental quality in complex interactions between physical, behavioral, and organizational processes (Spasojevic Brkic et al., 2024; Spasojevic Brkic, 2024). It also suggests a paradigm shift from pure technology to Human and Data-Centric Engineering, which is simple to transfer to other industries (Spasojevic Brkic et al., 2024). Our initial study focus was on the microenvironmental well-being of mining machinery operators and their cyclical alignment with value chain stakeholders (Spasojevic Brkic, 2024). In order to address environmental and human health concerns and improve overall performance, the project's primary objective is to develop intelligent, ergonomic, non-invasive, and dependable operator aid systems for controlling physical environment job stressors, such as noise, human vibration, lighting, temperature, air quality, and workplace layout issues (Spasojevic Brkic et al., 2024; Spasojevic Brkic, 2024). Organizational resilience is a necessary prerequisite for meeting project objectives (Mihajlovic et al., 2023). The project was initiated in May 2023 and will last until May 2025, so at this point, only some of the results developed until present date can be presented (<https://smartminer.mas.bg.ac.rs/>).

Entire scope of this project was realized through five work packages, which are as follows (Spasojevic Brkic et al., 2024; Ducheck, 2020):

- WP1: Project management and coordination (duration: M1 - M24)
- WP2: User/operator and stakeholders' issues, requirements and needs – inputs for co-design process (duration: M2 – M12)
- WP3: Development of context-specific multi-sensorial mining machinery operator aid system (duration: M10 – M20)
- WP4: Smart, Ergonomic and Sustainable Mining Machinery Workplaces System development (duration: M18 – M24)
- WP5: Dissemination activities and stakeholders' collaboration (duration: M1 – M24).

All work packages are consisted of different phases and activities.

2 Literature Review

According to Hollnagel et al. (2006), resilience is the inherent ability of a system to alter how it operates prior to, during, and after a disruption in order to continue working under both predicted and unforeseen circumstances.

Organizational resilience in industrial processes is a critical aspect of ensuring a company's ability to withstand and recover from disruptions, whether they are related to workplace safety disruptions, natural disasters, supply chain issues, or other unexpected events (Bento et al., 2021; McCarthy et al., 2017). Nonetheless, results from a previous study of resilience in the business and organizational setting indicate that, despite a rise in empirical research on the topic, further clarification regarding its measurement is still required (Hillman & Guenther, 2021).

A resilience approach is currently preferred in the contemporary research, due to the limits of risk formulations, but the measurement of resilience is also a challenge (Elms et al., 2019). Provan et al. (2020) insists on the fact that organizational resilience is highly correlated with decentralization, so the attitudes of all organizational levels' employees are important, together with an adequate organizational structure for the examined context

Accordingly, organizational resilience can be defined as the ability of an organization to adapt, recover, and thrive in the face of adversity, uncertainty, and change (Jiabao et al., 2024). An inventive organizational resilience model is put forth by Bragatto et al. (2021) with the goal of enhancing capacity to handle upcoming safety crises. Also, in addition to being worn by employees, sensors may be widely dispersed around the plant and workplace (Ansaldi&Braggato, 2022). When combined with artificial intelligence, they present an excellent opportunity to enhance the dynamic and participative nature of safety management (Ansaldi&Braggato, 2022). Mc Carthy et al. (2017), Lin and Fun (2024) and Ciasullo et al. (2024) point in the direction of an eco-social understanding of organizational resilience, whose effects on the firm's sustainability should be evaluated by taking environmental sustainability into account and discuss an ecosystem's sustainability and organizational resilience.

Accordingly, one of important issues, set to be addressed at the latter stages of the project, is the assessment of the organizational resilience (RI), based on the observed safety climate factors at the workplaces in the mining companies, which include heavy machinery operators and transport and logistics workplaces. This stage of the research is crucial element in the future direction of upgrading the defined project goals.

3 Methods

The research on this project can be shortly described as organized in twofold directions:

DIRECTION 1: Direct measurement during the field work of the project participants. Our project Team members had the opportunity to visit many mines

and test our innovative solutions and perform measurements on the machines in the open pit mines in Serbia and Montenegro. The process indicators (KPIs) that are being measured are: Date and Time; Atm. Pressure [mbar]; CO₂ concentration in air [ppm]; SO₂ concentration in air [ppm]; NO₂ concentration in air [mg/m³]; SO₂ concentration in air [mg/m³]; CO concentration in air [ppm]; NO concentration in air [ppm]; NO_x concentration in air [ppm]; PM_{2.5} concentration in air [μm]; PM₁₀ concentration in air [μm] Temperature [°C]; Air Humidity [%]; Degree of Noise; Human Vibration Degree. Also, CO and CO₂ concentrations are measured on the exhaust systems of the industrial machines. The measurements are conducted using two multisensory systems. One is with the standardized measuring equipment, consisted by the commercial “off the shelf” measuring devices. The second multisensory system is constructed as the result of this project, with specially designed and programed sensors, which enables direct measurement and storing of the measured KPIs, directly in the central cloud based data base.

DIRECTION 2: Data collection using questionnaire to assess mining machinery operators’ opinion on the workplace ergonomics factors, combined with the data collection using questionnaire to assess operators and management opinion on safety climate, organizational factors and sustainability performance - to be used for organizational resilience assessment. Both questionnaires are used as the paper forms, as well as the online survey forms, using the Google Forms. Collected responses are transferred directly to the central database, located on the Google platform of the project.

Based on the collected data, organizational resilience is assessed, and measured, based on the data collection and analysis model, presented in the Figure 1.

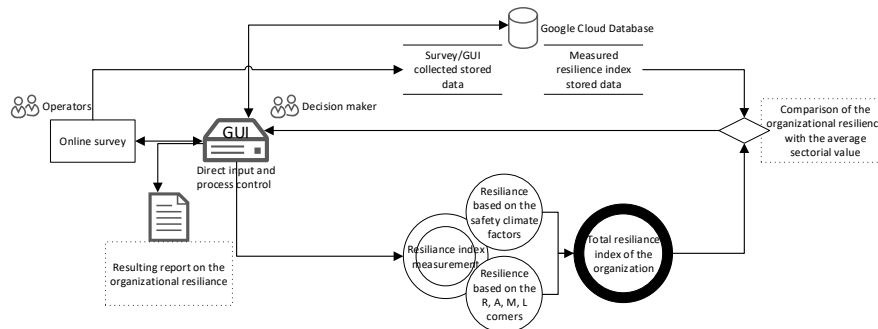


Figure 1. Research Model of the SmartMiner Resilience Index assessment (Mihajlovic et al., 2023)

The survey used for the data collection is consisted of six parts: 1st part of the survey is collecting the demographic data about respondents, such are: Age, Years of working experience, Qualifications, Position in the organization, Previous experience with injuries at work, ... 2nd part of the survey included the questions about the organization: Number of employees, The age of the company, The

industrial area of operations, 3rd part of the survey is dealing with technical factors of the working places. Two subgroups of technical factors were analyzed: workplace equipment and the working environment conditions. 4th part of the survey is dealing with investigation of human factors, classified in three subgroups: Knowledge about workplace safety, Employees motivation regarding the workplace safety issues, accepting the regulations on workplace safety. 5th part of the survey is dealing with organizational factors and was segmented in 8 subgroups of questions: Organizational support, Co-workers support, Superiors support, Employees engagement, Work safety training, Superiors dedication, Regulations and procedures on workplace safety, Employees encouragement towards workplace safety. 6th part of the survey is dealing with sustainability issues of the organization, including Economic, Environmental, Social, Stakeholder and Voluntariness dimensions (Alsharif et al., 2024). Also, organizational growth and profitability, financial indicators and organizational performances were in this segment. Each of those subgroups consisted of 3 to 11 questions, making the total number of 71 questions in the survey.

Obtained results of the survey are located directly in the Google cloud database. Developed application is analyzing the data and calculating the organizational resilience index (RI) of the respondents' workplaces. It is storing obtained RI values and calculating the average values. Subsequently, it enables comparison of the calculated RI of the individual workplaces, or the individual organization, with the industrial average. Based on this cooperation, the application, in its final form, will be able to create adequate advices for the decision makers and the operators.

3 Results and Discussion

Using the questionnaire form, until now, 447 responses are collected from the operators and 178 from managers at different organizational levels. Processing the collected responses and calculation of the resulting RI are described in details in the reference (Alsharif et al., 2024). Calculation of the RI is based on the SMART method (Zhang 2014). SMART method requires that the response rate each of the 71 questions of the questionnaire twice. First rating is considering their assessment of the present values, while the second rating is considering the importance of each of the question in the survey. Based on obtained importance ratings, the application is calculating the SMART utilities of each of the questions, and then, the resilience index value.

To be able to assess the organizational resilience in enough details, it was calculated separately for eleven safety areas: safety awareness, safety communication, organizational environment, management support, risk assessment, safety measures and prevention, safety training, safety policy, safety procedures, job satisfaction and safety performances. Each of the questions are

located in one of the named safety groups. Besides such classification, the questions are classified at the same time in four resilience corners, as described in the methodology of Bragatto et al. (2021). The four resilience corners considered are: Anticipate - A, Monitor - M, React – R and Learn – L. Besides this partial RI, the application is calculating the overall organizational RI and storing it in the central database. Based on all collected questionnaire responses, overall RI values, for the investigated organizations in the mining sector in Serbia and Montenegro, are presented in Table 1.

		Top level managers	Middle level managers	First level managers	Transport and mining machines operators	Other workers
	Total Reliance Index	4.3	3.4	3.7	3.8	3.7
Safety Areas		Partial Resilience Index				
	Work equipment	4.5	3.7	4.4	4.5	4.3
	Working environment conditions	3.9	3.7	4.4	4.5	4.3
	Knowledge of occupational safety	4.3	3.4	4.1	4.0	3.9
	Employee motivation regarding safety and health at work	4.4	3.3	2.8	2.9	3.2
	Organizational support	4.2	3.3	3.3	3.5	3.3
	Associate support	3.9	3.3	2.8	3.0	2.8
	Support from superiors	4.5	3.7	3.8	3.9	3.8
	Employee engagement	4.4	3.0	4.6	4.3	4.2
	Trainings related to safety and health at work	4.0	3.5	3.9	3.6	3.6
	Management commitment	4.5	3.5	4.0	3.8	3.8

	Rules and procedures on safety and health at work (with important indication that only for this factor 1 would be the best and 5 the worst case)	3.3	3.2	3.7	3.9	3.7
	Encouraging employees to improve safety at work	4.3	3.6	3.5	3.7	3.4
Organizational indicators rated only by the top management structures	Economic, environmental, social, stakeholder and voluntary dimensions	4.2	/	/	/	/
	Organizational performance	4.2	/	/	/	/
	Organizational growth and business profitability	4.2	/	/	/	/
	Financial indicators of business	3.9	/	/	/	/
Resilience Corners	Anticipate	4.25	3.4	3.7	3.8	3.6
	Monitoring	2.85	3.2	4.0	3.8	3.9
	React	4.62	3.4	3.8	3.9	3.7
	Learn	4.36	3.6	3.5	3.7	3.4

Table 1. Calculated values of the Resilience Indexes based on all collected survey responses

Results presented in Table 1 are the values of the resilience indexes, calculated for the employees at the different organizational positions (including top, middle, lower level managers, operators and support workers), and considering all analyzed safety and organizational groups of factors. Those values represent the average values, obtained for all investigated organizations in the mining industrial sector.

The final form of the RI calculating application, will include the comparison with such overall RI values with the RI values calculated for the individual organization. This comparison will be the base for generating adequate advices form the decision makers and operators. Generation of the advices will be facilitated using the artificial intelligence (AI) chat – bot. AI is a technology that enables machines to mimic human intelligence and perform tasks such as learning, reasoning, and problem-solving. AI ChatBot is a program that uses artificial intelligence to simulate human conversation and assist users by providing information or performing tasks. This concept was tested on one organization, in which 15 decision makers were asked to complete the survey, and based on their responses RI of that organization was calculated. Based on their response, following query for the AI ChatBot was formed:

“Organizational resilience was calculated for the organization, based on the Four Corners principle. The four resilience corners considered are: Anticipate, Monitor, React and Learn. These corners must be viewed as capabilities, i.e., Anticipate (A) as the ability to deal with potential circumstances, e.g. to prevent hazards and adapt to changes, Monitor (M) as the ability to deal with the critical circumstances, e.g. to control system performance and the ability to identify potential weaknesses, React (R) as the ability to deal with the actual situation, e.g. to quickly respond to changes and avoid major damage, and Learn (L) as the ability to deal with the factual situation, e.g. to learn from previous events with the aim of increasing the level of safety.”

“Besides those corners, the resilience of the organizations are also assessed based on following Safety and organizational areas: Work equipment; Working environment conditions; Knowledge of occupational safety; Employee motivation regarding safety and health at work; Organizational support; Associate support; Support from superiors; Employee engagement; Trainings related to safety and health at work; Management commitment; Rules and procedures on safety and health at work; Encouraging employees to improve safety at work; Economic, environmental, social, stakeholder and voluntary dimensions; Organizational performance; Organizational growth and business profitability; Financial indicators of business.”

“For investigated organization, total resilience index – obtained based on the Top Managers assessment was 4,3. Partial resilience indexes, from the four corners perspective were: 4,25 for the A corner, 2,85 for the M corner, 4,62 for the R and 4,36 for the L corner. Also, from the aspect of Safety and organizational areas, following partial resilience indexes were calculated: 4,5 for the Work equipment; 3,9 for the Working environment conditions; 4,3 for the Knowledge of occupational safety; 4,4 for the Employee motivation regarding safety and health at work; 4,2 for the Organizational support; 3,9 for the Associate support; 4,5 for the Support from superiors; 4,4 for the Employee engagement; 4,0 for the Trainings related to safety and health at work; 4,5 for the Management

commitment; 3.3 for the Rules and procedures on safety and health at work (with important indication that only for this factor 1 would be the best and 5 the worst case); 4.3 for the Encouraging employees to improve safety at work; 4.2 for the Economic, environmental, social, stakeholder and voluntary dimensions; 4.2 for the Organizational performance; 4.2 for the Organizational growth and business profitability; 3.9 for the Financial indicators of business.”

”This was compared with the average organizational resilience, calculated for collected responses of large number of Top Managers, from the organizations in same and similar industry. Obtained average values were: total resilience index – obtained based on the Top Managers assessment was 4,4. Partial resilience indexes, from the four corners perspective were: 4,46 for the A corner, 3,04 for the M corner, 4,62 for the R corner and 4,46 for the L corner. Also, from the aspect of Safety and organizational areas, following partial resilience indexes were calculated: 4.5 for the Work equipment; 4.1 for the Working environment conditions; 4.6 for the Knowledge of occupational safety; 4.6 for the Employee motivation regarding safety and health at work; 4.4 for the Organizational support; 4.5 for the Associate support; 4.6 for the Support from superiors; 4.4 for the Employee engagement; 4.3 for the Trainings related to safety and health at work; 4.6 for the Management commitment; 2.6 for the Rules and procedures on safety and health at work (with important indication that only for this factor 1 would be the best and 5 the worst case); 4.2 for the Encouraging employees to improve safety at work; 4.4 for the Economic, environmental, social, stakeholder and voluntary dimensions; 4.2 for the Organizational performance; 4.2 for the Organizational growth and business profitability; 4.1 for the Financial indicators of business.”

The questions that were asked to the AI ChatBot, at the end of the query, were:

- What should be the list of advices, which should be given to the investigated organization, based on obtained comparisons?
- The list of advices should include obtained value for total organizational index and all partial indexes, compared to average values.
- The advices should be with adequate detailing.

Bases on such queries, the AI has generated following advices:

Based on the comparison between the investigated organization's resilience indexes and the industry average, here are some tailored suggestions for improvement:

Total Organizational Resilience Index:

Investigated Organization: 4.3

Industry Average: 4.4

Advice: While the organization's overall resilience index is slightly below the industry average, it's important to continue efforts in enhancing resilience capabilities across all areas to close this gap. Focus on areas with notable disparities to align more closely with industry standards.

Partial Resilience Indexes (Four Corners Perspective):

Anticipate (A) Corner:

Investigated Organization: 4.25

Industry Average: 4.46

Advice: Enhance anticipation capabilities by investing in proactive measures such as scenario planning, trend analysis, and risk assessments to better prepare for potential hazards and adapt to changes effectively.

Monitor (M) Corner:

Investigated Organization: 2.85

Industry Average: 3.04

Advice: Strengthen monitoring systems and processes to improve control over system performance and identify potential weaknesses in real-time. Consider adopting advanced monitoring technologies or enhancing existing monitoring processes.

React (R) Corner:

Investigated Organization: 4.62

Industry Average: 4.62

Advice: Maintain the current level of responsiveness in reacting to actual situations. Continuously seek opportunities for improvement to ensure quick and effective responses to changes, minimizing damage and maximizing adaptability.

Learn (L) Corner:

Investigated Organization: 4.36

Industry Average: 4.46

Advice: Foster a culture of continuous learning and improvement to further enhance the organization's ability to learn from previous events. Implement robust post-event analysis processes and knowledge-sharing initiatives to capitalize on lessons learned.

Partial Resilience Indexes (Safety and Organizational Areas):

Work Equipment:

Investigated Organization: 4.5

Industry Average: 4.5

Advice: Maintain the current standard of maintaining safe work equipment. Regularly assess equipment performance and safety standards to ensure compliance with regulations and industry best practices.

Working Environment Conditions:

Investigated Organization: 3.9

Industry Average: 4.1

Advice: Focus on improving working environment conditions to ensure optimal health and safety for employees. Address factors such as ergonomic design, air quality, and noise levels to enhance overall workplace safety and well-being.

Knowledge of Occupational Safety:

Investigated Organization: 4.3

Industry Average: 4.6

Advice: Increase efforts to improve knowledge and awareness of occupational safety practices within the organization. Provide regular training and educational opportunities to ensure employees are well-informed and compliant with safety protocols.

Partial Resilience Indexes (Safety and Organizational Areas):

Employee Motivation Regarding Safety and Health at Work:

Investigated Organization: 4.4

Industry Average: 4.6

Advice: Sustain and enhance employee motivation regarding safety and health initiatives through continued engagement, recognition, and communication. Foster a culture where safety is prioritized and celebrated.

Organizational Support:

Investigated Organization: 4.2

Industry Average: 4.4

Advice: Strengthen organizational support mechanisms to empower employees in promoting safety. Provide resources, training, and encouragement to facilitate a collaborative approach to safety management.

Associate Support:

Investigated Organization: 3.9

Industry Average: 4.5

Advice: Increase efforts to provide adequate support to associates, fostering a culture of mutual assistance and collaboration. Encourage open communication channels and peer support networks to address safety concerns effectively.

Partial Resilience Indexes (Safety and Organizational Areas):

Support from Superiors:

Investigated Organization: 4.5

Industry Average: 4.6

Advice: Maintain strong support from superiors in driving safety initiatives within the organization. Ensure leaders actively demonstrate commitment to safety through their actions and decisions.

Employee Engagement:

Investigated Organization: 4.4

Industry Average: 4.4

Advice: Continue efforts to sustain and enhance employee engagement in safety initiatives. Involve employees in decision-making processes, solicit feedback, and recognize contributions to safety improvements.

Trainings Related to Safety and Health at Work:

Investigated Organization: 4.0

Industry Average: 4.3

Advice: Increase investment in training programs to further enhance safety awareness and skills among employees. Offer a variety of training formats and topics to cater to diverse learning needs and preferences.

Management Commitment:

Investigated Organization: 4.5

Industry Average: 4.6

Advice: Maintain strong commitment from management in prioritizing safety and health initiatives. Ensure leaders actively participate in safety initiatives, provide resources, and set clear expectations for safety performance.

Partial Resilience Indexes (Safety and Organizational Areas):

Rules and Procedures on Safety and Health at Work:

Investigated Organization: 3.3

Industry Average: 2.6

Advice: Review and refine existing rules and procedures to ensure alignment with best practices and regulatory requirements. Streamline processes, clarify expectations, and provide training to ensure compliance and consistency.

Encouraging Employees to Improve Safety at Work:

Investigated Organization: 4.3

Industry Average: 4.2

Advice: Continue to effectively encourage employees to participate in safety improvement initiatives. Recognize and reward proactive safety behaviors, and provide opportunities for employee input and involvement in safety initiatives.

Economic, Environmental, Social, Stakeholder, and Voluntary Dimensions:

Investigated Organization: 4.2

Industry Average: 4.4

Advice: Maintain balanced consideration of various dimensions in safety and organizational practices. Continue to assess and address economic, environmental, social, stakeholder, and voluntary factors to ensure sustainable and resilient operations.

Partial Resilience Indexes (Safety and Organizational Areas):

Organizational Performance, Growth, and Profitability:

Investigated Organization: 4.2

Industry Average: 4.2

Advice: Ensure organizational performance and growth align with safety and resilience objectives. Regularly evaluate performance metrics and adjust strategies as needed to promote long-term sustainability and profitability.

Financial Indicators of Business:

Investigated Organization: 3.9

Industry Average: 4.1

Advice: Pay closer attention to financial indicators in the context of safety and resilience. Identify opportunities for cost-effective safety investments and demonstrate the value of safety initiatives in enhancing organizational performance and profitability.

Conclusions

It should be remembered that measuring resilience is complex operation, as it involves capturing both individual and contextual factors. The choice of resilience framework and survey design has to align with our specific research and programmatic goals. Additionally, but not less important, ethical considerations, such as ensuring participant consent and data privacy, were and still are crucial throughout the survey process.

In this research, combined method was used to collect both the real – physical environment indicators in the mining machinery workplaces, using the multisensory system. For the same workplaces, the employees at different organizational level were asked to assess the workplace condition using the predefined questionnaire.

Obtained results were used to calculate the resilience index of the investigated organizations. Obtained results of individual organizations were compared with the industry averages and accordingly, adequate advices for the decision makers were generated. Generation of the advices was facilitated using the AI ChatBot, as contemporary tool.

It should be noted, that the process of the ChatBot training is still at the initial level, so the advices are still in generalized form. The precision of advices will increase with time and with additional training of the tool. Accordingly, the requirements for the detailed queries will decrease, considering that trained ChatBot will have all previous queries stored, analyzed and learned.

This will be the subject of our further research in this project, as well as, fine tuning of obtained results, based on obtained results of physical KPI measurements on the analyzed work places.

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Measuring Reliability and Validity of Operator - Mining Machine System's Characteristics

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Abstract: Mining is widely recognized as a high-risk industry with elevated accident rates, yet the ergonomics and safety issues of machinery in open-pit mining operations remain underexplored in previous research. Therefore, this paper aims to examine the reliability and validity of the characteristics of operator-mining machine systems, based on a questionnaire survey conducted among operators in several Serbian open-pit mining companies. Descriptive statistics were first applied to analyse operators' and machines' characteristics. Reliability analysis using Cronbach's Alpha identified and eliminated three questions that did not meet acceptable thresholds. Factor analysis was performed to assess construct validity, and after analysis, one questionnaire item has been removed. The final set of questions was grouped into four groups, each containing one or two components, establishing the instrument's reliability and validity. This research contributes to the understanding of ergonomic characteristics of operator-mining machine systems and shows that factors such as seat adjustability characteristics, armrests adjustability, vibrations in the cabin, and hand- and foot-operated controls are significant in providing a foundation for improving workplace conditions in open-pit mining environments. These results lay the groundwork for future research, such as regression analysis and/or confirmatory factor analysis, or further studies with larger samples.

Keywords: working conditions; mining machinery; operators; reliability and factor analysis

1 Introduction

Safety is one of the most current topics of today's research in the field of risk assessment and it is a legal requirement of mining industry (Matloob et al., 2021; Bluf et al, 2014), Although mining is well known as a high-risk industry with high accident rates, in the scientific literature, the safety of mining machinery of open mining pits is not sufficiently covered (Noraishah Ismail et al., 2021; Duarte et al., 2021; Qiu et al., 2021). Risky behavior, risky conditions, and unsafe factors make the mining industry unsafe (Fu et al., 2020; Deng et al., 2024). Due to its complicated workflow, mining is considered the most dangerous mechanism (Matloob et al., 2021), and in that sense mechanical failure was identified as the main cause of mining accidents (Noraishah Ismail et al., 2021). Previous studies suggests that accidents and/or incidents involving heavy machinery are unanticipated and unfortunate occurrences most frequently caused by human error (Brkic et al., 2024). According to earlier studies, the vast majority of these incidents are caused by the operator's behavior (Papic et al., 2024).

A human-machine system is a composite system that consists of both humans and machines collaborating in order to monitor and control an environment for a common goal, while the primary aim of ergonomics is to improve human operations and overall performance, so proper integration helps achieve this goal (Ling et al., 2024). Operator and mining machine represent complex system, which deserves special attention due to the fact that risks there are mainly caused by operator behavior and interaction with mining machine (Papic et al., 2024; Spasojevic Brkic et al., 2023).

Some authors (Bogdanović et al., 2016) have already studied the working conditions of mining operators, and ranked the jobs of operators, focusing on the influence of the working environment, and came to the conclusion that the worst working conditions among mining operators are those who operate excavators. Heavy mobile machinery cabs and their equipment are still not well adjusted to operators, so it is not surprising that we are still witnessing huge consequences of accidents at sites where they operate (Spasojević Brkić et al., 2023). Many procedures in the development process of cabins today are still based on the specific experience of manufacturers and historical guidelines. It is not surprising that they fail to meet the needs of a large proportion of operators (Spasojević Brkić et al., 2015). The ergonomic inadequacy of workplaces in the cabs of operators of mining machines can lead to numerous consequences (Horberry et al, 2013; Horberry et al, 2016). Horberry et al. (2013, 2016) acknowledge the importance of participatory ergonomics in enhancing the design of mining

equipment, the role that human factors and ergonomics play in minimizing risks in the mining industry, and the significance of these concepts in creating emergency response management systems. Poor visibility, limited room in the cabin, excessive forces required operating levers/pedals and improper seat designs are some of the characteristics of a poorly designed cab (Spasojević Brkić et al., 2015). If not controlled, awkward posture of any body part can result in increased risk of fatigue, pain or injury (Kittusamy, 2003). Utilizing manikins and RAMSIS ergonomic modeling software, Mansfeld et al. (2022) evaluated a variety of excavator actions, including driving, digging, touch screen and control use, in order to analyze comfort, reachability, and visibility in excavator cab design for each operator type. Also, Spasojevic Brkic et al. (2024) proved that prove that mining machines have better ergonomics characteristics of the chair, hand-operated controls and less vision field issues in comparison to transport machines.

Occupational health and safety in mining has clearly improved over the past twenty years, influencing improved working conditions, but accidents and illness still occur with unacceptable frequency (Boudreau-Trudel et al., 2014). Operators of construction and mining equipment perform various duties at work that expose them to a variety of risk factors that may lead to health problems. A few of the health hazards among operators of construction equipment are: (a) whole-body vibration, (b) awkward postural requirements (including static sitting), (c) dust, (d) noise, (e) temperature extremes, and (f) shift work (Kittusamy & Buchholz, 2004).

Some of insufficiently adjusted working conditions in operator and mining machine complex system, were investigated in this paper, with the aim of determining the dependence between the characteristics of the operators of certain types of mining machines and their attitudes regarding the working conditions. Namely, the aim of this research is to investigate reliability and validity of ergonomic characteristics of workplaces on bulldozer, drill rig, dump truck, excavator and wheel loader, using data obtained by questionnaire survey of machine operators in aim to come closer to optimization of operator- mining machine complex system.

2 Research methodology

In previous researches, we investigated the evaluation of working conditions of mining machine operators by a survey questionnaire (Spasojević Brkić et al., 2023, 2024). The data was collected using a survey questionnaire proposed by Spasojević Brkić et al. (2023, 2024) during 2023 in several Serbian open mining pit companies. Questions were rated by marks from 1 to 5, where 1 represents the worst answer and grade 5 is the best. The following questions were used for analysis in this paper:

1. Is the seat height adjustable?
2. Can the seat be adjusted horizontally?
3. Is the seat set at the appropriate height?
4. Does the seat have back support?
5. Does the seat have lumbar support?
6. Does the seat have armrests?
7. Are the armrests adjustable?
8. Are the armrests placed at the appropriate height?
9. I don't feel vibrations through the seats.
10. I don't feel vibrations from the equipment through the floor.
11. I don't feel vibrations from the equipment through the controls.
12. Is the seat firmly attached to the cabin floor?
13. Can the seat be reclined?
14. Can the seat rotate?
15. Can the location of the controls or handles be adjusted?
16. Can you easily reach controls or handles?
17. Can you easily operate controls or handles?
18. Can you easily reach the pedal?
19. Can you use the pedal easily?

In addition to questions about working conditions, this survey included questions related to the respondents themselves, namely to their age, height (H), weight (W), work experience (WE) and machine age (MA).

3 Experimental research

This survey was answered by operators of various types of mining machines - bulldozer, drill rig, dump truck, excavator, and wheel loader, a total of 63 of them (N).

After that, descriptive statistics were conducted on the obtained sample, that is Mean, Median (Med), Minimum (Min), Maximum (Max), Range (R), Standard Deviation (σ) and Coefficient of Variation (CV) for all Variables (V) which is shown in table 1.

V	N	Mean	Med	Min	Max	R	σ	CV
A	63	35,031	35,000	19,000	54,000	35,000	8,782	25,069
H	63	179,095	180,000	166,000	188,000	22,000	5,534	3,090
W	63	90,000	90,000	60,000	150,000	90,000	16,796	18,663
WE	63	11,079	10,000	1,000	38,000	37,000	9,762	88,111
MA	63	5,666	4,000	1,000	13,000	12,000	3,959	69,873
Q1	63	3,936	4,000	1,000	5,000	4,000	1,162	29,524
Q2	63	3,968	4,000	1,000	5,000	4,000	1,217	30,686
Q3	63	4,047	4,000	1,000	5,000	4,000	1,084	26,781
Q4	63	3,857	4,000	1,000	5,000	4,000	1,229	31,874
Q5	63	2,714	2,000	1,000	5,000	4,000	1,549	57,086
Q6	63	2,587	1,000	1,000	5,000	4,000	1,783	68,942
Q7	63	2,619	1,000	1,000	5,000	4,000	1,887	72,063
Q8	63	2,619	1,000	1,000	5,000	4,000	1,808	69,064
Q9	63	3,428	4,000	1,000	5,000	4,000	1,488	43,423
Q10	63	2,428	2,000	1,000	5,000	4,000	1,376	56,668
Q11	63	2,619	2,000	1,000	5,000	4,000	1,539	58,763
Q12	63	3,777	4,000	1,000	5,000	4,000	1,313	34,756
Q13	63	3,952	4,000	1,000	5,000	4,000	1,236	31,295
Q14	63	1,349	1,000	1,000	5,000	4,000	0,986	73,105
Q15	63	3,317	4,000	1,000	5,000	4,000	1,532	46,201
Q16	63	4,254	5,000	1,000	5,000	4,000	0,999	23,495
Q17	63	4,301	5,000	2,000	5,000	3,000	0,873	20,298
Q18	63	4,301	5,000	1,000	5,000	4,000	1,087	25,271
Q19	63	4,174	5,000	1,000	5,000	4,000	1,115	26,709

Table 1. Descriptive statistics of obtained sample

After the descriptive statistics, all the questions are grouped, based on what kind of adaptation of working conditions they refer to. Formed groups of questions are as follows:

- Group 1 (questions related to the adjustability of the seat): Initial questions 1, 2, 3, 4, 5, 12, 13 and 14.
- Group 2 (questions related to armrest adjustability): Initial questions 6, 7 and 8.
- Group 3 (questions related to vibrations): Initial questions 9, 10 and 11.
- Group 4 (questions relating to hand and foot operated controls): Initial questions 15, 16, 17, 18 and 19.

On these groups of questions, a reliability analysis was performed, for ensuring the accuracy of the research. Reliability is estimated by Cronbach Alpha Value that is more than 0.7, as it is suggested in (Hair et al., 1986). Results of the reliability analysis are shown in Table 2.

Groups of questions	Number of items		Cronbach Alpha Values
	Initial	Final	
Group 1	8	7	0.739
Group 2	3	3	0.970
Group 3	3	2	0.738
Group 4	5	4	0.747

Table 2. Reliability analysis of groups of questions

The reliability analysis conducted on the data groups yielded the following data:

For group 1, which contained 8 questions, and had a Cronbach Alpha value of 0.739 one question was singled out, namely question 14. Group 2 remained unchanged in structure, that is, no question was singled out from this group, and the Cronbach Alpha value was 0.970. When it comes to group 3, before the reliability analysis it contained 3 questions, while after the analysis, question 9 was singled out, with a Cronbach Alpha value of 0.738. With group 4, which has a Cronbach Alpha value of 0.747, one question, 15, was singled out, so that before the analysis it contained 5 questions, and after the analysis 4 questions. Questions were singled out from these groups because of insufficient reliability, calculated based on Cronbach Alpha values.

After the reliability analysis, a factor analysis was conducted on the sample, which aims to determine the groups of factors to which the questions from the survey belong. All questions participated in this analysis, except for those that the reliability analysis eliminated, due to insufficient reliability. Considering the size of the sample, which in this case is 63, because such a large number of operators participated in the survey, the threshold value of Factor Loading, as stated in (Hair et al., 1986) is 0.65, so those questions with a lower value are removed from sample. Factor analysis was performed by using Varimax with Kaiser Normalization rotation method and Principal Component Analysis as extraction method. The results of the factor analysis, that is, Rotated Component Matrix of the seat related questions is shown in table 3.

	Component	
Q1	0,365	0,675
Q2	0,767	0,311
Q3	0,555	0,661
Q4	0,824	0,069
Q5	0,677	0,073
Q12	0,233	0,617
Q13	-0,360	0,740

Table 3. Rotated Component Matrix of Group 1

In the Table 3, we can see that the Group 1 which included questions 1, 2, 3, 4, 5, 12 and 13, with question 12 being singled out due to insufficient value of Factor Loading, which is below 0.65, were divided into two components, the first one concerning horizontal adjustment seat and back adjustment (questions 2, 4 and 5), and the other seat height adjustment (1, 3 and 13). Table 4 shows Component Matrix of Group 2 question.

	Component
Q6	0,986
Q7	0,975
Q8	0,955

Table 4. Component Matrix of Group 2

Group 2, without eliminated questions, contains 3 questions, namely questions 6, 7 and 8. All questions belong to one component, and they are in relation to armrests of the seats. Component Matrix of Group 3 is shown in table 5.

	Component
Q10	0,891
Q11	0,891

Table 5. Component Matrix of Group 3

Analysis of Group 3 shows that questions 10 and 11 can be consider as one component. These questions are questions about vibrations operators feel in cabin. Finally, Table 6 shows Rotated Component Matrix of the Group 4.

	Component	
Q16	0,074	0,944
Q17	0,166	0,927
Q18	0,966	0,065
Q19	0,947	0,182

Table 6. Rotated Component Matrix of Group 4

Through the analysis of Group 4, we can see that it contains 4 questions, which belong to two components. The first component includes questions 16 and 17, which concern manual, hand-operated controls, and the second includes questions 18 and 19, which concern foot-operated controls, i.e. pedals.

Conclusions

Mining is widely recognized as one of the most hazardous industrial sectors; however, issues related to working conditions in this field remain insufficiently explored in the literature. The aim of this research is to come closer to optimization of operator- mining machine complex system and investigate reliability and validity of ergonomic characteristics of workplaces on bulldozer, drill rig, dump truck, excavator and wheel loader, using data obtained by questionnaire survey of machine operators.

The research utilized 19 questions from a survey administered to operators of mining machines in Serbian mining companies. The initial phase involved descriptive statistics of the collected data. Subsequently, a reliability analysis was conducted to assess the accuracy of the research findings. The survey questions were categorized into four groups, for which Cronbach's Alpha values were computed, leading to the elimination of certain questions within these groups.

The remaining questions were subjected to factor analysis, which resulted in the identification of four distinct groups of factors. Group 1, that is seat related, is divided in two different factors, one about horizontal seat characteristics, and other factor with vertical seat characteristics. Secondly, Group 2 forms one factor, related to armrests. Group 3, also forms one factor related to cabin vibrations. Finally Group 4 is divided in two factors, one that contains hand-operated control and other that is foot-operated control.

This shows that the issues contained in these factors can be viewed as one variable, instead of individually, which will significantly simplify the model during further regression analysis or structural equation modelling (SEM).

For future research, it is recommended to increase the sample size by analysing a larger number of survey responses. Also, additional anthropometric data analysis of operators in order to improve ergonomics conditions can be conducted.

Acknowledgement

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Artificial intelligence as an innovative tool for e-commerce

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Abstract: In my article, I conducted an in-depth review of the e-commerce process based on extensive literature research. This review explores the most significant applications of artificial intelligence (AI) in e-commerce as identified in existing studies, shedding light on how AI technologies are currently transforming key aspects such as personalized customer experiences, inventory management, fraud detection, and supply chain optimization.

Additionally, I examined the potential new and innovative uses of AI that are still emerging within the e-commerce sector, including advancements like hyper-personalization through machine learning, AI-powered chatbots for customer service, and the automation of product recommendations using deep learning algorithms.

Furthermore, I discuss the possibilities for AI integration in the near future, focusing on emerging trends such as the use of AI for visual search, voice-activated shopping, and even predictive analytics for anticipating consumer behavior. In conclusion, I assert that having a deep understanding of AI and its applications is essential for anyone involved in e-commerce.

The ability to harness AI tools effectively is no longer a luxury but a necessity in staying competitive in a rapidly evolving digital marketplace. Mastery of AI will empower businesses to optimize their operations, enhance customer experiences, and drive innovation, while also addressing the risks and challenges that accompany the adoption of these transformative technologies.

Keywords: e-commerce; IT security; AI applications in e-commerce

1 Definition of E-commerce?

The definition of e-commerce may vary according to different authors and researchers;

Kalakota and Robinson (2001) Kalakota and Robinson describe e-commerce as business transactions that take place over digital networks, including the Internet,

intranet and extranet. They relate e-commerce not only to buying and selling but also to other forms of electronic communication (e.g. information sharing, marketing and customer service). They define e-commerce as a new way of doing business, a transformation of business models.

Laudon and Traver (2018) Laudon and Traver describe e-commerce as a set of commercial transactions over the Internet and view it as the exchange of information through digital platforms for the sale, purchase and promotion of products and services. In their definition, e-commerce includes B2B (business-to-business), B2C (business-to-consumer) and C2C (consumer-to-consumer) business types and emphasises the integration of e-commerce with traditional business models.

As a conclusion, the basic concepts are roughly the same: e-commerce is the electronic exchange of goods, services and information via the internet or other digital platforms.

2 Case studies of AI usage in E-commerce

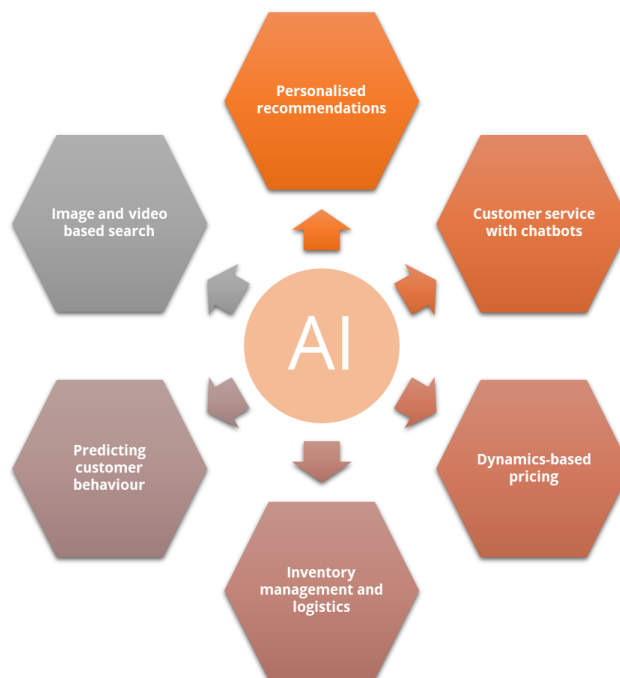


Figure 1. Most important AI usecases in E-commerce based on the literature review

Personalised recommendations

AI-based recommender systems can understand users' preferences and shopping habits and offer recommendations based on them. Machine learning and deep learning algorithms analyse customer data, such as browsing history, purchase history or search patterns, to recommend products that match the customer's interests. This improves the customer experience and increases conversion rates. (Khusro et al. 2016, Vanneschi et al. 2018)

Customer service with chatbots

AI chatbots can automatically answer customer questions, providing 24/7 customer service. Using natural language processing (NLP), chatbots can interpret and respond to language elements used by customers, providing answers to common questions or guidance during the purchase process. Chatbots can also assist live agents when more complex questions arise. (Brawn et al 2024, Paliwal et al 2019)

Dynamics-based pricing

AI can also be used to optimise pricing. Algorithms can analyse market changes, competitor prices and customer demand in real time to offer the best price for products. AI thus helps maximise revenue and profits. (Devarashetty 2023, Pallathadka et al. 2023)

Inventory management and logistics

AI can also help make inventory management and logistics more efficient. Machine learning and predictive models enable more accurate demand forecasts that help optimise inventories, reducing excessive storage costs and stock outs. AI can also help with automated warehouse operations. (Lechtenberg, Bernd , 2021)

Predicting customer behaviour

AI can predict customer behaviour, such as which products they will buy, when, and at what price. By analysing customer data and behaviour patterns, machine learning algorithms enable e-tailers to develop personalised marketing strategies. (Huang, Rust, 2021, Zhao et al. 2019)

Image and video based search

Artificial intelligence is also capable of using image analysis and video recognition technologies, allowing shoppers to search using images or videos of

products. This not only improves the customer experience, but also helps them find products faster. (He, Sun 2015, Dragan et al. 2023)

Conclusions

Artificial intelligence applications are fundamentally transforming the way e-commerce works, improving the customer experience, increasing efficiency and helping to optimise business decisions. AI technologies such as machine learning, natural language processing, and image recognition all contribute to personalised services and faster, more accurate operations.

However, the use of AI tools also raises financial and information security concerns, affecting the security of supply chains, operational and strategic levels of the company.

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Empowering or Misleading? The Influence of Social Media Use and Misinformation on Rural Development Perceptions

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Abstract: In the face of an evolving media landscape and the potential for digital platforms to foster rural growth, it is crucial to understand how social media use interacts with trust in information to influence community engagement and development outcomes. This research explores the role of social media in shaping perceptions of rural development in Albania, with a particular focus on the challenges posed by misinformation and the importance of media credibility. We interviewed one hundred fifty respondents from rural areas about their media usage and the perceived role of social media in rural development. The findings from the moderation model show that while the frequency of social media use alone does not significantly affect perceptions, misinformation reduces social media's perceived utility in promoting rural development. However, frequent users show resilience to misinformation, suggesting that digital literacy may mitigate its adverse effects. These insights underscore the need for targeted digital literacy programs to enhance trust and leverage social media for rural development in areas with high rural exodus.

Keywords: social media use, rural development, misinformation, digital literacy, Albania

1 Introduction

The evolving media landscape presents a significant opportunity for countries like Albania, which have undergone rapid urbanization and substantial rural depopulation (Kokkali, 2024). This shift allows social media to play a unique role in fostering rural development in regions facing rural exodus, underscoring the urgent need for institutional support to aid in rural revitalisation. In this context, understanding rural communities' perceptions of media's impact on development is essential to exploring pathways for sustained rural advancement. The diffusion of innovations theory Rogers, (1995) suggests that social media can serve as a bridge, increasing access to information that encourages community cohesion and supports local initiatives, vital in areas experiencing population loss. Additionally, as Hoffman et al. (2009) indicate, the Uses and Gratifications Theory (Katz et al., 1973) highlights how media consumption habits shape perceptions of media's utility, especially in contexts where misinformation might influence rural perspectives. Also, the social capital hypothesis in rural development suggests that marginalised rural territories with limited economic and human capital can enhance resilience by generating social capital, fostering community cohesion, shared resources, and collaborative problem-solving (R. Putnam, 2022; Wiesinger, 2007). Social media platforms play a pivotal role by connecting isolated communities, disseminating valuable information, and building networks that strengthen collective action and support local development initiatives (Granovetter, 2018; Penz et al., 2018). Trust is central to this dynamic, which serves as the foundation for meaningful interactions within social networks, ensuring the credibility of shared information and enabling the cooperation necessary for effectively leveraging social capital (Fukuyama, 2001).

In addition, trust in institutions, particularly regarding the reliability of information shared, plays a crucial role in shaping rural communities' engagement with social media as a tool for development (Bencsik et al., 2022; Kaçani et al., 2024; Kokthi, Guri, et al., 2021; Pangil & Moi Chan, 2014; Zúñiga et al., 2019). When trust in media is high, communities are more likely to perceive it as a positive driver, fostering higher engagement levels and supporting rural initiatives (Thompson, 2021). Similarly, perceptions of misinformation can significantly impact this trust, as misinformation has the potential to erode confidence in social media's credibility, thereby limiting its effectiveness as a development resource (Caled & Silva, 2022; Lewandowsky et al., 2017; Torres et al., 2018). Research indicates that when users believe information sources are credible, they are more inclined to interact with and support initiatives shared on these platforms, which can positively influence rural development outcomes (Chowdhury & Odame,

2013; Rama et al., 2022; Zúñiga et al., 2019). In this vein, building trust by addressing misinformation concerns is a key strategy to enhance the role of media in rural areas, making it a more powerful tool for promoting sustainable development and local engagement in Albania's rural regions.

This research examines the role of social media in shaping perceptions of rural development in Albania, with a particular focus on the challenges posed by misinformation and the importance of media credibility. Given the evolving media landscape and the potential for digital platforms to incentivise rural development, it is critical to understand how social media use interacts with trust in information to influence community engagement and development outcomes. This study suggests three key hypotheses to explore these dynamics: (1) *increased frequency of social media use leads to a more positive perception of its role in rural development (H1)*; (2) *exposure to misinformation negatively impacts perceptions of social media's developmental role (H2)*; and (3) *frequent social media users are more likely to view social media's benefits positively when misinformation is minimized (H3)*. By testing these hypotheses, the study aims to contribute to a deeper understanding of how social media can be strategically used to advance rural development while addressing the challenges associated with misinformation. The remainder of the paper is organised into sections covering the introduction, literature review, methodology, results, discussion, and conclusion and recommendations.

2 Literature Review

As digital platforms become more accessible to rural communities, the role of social media in rural development has drawn increasing academic interest (Chowdhury & Odame, 2013; Marquardt et al., 2012; Rama et al., 2022; Torres et al., 2018; Wiesinger, 2007; Zhou & Li, 2017; Zúñiga et al., 2019). This section explores key theories and empirical studies on how social media influences rural development, focusing on challenges such as misinformation. Communication for agriculture and rural development innovation involves interactive and multi-stakeholder approaches that mobilise ideas and resources from the public and private sectors and civil society (Chowdhury & Odame, 2013). Digital tools broadly referred to as Web 2.0 technologies, and in particular, social media such as Facebook, Twitter, blogs and webinars, are allegedly channels of communication for innovation (Chowdhury & Odame, 2013; Marquardt et al., 2012; Rama et al., 2022; Zhou & Li, 2017). Social media's influence on rural development is well-aligned with Rogers' Diffusion of Innovations Theory (1995), which suggests that media is critical in disseminating information and encouraging innovative practices (Ei Chew et al., 2011; Rogers, 1995). Rogers argues that

when individuals are exposed to new ideas, they are more likely to adopt practices that lead to beneficial changes, particularly in rural contexts where traditional information channels may be limited. By providing widespread access to developmental information, social media enables communities to become more informed and engaged with local initiatives (Chowdhury & Odame, 2013; Uddin et al., 2021; Utz & Muscanell, 2015; Vos et al., 2024, 2024).

Another foundational theory is the Uses and Gratifications Theory by Katz, Blumler, and Gurevitch (1973)(Katz et al., 1973). It proposes that media users actively select content that meets their needs and goals. This theory is particularly relevant in rural settings where social media is crucial for information dissemination and community engagement (Gilbert et al., 2010; Saravanan & Rajan, 2024; Vos et al., 2024). Rural residents utilise social media platforms primarily to access information about agricultural techniques, community events, and developmental opportunities (Saravanan & Rajan, 2024). As traditional media outlets have diminished in coverage, social media has emerged as a vital source of information, allowing rural populations to stay connected and informed about local issues and resources (Chowdhury & Odame, 2013; Ei Chew et al., 2011; Gillmor, 2006; Marquardt et al., 2012; Waldman, 2011). Social media fosters civic participation among rural residents, who often engage more deeply with their communities than their urban counterparts (Chowdhury & Odame, 2013; Ei Chew et al., 2011; Newman, 2009; Rama et al., 2022; Saravanan & Rajan, 2024; Thompson, 2021; Utz & Muscanell, 2015; Vos et al., 2024). This engagement is facilitated through platforms like Facebook and YouTube, which are popular among rural users for sharing experiences and mobilising community initiatives (Utz & Muscanell, 2015; Vos et al., 2024; Waldman, 2011; You & Hon, 2019, 2019; Zúñiga et al., 2019). Connecting with local organisations and leaders enhances social capital, essential for effective rural development (Uddin et al., 2021; Vos et al., 2024). In addition to information dissemination and civic participation, social media plays a crucial role in building trust and strengthening social networks, key components of social capital essential for rural development (Fukuyama, 2001)). By facilitating transparent communication and fostering collaboration among community members and local leaders, social media helps bridge social and economic resource gaps, enabling marginalised rural areas to enhance resilience and sustainable development (Uddin et al., 2021; Vos et al., 2024).

However, the challenge of misinformation is a significant barrier to realising social media's full potential in rural contexts. Tandoc et al. (2018) define misinformation as a pervasive issue on social media, characterised by the spread of unverified or deliberately misleading content. Similarly, **misinformation** refers to false or misleading information disseminated without harmful intent, whereas **fake news** denotes deliberately fabricated content designed to mislead the audience (Kim et al., 2019; Tandoc et al., 2018; Torres et al., 2018; Zúñiga et al.,

2019). Common sources of misinformation include social media platforms, unverified websites, and occasionally traditional media outlets. The rapid dissemination of information through social media amplifies false narratives, making it increasingly difficult for users to distinguish between credible and non-credible sources (Zúñiga et al., 2019). This problem is further exacerbated by social media algorithms that prioritise sensational information, often creating echo chambers that reinforce misinformation (Vosoughi et al., 2018). Misinformation and fake news are significant challenges in the digital age, particularly in shaping public perceptions of rural development in low trust societies such as Albania. Scholars show that while media can strengthen community ties and trust, misinformation can erode this trust, leading to scepticism about credible sources (Pangil & Moi Chan, 2014; Singh et al., 2024; Torres et al., 2018; You & Hon, 2019). Also, the rapid spread of false information can disrupt community cohesion and undermine efforts toward development, especially in low-trust countries such as Albania (Bencsik et al., 2022; Kaçani et al., 2024; Kokthi et al., 2023; Kokthi, Guri, et al., 2021; Kokthi, Muço, et al., 2021).

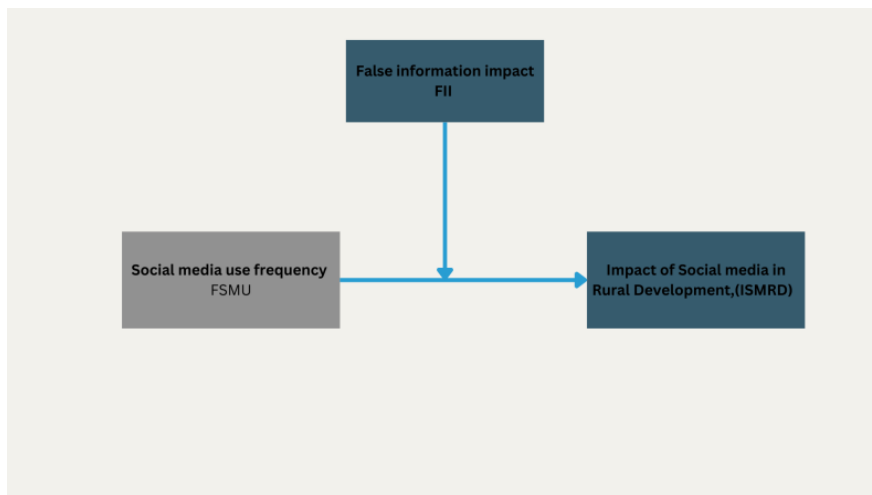


Figure 1: Conceptual Framework
Source: Authors elaboration

3 Methodology

This section describes the methodology used to assess the impact of social media on perceptions of rural development in Albania, based on the theories and empirical framework presented in the previous section. Based on the Diffusion of Innovations theory and the Uses and Gratifications Theory, our study aims to explore the relationship between the frequency of social media use and perceptions of rural development, taking into account the effect of misinformation. The main hypothesis we propose is that higher frequency of social media use is associated with more positive perceptions of rural development, with the impact of misinformation serving as a mediating factor.

3.1 Research Design and Participants

The study was conducted using a quantitative research methodology. The questionnaire was designed to elicit quantitative insights, incorporating Likert-scale questions, multiple-choice items, and open-ended questions. This approach aimed to capture participants' experiences and perspectives regarding social media's influence on rural development.

The questionnaire was distributed in key rural regions of Albania, including Fier, Berat, and Tirana. The inclusion of Fier, Berat, and Tirana in the study was chosen based on their unique characteristics representing diverse rural dynamics in Albania. Fier and Berat are traditional agricultural regions known for relying on farming and local production, making them ideal for exploring the role of social capital and information access in rural development (INSTAT, MARD)¹. While primarily urban, Tirana includes peri-urban and rural areas undergoing rapid socio-economic transitions due to urbanisation, offering valuable insights into how rural-urban linkages influence social media use and social capital formation. These areas provide a balanced perspective on rural development challenges and opportunities, reflecting Albania's traditional and transitioning rural contexts. Participants included farmers and rural residents, ensuring a diverse and representative population sample see Table 1 for more details on demographics.

¹ Albanian Institute of Statistics and Ministry of Agriculture and Rural Development

Demographics	Value	Frequency	Frequency
Gender	Female	61	37%
	Male	89	63%
Age	18-25	18	12%
	26-35	36	24%
	36-45	24	16%
	46-55	39	26%
	Over 55	33	22%
	Educational	No education	2
Up to 9 years		23	15%
12 years		83	55%
University degree		39	26%
Post university		3	2%
Region		Tirane	40
	Fier (Lushnje)	70	46%
	Berat	40	27%
Occupational	Farmer	101	71%
	Government	14	6%
	Entrepreneur	18	12%
	Unemployed	5	2%
	Other	12	9%

Table 1: Demographics of the study

Source: Author's elaboration

Data collection occurred over several weeks, utilizing in-person to ensure comprehensive coverage of the target population. This approach allowed for a diverse and representative sample, providing valuable insights into the impact of social networks on rural development, particularly from the farmers' perspective.

3.2 Research Instrument

A structured questionnaire was developed to gather data across several key dimensions: demographic information (age, gender, and education level), frequency of social media use (including specific platforms like Facebook and Instagram), perceptions of social networks' impact on rural development, and perceptions of misinformation's influence on these networks. This research is based on the established theories of Uses and Gratifications and Diffusion of

Innovations to assess whether social media users perceive these platforms as reliable sources of information.

3.3 Data Collection Procedure

Data collection was conducted through face-to-face interviews and online surveys to include a wide range of participants and ensure access to accurate and reliable data. The data collection period lasted several weeks, allowing participants to reflect and provide thoughtful responses.

3.4 Data Analysis

The analysis involved the use of a **Moderation Model 1** by Andrew F. Hayes (Igartua & Hayes, 2021) to test the impact of social media use frequency on perceptions of rural development, considering misinformation as a mediating variable. This model is suitable for examining how the strength or direction of the relationship between an independent variable (X =Frequency of Social Media Use (FSMU)) and a dependent variable (Y =Impact of Social media in Rural Development, (ISMRD) changes based on different levels of a moderator (W =False information, 1=low, 2=high (FII)). The moderation analysis underscores how misinformation moderates social media use's impact on rural development.

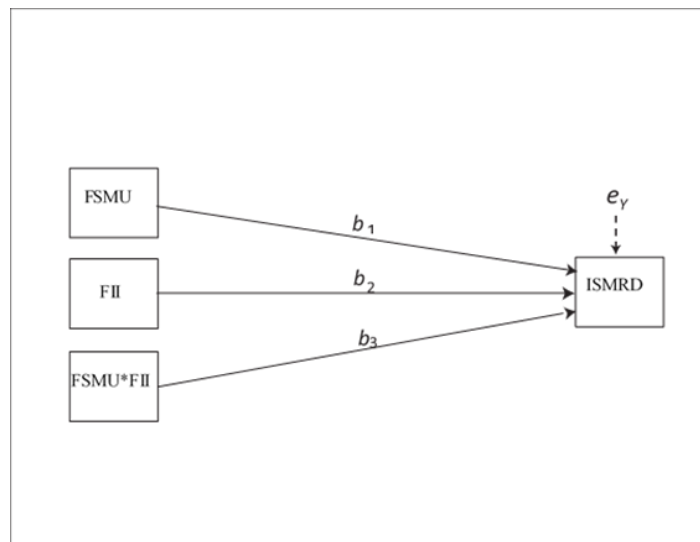


Figure 2: Statistical diagramme
Source: Authors elaboration

4 Discussion of Results

The analysis of the survey data reveals several critical insights into the interplay between social media usage and perceptions of rural development among farmers in the study regions. The correlations observed among various variables suggest distinct relationships that highlight the complexities of social media's impact on rural communities. The correlation coefficients presented in Table 2 illustrate several noteworthy relationships among selected variables.

Variable 1	Variable 2	Correlation Coefficient	p-value
Age	Education	-0.63	0.001
Age	Occupation	-0.219	0.01
Education	Occupation	0.393	0.00
Education	Social media	0.451	0.001
Education	Traditional Media Frequency	0.242	0.005
Education	Social Media Impact	-0.388	0.00
Occupation	Challenges in Using Social Media	-0.345	0.03
Social media	False Information Impact	-0.271	0.002
Frequency of Social media Use	Social Media Impact	0.455	0.00
Traditional Media Frequency	Social Media Impact Areas	0.371	0.01
Social Media Impact	Traditional Media Impact Areas	-0.26	0.04
Traditional Media Impact Areas	What measures do you think should be taken to improve the use of social media and media in rural development?	-0.325	0.03
Challenges in Using Social media	Social Media Impact Areas	-0.208	0.04
What measures do you think should be taken to improve the use of social media and media in rural development?	How can social media and media be used more effectively to promote rural development?	-0.102	0.01

Table 2: Correlation analysis
Source: Authors elaboration

Firstly, a demographic consideration shows a significant negative correlation between age and education ($-0.63, p < 0.001$), indicating that younger respondents tend to have higher educational levels, suggesting a potential generational gap in digital literacy and access to social media platforms. This result also suggests that efforts to enhance educational opportunities for younger demographics could play a vital role in rural development. This finding is consistent with previous research showing that younger individuals are generally more adept at utilizing technology for information sharing (Allen et al., 2013; Ei Chew et al., 2011). Additionally, the positive correlation between education and the frequency of social media use ($0.451, p < 0.001$) underscores the idea that higher educational attainment may lead to greater engagement with social media, potentially enhancing the perceived benefits of these platforms in promoting rural development. A significant negative correlation ($r = -0.271, p = 0.002$) was observed between social media and the perceived impact of false information. This finding underscores the detrimental effect of misinformation on the perceived utility of social media, reinforcing concerns about the credibility of information shared online.

Similarly, the moderation analysis demonstrates that about 20% of the variance in perceptions of social media's impact on rural development can be explained by the frequency of social media use, perceived impact of false information, and their interaction. While the direct effect of social media use on perceptions was not statistically significant ($b = -0.186, p = 0.259$), the significant negative effect of perceived false information ($b = -1.742, p < 0.001$) suggests that misinformation significantly undermines trust in social media as a tool for rural development. This aligns with existing literature indicating that misinformation erodes user trust and reduces the perceived credibility of social media platforms (Caled & Silva, 2022, 2022; Lee & Choi, 2024; Lewandowsky et al., 2017).

Moreover, the interaction effect indicates a nuanced relationship where low levels of perceived misinformation allow frequent users to view social media positively as a vehicle for rural development (effect = $0.088, p = 0.039$). In contrast, as perceived false information increases, the positive perception of social media's impact strengthens (effect = $0.3644, p = 0.0109$). This suggests frequent users may develop resilience, becoming more critical and selective in their social media engagement. Instead of dismissing social media due to misinformation, they adapt by scrutinizing the content they consume and share, enhancing its utility as a resource for community engagement and development.

Variable	Coefficient	SE	t-value	p-value	LLCI	ULCI
Model Summary	R = 0.44	-	-	<0.001	-	-
Constant	4.5025	0.5413	8.3187	<0.001	3.4317	5.5733
Frequency of Social Media Use (FSMU)	-0.1869	0.165	1.1327	0.2594	0.5132	0.1395
False Information Impact (FII)	-1.7428	0.5023	3.4696	0.0007	2.7365	-0.749
Interaction (FSMU x FII)	0.2756	0.1474	1.87	0.0637	-0.016	0.5672
Conditional Effect (FII= 1 low)	0.0888	0.0428	2.0756	0.0399	0.0042	0.1734
Conditional Effect (FII = 2 high)	0.3644	0.1411	2.5835	0.0109	0.0854	0.6435

Table 3: Moderation model results
Source: Authors elaboration

The findings of this study align with existing literature on the role of social media in rural development, particularly concerning the nuanced relationship between social media use and perceptions of its impact (Rama Devi & Venugopal, 2022). The relationship between education levels and perceptions of social media's effectiveness reflects Social Capital Theory (R. Putnam, 2002; R. D. Putnam, 2007), emphasizing that social connections and trust foster community development. Notably, the significant negative influence of false information on users' perceptions aligns with findings from Kim et al., 2019 and Singh et al., (2024) who demonstrated that false information spreads faster than accurate information, particularly on social media, which can erode trust in information sources. Similarly, (Pennycook et al., 2018 and Lewandowsky et al., (2017) discuss how exposure to false information can skew public perceptions, diminishing the perceived utility of social media for developmental objectives. This is especially relevant in rural contexts, where access to accurate information is crucial for informed decision-making and community engagement. Moreover, the results resonate with the principles of the Diffusion of Innovations theory (Rogers, 1995), which posits that the dissemination of information is essential for the adoption of innovations. Our finding that higher frequency of social media use correlates with more positive perceptions of its role in rural development supports Rogers' assertion that increased exposure to information facilitates the acceptance and integration of new ideas. This is also supported by Saravanan & Rajan, (2024) who reinforces the idea that media can enhance social capital and local development initiatives, as frequent social media users are likely to perceive these platforms as beneficial for rural community progress. In conclusion, the findings

indicate that while social media has the potential to enhance rural development perceptions, the influence of misinformation presents a significant challenge. Enhancing digital literacy and fostering critical engagement with information sources are essential for leveraging social media's full potential in rural contexts. This study underscores the need for targeted interventions to improve media literacy, thereby enabling rural communities to harness social media effectively for development goals.

Conclusions

This study provides valuable insights into the complex interplay between social media use, misinformation, and perceptions of rural development. The analysis shows that the frequency of social media use is linked to perceptions of its impact on rural development, but the presence of misinformation significantly moderates this relationship. Specifically, while increased social media engagement can foster positive perceptions of its role in rural development, the detrimental effects of misinformation pose significant challenges to this relationship.

The findings indicate that education and digital literacy are critical factors in enhancing the effectiveness of social media as a tool for rural development. Individuals with higher education levels not only engage more with social networks but also exhibit greater resilience against the negative influences of misinformation. This underscores the importance of implementing educational initiatives that promote critical thinking and information literacy among rural populations.

Moreover, the study highlights the need for stakeholders to prioritize credible information dissemination within social media platforms to strengthen the trustworthiness of these channels. By addressing misinformation and enhancing digital literacy, rural communities can better harness the potential of social media to drive development initiatives, facilitate knowledge sharing, and foster community engagement.

Practical implications

Frequent social media users exhibit resilience to misinformation, becoming more critical and selective, which enhances social media's role as a tool for rural development. Despite high levels of perceived false information, users continue to recognize social media's potential to foster community engagement and local development.

Study Limitations

The study's regional focus (Fier, Berat, and Tirana) limits its generalizability to other rural areas in Albania, and reliance on self-reported data may introduce subjective biases. Additionally, the cross-sectional design and lack of platform-specific analysis constrain the ability to capture long-term trends and differentiate the roles of various social media platforms. This study represents the initial step in analyzing the role of social media in rural development, focusing on the interaction between misinformation, social media use frequency, and its perceived impact. Future research will build on this foundation by employing a more complex conceptual framework that integrates additional variables, such as digital literacy, platform-specific differences, and longitudinal trends, to provide a deeper and more comprehensive understanding of social media's role in enhancing resilience and fostering development in rural areas.

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Export competitiveness analysis of the Hungarian economy 1992-2022

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Abstract: The aim of the research is to analyse the competitiveness of domestic agricultural production and its development and changes in the past decades. It also aims to identify the reasons behind the changes. Hungary has very good agricultural potential, but is not particularly rich in mineral resources. It is logical to develop an industry based on agriculture. Although agriculture has a small share of production, it is the leader in terms of competitiveness. This is why the article focuses on agriculture. I have calculated Balassa indices for the period 1992 to 2023 for the entire product range of the WITS database. In the early 1990s, several products of the Hungarian economy were still exceptionally competitive on international markets. Mainly basic agricultural products and processed products were in this category.. The product coverage remained the same for the main export products, but the competitiveness index dropped significantly. Live animals and cereals, i.e. basic products, remained competitive to a more significant extent, but among the other products there are hardly any competitive goods. Exports of basic products are based on agricultural exports, while industrial exports are dominated by light industry products such as machinery, clothing and plastics. By looking at the data, administrations and policy makers can make more informed decisions in the future.

Keywords: Balassa index, competitiveness, Hungary, Agriculture, export and import

1 Introduction

The aim of the research is to analyse the competitiveness of domestic agricultural production and its development and changes in the past decades. It also aims to identify the reasons behind the changes.

Hungary is located in the Carpathian Basin, as it is flat and suitable for agricultural production. It is located in about a quarter of the Carpathian Basin. The country has a continental climate with a shortage of rainfall. Unfortunately, there are frequent droughts. The number of hours of sunshine is favourable for the cultivation of cereals. In general, the soil quality is good, with a large area of the

country characterised by black field and brown forest soils. Given Hungary's climatic conditions, practically all temperate zone crops can be grown, and overall the agricultural conditions in Hungary are above average (Szűcs, 2017).

In arable crops, significant variability in yields remains a problem, calling attention to the importance of irrigation and the modernisation of agrotechnology. In livestock production, market crises and epidemics are a major challenge. Hungarian agriculture has made significant progress in recent years, but the problems that still remain and the international challenges require further efforts to increase competitiveness (Bakota and Páll, 2019).

In Hungary, the total output of agriculture at current prices in 2009 and its gross value added has been growing since 2013, with the exception of the drought-hit year 2022. In 2023, output exceeded HUF 4.4 billion, up 8.4% year-on-year. The main contributors to the expansion were increases in the value of output of horticultural products, feed crops, live animals and fruits (KSH 2023a).

2 Literature Review

The volume of gross value added in domestic agriculture increased by 76%, or 17% at current prices. The favourable development in production volume was accompanied by a 14% decline in the output price index. Crop production accounted for 56% of output and livestock production for 37%, the former up 6.4% and the latter up 11% compared to 2022. Hungary accounted for 2.1% of EU agricultural output.

In 2023, the volume of total agricultural output (value at previous year's prices) increased by 26% compared to the low base. The largest contributors to the volume increase were maize (9.9 percentage points), wheat (4.9 percentage points) and sunflower (4.4 percentage points).

Production of all product groups in the crop production sector increased (by 45% combined), with the exception of a few crops such as peaches, nursery products, basket and spinning materials, other fresh fruit, table grapes and cauliflower. Several of our most economically important crops, such as maize, sunflowers, apples and wheat, were also affected by the largest increases in production.

The cereals harvest was 15.1 million tonnes from 2.4 million hectares. The harvested area increased by 158 thousand hectares, after a decrease in the previous year, and the yield increased by 66%. Wheat harvested on an area 7.6% larger than the previous year (1 053 thousand hectares) was 36% higher at 5.9 million tonnes. Cereals production increased the volume of total agricultural output by 18 percentage points, including wheat by 5.2 and maize by 9.9 percentage points.

The harvested area of industrial crops was reduced by 2.4%, while the volume of crops increased by 40%. The harvested area of oilseeds decreased by 2.3%, including rape by 7.8% and sunflower by 0.9%. The yields were higher for both crops (626 thousand tonnes and 1970 thousand tonnes respectively), with rape up by 24% and sunflower by 53%. The production of industrial crops increased the volume of total agricultural output by 6.0 percentage points, and that of oilseeds by 5.7 percentage points, of which rape and sunflower by 0.8 and 4.4 percentage points respectively. Sugar beet yields increased by almost 1.9 times to 876 thousand tonnes. Vegetables rose by 17% to 1.4 million tonnes.

The main fruit crops (642 thousand tonnes) were 22% up on the previous year. The yield per hectare of apple fruit was up 44%, while that of stone fruit and raspberries fell. The grape yield in 2023 was 411 thousand tonnes, 0.9% less than in 2022.

The performance of the livestock sector was positively influenced by the strengthening of fodder crop production and the concomitant fall in bulk and grain feed prices, but the evolution of its volumes is mixed. Our major livestock holdings, other than cattle, have increased, but the production of animal products has declined by almost the same rate.

In December 2023, there were 2.6% fewer cattle (862 thousand head) on farms than a year earlier. Together with dairy production, cattle holdings reduced the volume index of total agricultural output by 0.2 percentage points. The December 2023 pig herd of 2.6 million was up 1.9% from the previous year.

The poultry population expanded by 1.7% to 35.6 million in December 2023, including a 1.3% year-on-year decline in the chicken population to 28.7 million. The change in poultry flocks, together with egg production, increased the volume index of total agricultural output by 0.5 percentage points.

The total weight of slaughtered animals (1.6 million tonnes) during the year was 1.7% higher than the previous year. Sheep for slaughter (20 thousand tonnes) fell by 2.3%, pigs for slaughter (549 thousand tonnes) by 1.5%, beef for slaughter (117 thousand tonnes) by 0.8% and poultry for slaughter (893 thousand tonnes) by 4.3%.

Among the main animal products, cow's milk production fell by 0.6 %, hen's eggs by 4.2 %, wool by 2.4 %, honey by 20 %, with only feather production increasing (KSH, 2023b).

Total agricultural output grew by 25%, an exceptionally high level among the 27 countries of the European Union. The significant volume growth in Hungary was helped by a low base due to the previous year's drought and this year's above-average cereal production. Of the top producing countries, only France's total output exceeded the previous year, Germany's was close to it and Italy's fell slightly.

The total output of EU agriculture reached €535 billion, 0.5% down on the previous year. The largest contributors to total agricultural output were France (18%), Germany and Italy (14-14%), while Hungary accounted for 2.1% of EU output (KSH, 2023c).

Hungary typically has an external trade surplus, mainly in agricultural products. How successful a product is depends on what kind of product it is. The type of products produced (raw or processed, perishable or non-perishable, etc.) and the level of trade integration. Hungary trades mainly with other Member States, with Germany typically being its main external trading partner. The share of raw materials is higher on the export side (cereals and oilseeds) than on the import side (e.g. meat and meat products or various confectionery products). Despite transport difficulties, Hungarian exports have increased, resulting in a growing trade surplus. On the other hand, international food prices remained stable. Overall, this has been beneficial for Hungary, as production significantly outstripped domestic demand, resulting in high food security, and the trade surplus increased (Mizik, 2021).

Exports, which account for 62% of industrial sales, fell by 5.3% and domestic sales by 2.8%. Among the branches of industry, manufacturing, which accounts for the bulk (95%) of production value, was 4.1% below the output of the first half of 2023, while energy and light mining were 7.2% and 17% above, respectively. Within manufacturing, output declined in most sub-sectors, moderated by volume growth in food, beverages, tobacco products, chemicals, chemical products and wood, paper and printing, which account for a larger share of output. Of the sub-sectors that have the most influence on the development of manufacturing:

among the sectors related to chemicals, negative changes in the production of coke, refined petroleum products and pharmaceuticals contributed to the decline in production volumes;

the low base of vehicle production, which had been growing steadily for a year and a half, came to a halt in November 2023 and was consistently below the same month of the previous year, except in February and April 2024;

the decline in the production of electrical equipment was mainly due to the decline in the production of batteries and dry cells, which account for around half of the subsector's output, and the drop in the production of electric motors, generators and power distribution and control equipment, which fell significantly in volume;

the decline in food industry output from the fourth quarter of 2022, in line with shrinking domestic demand, was replaced by an increase from January 2024, so that, apart from a small decline in March and June, overall, the volume of production in the first half of 2024 was higher than a year earlier; both domestic and export sales were higher than in the first half of 2023;

the heavily export-oriented electronics industry, which accounts for 9.5% of manufacturing, has been in steady decline since November 2022 compared to the same months in previous years; production volumes in the two largest sub-sectors, the manufacture of electronic components and boards and the manufacture of electronic consumer goods, fell by 23% and 4.7% respectively (KSH, 2024).

3 Methods

In 1965, Hungarian-born American economist Béla Balassa published his measure of comparative advantage in international trade (Balassa, 1965).

Although several critics have criticized his formula, it has been shown that the coherence between the original Balassa index and its variants is so strong that no other result is served by the modified formula (Jámbor, 2017a).

I got the export values from the World Bank database (WITS, 2024), but I also collected statistics and results from other databases, such as FAOSTAT.

The Balassa index is calculated using the following formula:

$$B_{ij} = RCA_{ij} = \left(\frac{X_{ij}}{X_{it}} \right) / \left(\frac{X_{nj}}{X_{nt}} \right),$$

Figure 1. Balassa index formula

where X is the export, i is the country, j is the product, t is the group of products, and n is the reference country, i.e. the index compares the share of the product under consideration in the exports of a country with the share of the same product in the exports of the reference country. In the present analysis, the product (j) is selected from among the agricultural product groups and the product group (t) is all products for both the country and the reference country.

4 Results

Hungarian GDP in value terms showed a steady year-on-year increase in the period under review until 2008. Then the economic crisis that was taking place in the world had a negative impact on Hungary's economy. Since then, there have been fluctuations between growth and decline in GDP. This growth was around

4% per year during the period under review. The two declines occurred in 2008 and 2020, as shown in Figure 2.

Hungary: Gross domestic product (GDP) in current prices from 1989 to 2029 (in billion U.S. dollars)

Gross domestic product (GDP) in Hungary 2029

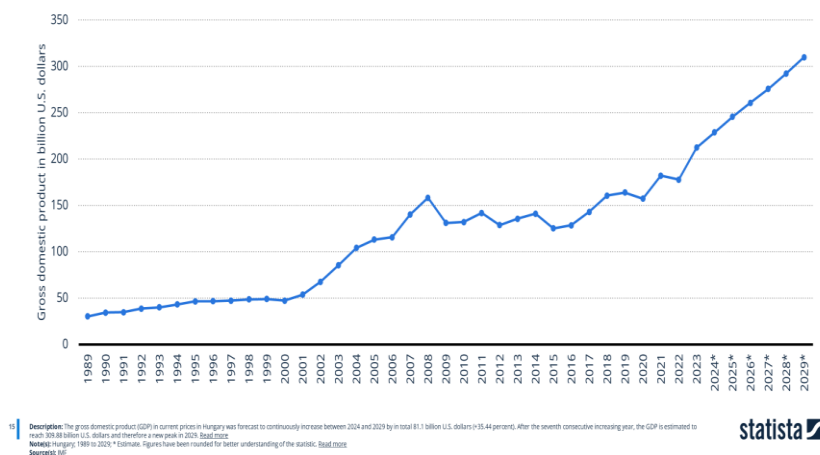


Figure 2. Hungarian GDP 1989-2029

Statista (December 6, 2024.) Economy of Hungary

<https://www.statista.com/study/108545/economy-of-hungary/>

The services sector accounted for 57% of GDP. Accommodation and food service, information and financial service were the main sectors. Industry accounted for 25%, with agriculture making up the remainder.

The inflation rate jumped sharply to 14.5% in 2022 and reached 17.6% in 2023, a significant rate, mainly because it reached 48% for food at the beginning of 2023. The export balance was positive until 2020, then in 2021 and 2022 (Statista, 2024a).

Main products exported from Hungary in 2023, by value (in thousand euros)

Main products exported from Hungary 2023, by value

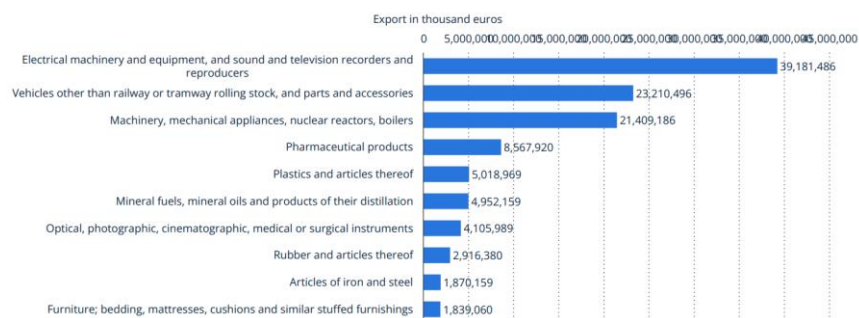


Figure 3. Main export products from Hungary

The most important export products include:

- Electrical machinery and equipment, and sound and television recorders and reproducers
- Vehicles other than railway or tramway rolling stock, and parts and accessories
- Machinery, mechanical appliances, nuclear reactors, boilers
- Pharmaceutical products
- Plastics and articles thereof
- Mineral fuels, mineral oils and products of their distillation
- Optical, photographic, cinematographic, medical or surgical instruments
- Rubber and articles thereof
- Articles of iron and steel Furniture; bedding, mattresses, cushions and similar stuffed furnishings (Statista 2024a).

Germany is the largest trading partner for exports. Besides Italy, products are exported to neighbouring countries and other EU countries (France, the Netherlands) and the UK. Imports are also significant. Germany is also the largest partner, followed by China. In addition to EU countries, there are significant imports from Korea and Russia (Statista, 2024a).

The most important imported products are:

- Electrical machinery and equipment and sound and television recorders and reproducers

- Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof
- Vehicles other than railway or tramway rolling stock, and parts and accessories thereof
- Mineral fuels, mineral oils and products of their distillation
- Pharmaceutical products
- Plastics and articles thereof Iron and steel
- Optical, photographic, cinematographic, medical, or surgical appliances
- Articles of iron or steel
- Miscellaneous chemical products (Statista, 2024a)

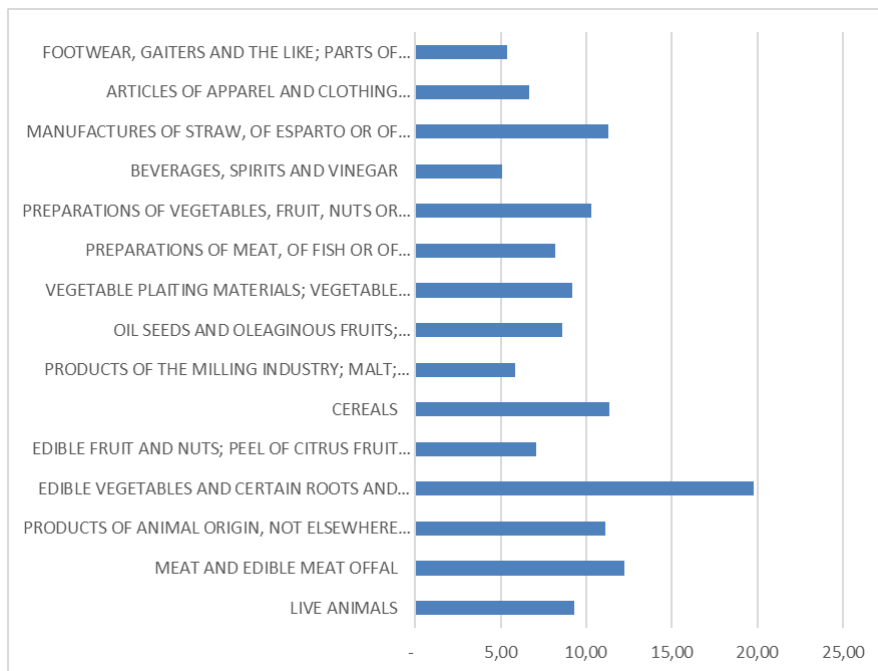


Figure 4. Most competitive Hungarian export products in 1992. Own calculation.

In the early 1990s, the Hungarian economy had even more products that were exceptionally competitive on international markets.

It was mainly agricultural commodities and processed products in this category, as Figure 4 shows.

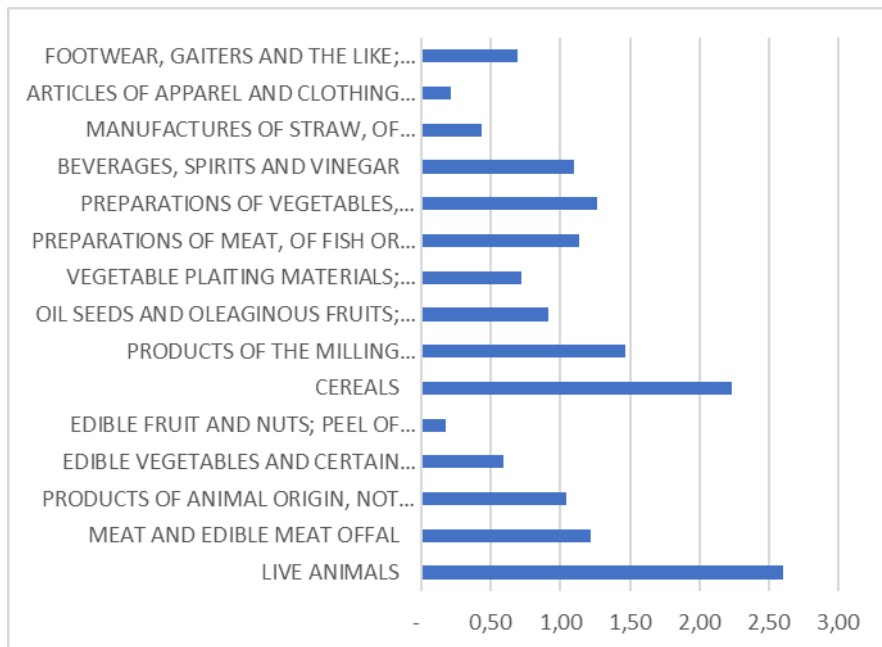


Figure 5. Most competitive Hungarian export products in 2023. Own calculation.

The range of products has remained the same for the main exports, but the competitiveness index has fallen significantly. Live animals and cereals, the basic products, remain more competitive, but there are hardly any competitive goods among the other products (Figure 5).

The extent of the decline is shown in Figure 6.

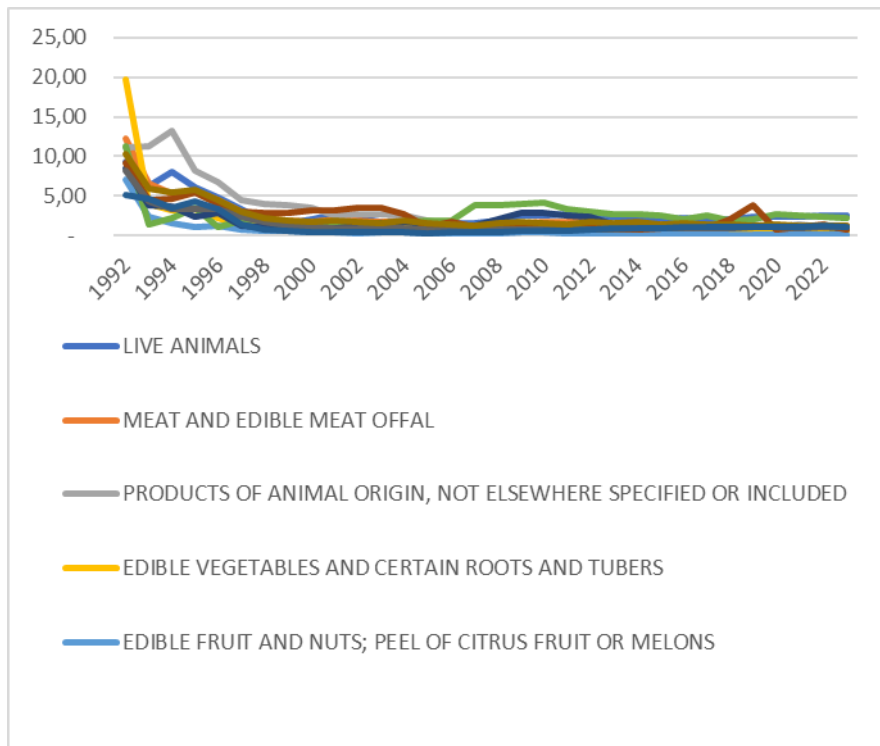


Figure 6. Balassa indexes changes between 1992 and 2023. Own calculation.

Conclusions and suggestions

The reasons behind this are. Most Hungarian production is sold domestically (Bozsik, N., & Magda, R. (2021).) Basic, unprocessed products go abroad. It is a structure problem and lack of investments. Exports of processed products have decreased. Reasons for this may include price competition, the rise of international competitors such as China. Reduction in innovation (49,3% of EU) (Statista 2024b). Changes in international prices have not favoured Hungarian production and exports (Révész, 2019).

As most successful products are agricultural, the proposals for agriculture could be extended to the whole economy. Hungarian agriculture can do the followings:

1. running efficient institutional systems
2. investing in physical infrastructure
3. a favourable macroeconomic environment
4. investment in health and education
5. facilitating market access
6. efficient land markets
7. effective agricultural risk management
8. developing innovation and technology absorption capacities
9. sustainable use of natural resources (Jámbor 2017b)

Acknowledgement

Thanks to my colleagues for their help!

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Evolution of post Soviet countries' cereal exports in terms of competitiveness 2010-2022

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Abstract: The article analysed the situation of grain production and trade in Russia, Ukraine and Belarus until 2021-22. Cereal production and trade data show that cereals are of particular importance in these countries. For Ukraine and Russia, clearly. Russia has been striving for self-sufficiency since 2015, while Ukraine is a world trade leader for both maize and wheat. We quantified the comparative advantage using the Balassa index. Ukraine has a comparative advantage on the world market for several cereals, as does Russia, but Belarus is not a large competitive producer. In terms of import volume, the share of cereals in Ukraine was only 1% of total imports between 2010 and 2023, while it was even lower in the other two countries. The volume of cereal exports in Belarus was also modest. However, in Russia they were 2-3%, while in Ukraine they were 30-40%. And had it not been for the war, it would have been much larger. In most cases, it is true that the products exported were those that had a comparative advantage. Russian wheat, and Ukrainian wheat, maize, barley are among them.

Keywords: Grain, Cereals, Balassa Index, Competitiveness, Post-Soviet Countries

1 Introduction

The aim of the research is to analyze the grain production and trade of the countries involved in the Ukraine-Russia war from 2010 until the data are available (2021 and 2022), i.e. Ukraine, Russia as the largest grain producer and Belarus. My aim is not to shed light on the reasons for the outbreak of the war, but to show (if data are available) its impact on the grain production, exports, and competitiveness of the countries in question. The question is how the grain production of these three countries and their role in international trade changed. Has their international competitiveness changed and, if so, in what direction?

My aim was to study the production and trade of rice, rye, millet, barley, oats, maize, and wheat. Because they are agricultural products, they are strongly influenced by the weather. The production of these cereals is stable not only in

terms of quantity but also in terms of the value of the currency sold and varies considerably over time. One of the reasons for this is the already mentioned weather effect, which affects quantity, and another is the volatility and fluctuation of world market prices (Forgács and Futó, 2014).

Looking at the national averages of annual mean and maximum temperatures, Pinke et al. 2021 find that they have increased significantly by about 1 ° C across Europe since 1961 over the period studied. Warming, as we can see, is more pronounced in the summer months compared to the average. It reaches 1.4 ° C. It is noted that the averages of the maximum temperatures exceeded the mean temperature averages. The only exception was northern Europe. In terms of precipitation, annual and summer rainfall have not changed significantly over the last 50 years in any place in Europe. With the exception of southern Europe, there has been a slight increase. Over islands, such as Great Britain and parts of Scandinavia, the increase was significant, while over the Mediterranean region and Hungary the increase was variable. The highest increases were in areas already prone to precipitation such as Alpine countries, countries with oceanic climate and the Adriatic region, while the driest areas were the countries of eastern Europe and nearby Finland (Pinke et al., 2021).

By the 21st century, Russia has become independent by retaining, and trying to retain, its economic, cultural and political influence over the former Soviet territories. After the break-up of the CIS, and following the events in Kiev in 2013-14, there was an attempt in 2022 to ensure that this interest did not change. These countries are in a transitional state in their transition to a market economy, but in a way that maintains the culture and milieu that characterised their political culture.

2 Literature Review

The market for cereals covers the total gross production value of 14 items, including barley, maize, oats, rice, rye, wheat, sorghum, triticale, millet, canary seed, buckwheat, quinoa, spelt and mixed cereals (Statista 2024a).

Until recent years, the agricultural competitiveness of the countries of the former Soviet Union has not been much discussed (Kozar et al., 2016). In 2012, Lioubimtseva and Henebry found that grain production in the countries of the former Soviet Union declined significantly until 2010 and only started to increase somewhat from 2010 onwards (Lioubimtseva and Henebry, 2012).

In 2019, Mizik found that agriculture is a major GDP producer and employer in Ukraine and Russia. Agricultural exports in Russia are less than 10%, while in Ukraine they are significant, even above 40%. In terms of imports, these countries were around 10%. One of the effects of the 2014 embargo on Russia was that

Russia's role in the direction of Ukrainian exports was sharply reduced. The Russian response was to seek self-sufficiency. This goal has now been achieved. In terms of competitiveness, Russia has a positive value for cereals. Ukraine's comparative advantage has indeed been on a downward trend until 2019, but it is significant for several agricultural product groups, including cereals (Mizik, 2019).

The Russian economy has been so successful in meeting the target of self-sufficiency in cereals that it has achieved overproduction in recent years. A major problem for the Russian economy is the proper storage and subsequent sale of the surplus. The author concludes that the Russian government's goal is to bring as much land as possible into production. In contrast, in Europe and the USA the aim is to take land out of production. High cereal production pursues the goal of food security in addition to self-sufficiency. Government policy has thus turned into inefficiency. Storage capacities are low and cannot adequately store this huge amount of product. The infrastructure is not sufficient for transport and efficient export. Increasing production is not matched by population growth. Livestock numbers are declining, the proportion of cereals in the diet is declining, and the embargo is leading to a reduced export of cereals leading to oversupply. Reduced investment as prices fall will reduce profits and could lead to the bankruptcy of several grain producers and traders. Meanwhile, grain storers are making record profits (Wegren, 2018).

The impact of the 2022 war was. A decline in Ukrainian grain exports, logistical damage, difficulties. Grain prices increased significantly. Reduced food security in low-income countries with significant imports. Typical examples are Africa and South East Asia (von Cramon-Taubadel, 2022).

3 Methods

In 1965, Hungarian-born American economist Béla Balassa published his measure of comparative advantage in international trade (Balassa, 1965).

Although there have been several criticisms of his formula, it has been shown that the coherence between the original Balassa index and its variants is so strong that no other result is served by the modified formulae (Jámbor, 2017).

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4 Results

World production of all cereals has fluctuated but been broadly stable over the past 15 years, with a significant drop in 2015, but since then it has been trying to catch up (Statista 2024b).

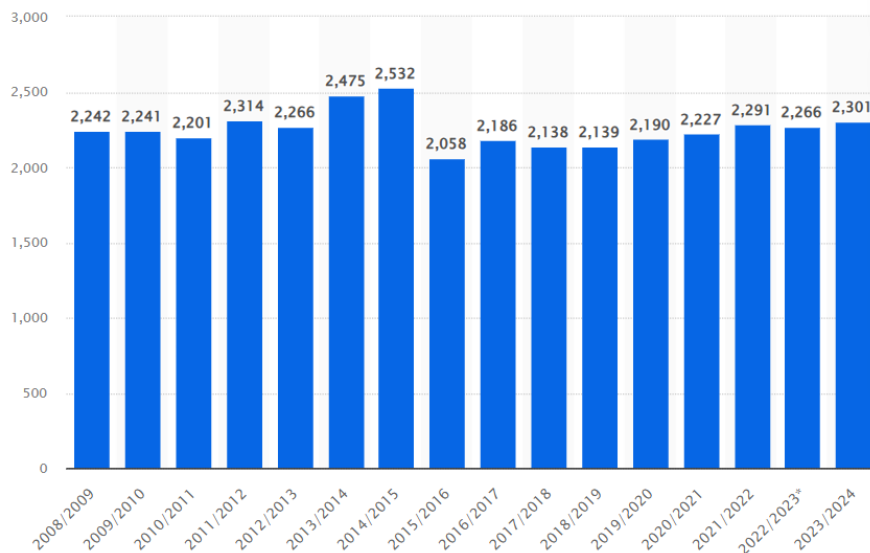


Figure 2. Total global grain production from 2008/2009 to 2023/2024(in million metric tons)

The world's largest wheat producers are Russia (4th) and Ukraine (9th), while the largest maize producers are Ukraine (7th) (Statizta 2024 c).

Belarus' arable land has been in steady decline since 2010. Until then, Russian areas had been growing until 2014, but have been fluctuating since then. The Ukrainian areas dropped by 30% when the war broke out Table 1.

Year	Belarus	Russian Federation	Ukraine
2010	679 959,0	4 939 554,0	4 316 900,0
2011	670 083,0	7 689 432,0	3 684 200,0
2012	556 949,0	7 641 131,0	3 293 000,0
2013	570 066,0	8 011 038,0	3 233 100,0
2014	545 796,0	9 002 498,0	3 003 100,0
2015	499 836,0	8 231 782,0	2 805 200,0
2016	450 814,0	8 133 765,0	2 859 200,0
2017	451 758,0	7 847 738,0	2 501 500,0
2018	429 261,0	7 873 944,0	2 484 300,0

2019	408 918,0	8 536 675,0	2 609 200,0
2020	410 955,0	8 267 448,0	2 374 500,0
2021	401 800,0	7 834 548,0	2 472 100,0
2022	331 500,0	7 939 724,0	1 740 200,0

Table 1. Crop production areas in the countries analysed Source: FAOSTAT 2024

Belarusian cereal production was steady until 2015, but since 2016 it has shown a significant decline and has been stable at around 1 million tonnes. Russian grain production, as I mentioned, also increased due to self-sufficiency and reached 23 million tonnes in 2022. Ukrainian production also showed stability during the period under study, but due to the war it reached only 5-6 million tonnes in 22 Table 3.

Year	Belarus	Russian Federation	Ukraine
2010	1 965 780,0	8 350 022,5	8484900,0
2011	1978794,0	16 938 002,4	9097700,0
2012	1917390,0	13 951 676,0	6936400,0
2013	1673272,0	15 388 704,0	7561640,0
2014	1988102,0	20 444 257,7	9046060,0
2015	1849035,0	17 546 155,4	8288380,0
2016	1252668,0	17 967 161,0	9435710,0
2017	1419829,0	20 628 955,0	8284890,0
2018	944341,0	16 991 907,0	7349140,0
2019	1098189,0	20 489 088,0	8916780,0
2020	1375015,0	20 938 993,2	7636340,0
2021	1077000,0	17 996 404,6	9 437 020,0
2022	1100000,0	23 393 510,0	5608170,0

Table 2. Crop production in the countries analysed Source: FAOSTAT 2024

In terms of returns, the Russian return was significantly below the Ukrainian and Belarusian returns. Ukrainian and Belarusian yields were high Table 3.

Year	Belarus	Russian Federation	Ukraine
2010	2 891,0	1 690,4	1 965,5
2011	2 953,1	2 202,8	2 469,4
2012	3 442,7	1 825,9	2 106,4
2013	2 935,2	1 920,9	2 338,8
2014	3 642,6	2 271,0	3 012,2
2015	3 699,3	2 131,5	2 954,6
2016	2 778,7	2 209,0	3 300,1
2017	3 142,9	2 628,6	3 312,0
2018	2 199,9	2 158,0	2 958,2
2019	2 685,6	2 400,1	3 417,4
2020	3 345,9	2 532,7	3 216,0
2021	2 680,4	2 297,1	3 817,4
2022	3 318,3	2 946,4	3 222,7

Table 3. Crop production yields in the countries analysed Source: FAOSTAT 2024

	2021/22	2022/23	2023/24	2024/25*
Corn	42 126	27 000	31 000	27 000
Wheat	33 007	21 500	23 000	21 000
Barley	9 923	6 100	6 350	5 200
Millet	214	90	215	100
Sorghum	173	40	45	90
Rice milled	32	3	13	15

Table 4. Ukrainian cereals production Source: Statista 2024c

Table 4 shows that it is no coincidence that Ukraine is the 7th largest maize producer and the 9th largest wheat producer in the world. Production varies, but the country is somewhat recovering from the war.

Table 5, which contains the Balassa index calculations, shows Belarus' competitiveness.

Belarus	Cereals	Wheat	Rye	Barley	Oat	Corn	Rice	Sorghum	Millet
2010	0,05	0,00	0,01	0,00	0,00	0,00	0,00	-	0,00
2011	0,01	0,00	0,00	0,00	0,00	0,00	0,00	-	0,00
2012	0,01	0,00	0,00	0,00	0,00	0,00	0,00	-	0,00
2013	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-	0,00
2014	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-	0,00
2015	0,04	0,00	0,00	0,00	-	0,00	0,00	-	0,00
2016	0,14	0,00	0,02	0,00	0,00	0,00	0,00	-	0,00
2017	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-	0,00
2018	0,01	0,00	-	0,00	0,00	0,00	0,00	-	0,00
2019	0,01	0,00	-	0,00	0,00	0,00	0,00	0,00	0,00
2020	0,09	0,00	0,00	0,00	0,00	0,00	0,00	-	0,00
2021	0,12	0,00	0,01	0,00	0,00	0,00	0,00	-	0,00

Table 5. Balassa indexes for Belarus grains

It can be seen that we cannot find any year when Belarusian cereals have shown competitiveness. This may be due to the tendency to self-sufficiency and inadequate export opportunities.

Russia	Cereals	Wheat	Rye	Barley	Oat	Corn	Rice	Sorghum	Millet
2010	0,84	1,82	0,05	1,02	0,02	0,05	0,13	-	0,12
2011	1,11	2,23	1,85	1,67	0,04	0,17	0,11	0,00	0,43
2012	1,45	2,51	4,57	2,79	0,08	0,56	0,20	0,07	0,57
2013	1,08	1,96	0,64	1,67	0,02	0,50	0,10	0,21	0,48
2014	1,77	3,35	1,22	2,85	0,03	0,73	0,14	0,12	0,68
2015	2,13	3,94	2,68	4,49	0,09	0,86	0,18	0,16	1,01
2016	2,48	4,72	0,06	2,71	0,11	1,47	0,18	0,17	0,73
2017	2,69	5,49	1,04	3,65	0,10	1,08	0,14	0,24	1,05
2018	3,24	7,10	4,13	4,48	0,32	0,89	0,10	0,14	0,91
2019	2,53	5,75	1,26	3,62	0,73	0,60	0,12	0,17	0,91
2020	3,34	7,75	0,10	4,89	0,47	0,48	0,12	0,13	1,41
2021	2,30	5,02	1,63	3,19	1,19	0,58	0,10	0,10	1,75

Table 6. Balassa indexes for Russian grains

The Balassa indices for Russian cereals are shown in Table 6. Overall, the comparative advantage of Russian cereals has increased. This is also due to the strong 5-7 value of wheat over the period considered. Rye, oats, sorghum and rice weakened the overall effect, as most of them were not competitive in the years under study. Barley strengthened it in most years. In other words, Russian cereals are sellable with the right uptake markets.

The comparative advantage of Ukrainian grain is shown in Table 7.

Ukraine	Cereals	Wheat	Rye	Barley	Oat	Corn	Rice	Sorghum	Millet
2010	8,24	7,28	6,92	34,76	0,87	10,40	0,03	1,67	6,04
2011	9,31	7,02	1,56	15,74	0,03	17,92	0,02	2,20	3,58
2012	17,20	12,94	1,51	18,80	0,10	34,21	0,13	7,01	4,68
2013	16,72	10,06	1,45	16,06	0,15	37,88	0,13	13,17	3,24
2014	20,11	15,27	8,33	30,42	0,36	41,51	0,03	9,02	3,18
2015	26,16	23,07	3,48	35,34	2,57	51,17	0,02	5,61	5,16
2016	27,04	28,13	1,21	38,13	2,36	43,91	0,01	5,14	8,41
2017	25,70	24,85	6,32	33,49	0,74	46,25	0,01	9,21	6,80
2018	26,98	25,45	14,89	28,88	0,65	49,99	0,04	8,95	4,16
2019	33,19	28,72	2,73	32,17	0,78	62,17	0,07	12,25	6,38
2020	27,45	25,14	1,06	34,36	1,01	50,46	0,05	6,08	8,27
2021	25,09	24,22	12,09	30,27	0,99	41,11	0,08	1,57	11,10
2022	29,75	22,17	11,56	22,73	0,59	54,70	0,02	3,04	8,00

Table 7. Balassa indexes for Ukrainian grains

Overall, Ukrainian cereals have shown strong competitiveness in the recent period. There was a year (2019) when the Balassa index was above 30. Wheat and maize are the cereals that support this very strongly. Barley has also shown very good values. Rye indicators also show strong competitiveness in most years, but millets and sorghum also demonstrated their comparative advantage. Rice is absolutely not a Ukrainian cereal, but oats are also questionable.

Conclusions

The article analysed the situation of grain production and trade in Russia, Ukraine and Belarus until 2021-22. Cereal production and trade data show that cereals are of particular importance in these countries. For Ukraine and Russia, clearly. Russia has been striving for self-sufficiency since 2015, while Ukraine is a world trade leader for both maize and wheat. In terms of import volume, the share of cereals in Ukraine was only 1% of total imports between 2010 and 2023, while it was even lower in the other two countries. The export volume of cereals in Belarus was also subdued. However, in Russia they were 2-3%, while in Ukraine they were 30-40%. And had it not been for the war, it would have been much

larger. In most cases, it is true that the products exported were those that had a comparative advantage. Russian wheat, and Ukrainian wheat, maize, barley are among them. The war has upset the trade lines, so it can be said that further investigation is needed, with more up-to-date data to establish who won the grain market in this conflict.

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Bridging the Divide - Expanding Access to Infertility Treatments

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Abstract: Access to assisted reproductive technologies (ART) varies significantly across socioeconomic and geographic contexts. In developed countries, financial barriers often hinder access, with costs reaching \$12,000–\$15,000 per IVF cycle in places like the U.S., making public funding and private grants vital. However, the challenges for people living in developing countries are even more extreme, where financial difficulties are compounded by cultural and religious pressures to become parents. Addressing stigma, improving healthcare infrastructure, and offering lowcost solutions are even more essential there. Bridging these disparities requires innovative global strategies. Government subsidies, NGO initiatives, and awareness campaigns could make treatments more equitable. Early screening programs and low-cost innovations like fertility tourism offer additional pathways, though ethical oversight remains crucial. By uniting efforts across developed and developing contexts, these solutions aim to create a more inclusive framework for infertility care worldwide.

Keywords: infertility; AVR; equal opportunities.

1 Introduction

Infertility treatment is an essential component of modern healthcare, addressing not only medical challenges but also the emotional, psychological, and social well-being of individuals and couples. The ability to conceive and have children is deeply intertwined with personal identity, family dynamics, and societal expectations. For those who experience infertility, the inability to have children can lead to profound emotional distress, impacting mental health and overall quality of life (Bunting - Boivin, 2010). Access to infertility treatment provides hope and a potential solution for individuals who wish to build a family but are unable to do so naturally (Ombelet, 2020).

The importance of infertility treatment extends beyond the individual to include broader societal implications. In many cultures, parenthood is regarded as a fundamental milestone, and those who cannot have children may face stigma, discrimination, or social exclusion (Mascarenhas et al., 2012). This is particularly pronounced in regions where fertility is closely tied to social status and gender roles. By providing effective infertility treatments, societies can alleviate the social pressures and emotional suffering associated with childlessness. These treatments help to foster inclusivity and support for those struggling with infertility, challenging outdated perceptions and reducing the stigma surrounding reproductive health issues (Inhorn - Patrizio, 2015). Moreover, infertility treatment is crucial for addressing the medical conditions that often underlie reproductive challenges. Infertility can result from a wide range of health issues, including hormonal imbalances, infections, structural abnormalities, and genetic factors (Zegers-Hochschild et al., 2017). By diagnosing and treating these conditions, infertility care not only enhances the chances of conception but also improves overall reproductive health. Early intervention through infertility treatment can prevent the progression of these conditions and reduce the risk of complications later in life (Carson - Kallen, 2021).

Infertility treatment is also important from an economic perspective. In countries with declining birth rates, such as Japan, South Korea, and many European nations, supporting individuals who wish to conceive can contribute to population sustainability (Trner, 2020). These countries face challenges related to aging populations and shrinking workforces, which can strain social services and economic growth. By investing in infertility treatments and making them accessible, governments can help mitigate these demographic challenges. Policies that support reproductive health, including subsidies for assisted reproductive technologies (ART) and comprehensive healthcare coverage, are vital for maintaining balanced population dynamics (Zhang et al., 2022).

Additionally, infertility treatment promotes gender equality by addressing reproductive health issues faced by both men and women. Historically, infertility has often been viewed as a female issue, but research has shown that male infertility is a contributing factor in about half of all cases (Kushnir et al., 2017). Modern infertility treatments, including options such as intrauterine insemination (IUI), in vitro fertilization (IVF), and intracytoplasmic sperm injection (ICSI), provide solutions for both male and female infertility (Agarwal et al., 2021). By acknowledging and addressing the reproductive health needs of all genders, infertility care supports a more equitable approach to healthcare and family planning (Colaco - Sakkas, 2018).

On top of all these, access to infertility treatment reflects a society's commitment to reproductive rights and healthcare equity. Infertility affects people from all socioeconomic backgrounds, but the ability to seek treatment is often limited by financial constraints (Chambers et al., 2019). In high-income countries, the cost of

ART can be prohibitive, while in low- and middle-income countries, a lack of medical infrastructure further compounds the issue (Ombelet, 2024). Ensuring that infertility treatment is available and affordable for all individuals, regardless of their economic status, is essential for upholding the principles of healthcare equity and human rights. Bridging these gaps through subsidies, public funding, and international cooperation can create a more inclusive and supportive environment for those facing infertility (Adamson et al., 2024).

All in all, infertility treatment is vital for addressing the medical, emotional, and societal challenges associated with reproductive health. It offers hope to individuals and couples, helps to reduce stigma, supports population sustainability, promotes gender equality, and reflects a commitment to healthcare equity. By prioritizing access to infertility care, societies can enhance the well-being of their citizens and foster a more inclusive and compassionate approach to reproductive health.

2 Infertility treatments in the past

Throughout history, cultural beliefs heavily influenced how infertility was perceived and treated. For instance, in many societies, childlessness was seen as a curse or divine punishment. As scientific understanding grew, these perceptions began to shift, though cultural stigma surrounding infertility persisted into the late 20th century (Holland – Hogg, 2010).

Infertility treatments before the end of the 20th century were shaped by a mix of medical innovation, cultural practices, and early scientific understanding. In ancient societies, infertility was often viewed as a spiritual or moral issue. Treatments involved rituals, prayers, and offerings to deities associated with fertility. For example, in Ancient Egypt, women would place a mixture of honey and natron in the vagina to promote conception (Haimov-Kochman - Sciaky-Tamir - Hurwitz, (2005). *Reproduction concepts and practices in ancient Egypt mirrored by modern medicine. European Journal of Obstetrics & Gynecology and Reproductive Biology*, 123(1), 3-8.). During the Middle Ages and Renaissance, infertility was often blamed on women, reflecting societal gender biases. Treatments included herbal remedies and various forms of “purgation” believed to cleanse the body of impurities (Lans - Taylor-Swansson - Westfall, 2018). However, the works of physicians like Avicenna (Ibn Sina) already in the 11th century included detailed descriptions of reproductive health and early attempts at diagnosing infertility (Gutas, 2001).

Luckily, the Enlightenment and advances in medical knowledge led to more systematic approaches to infertility. Doctors began to understand the role of anatomy and physiology in reproduction. For example, John Hunter, an 18th-

century Scottish surgeon, performed one of the earliest recorded artificial inseminations in 1790 by inseminating a woman with her husband's sperm (Johnson, 2013). This marked the beginning of scientific interventions in infertility treatment. However, it wasn't till the early 20th century that surgical techniques to address infertility caused by anatomical issues, such as tubal blockages, were developed. Surgeons like Robert Lawson Tait and Howard Atwood Kelly were instrumental in pioneering procedures to repair damaged fallopian tubes and correct other gynecological disorders that contributed to infertility (Wallach – Siegler, 1977). Their work laid the foundation for modern reproductive surgeries, offering hope to women facing structural infertility issues.

Artificial insemination became more widely practiced in the mid-20th century, providing a solution for male infertility (Eisenberg et al., 2023). The first successful pregnancy through frozen sperm occurred in 1953 (Bunge - Sherman, 1953). By the 1960s and 1970s, research into in vitro fertilization (IVF) was advancing. The groundbreaking birth of Louise Brown in 1978 marked the first successful IVF procedure by Dr. Robert Edwards and Dr. Patrick Steptoe (Steptoe - Edwards, 1978). This milestone laid the foundation for modern infertility treatments. Additionally, the discovery of hormones and their role in reproduction led to the use of hormone therapy to treat conditions like anovulation.

3 Infertility treatment in the 21st century

Advances in 21st-century reproductive medicine have provided an array of treatment options that cater to the diverse causes of infertility. From ovulation induction and in vitro fertilization (IVF) to specialized techniques like intracytoplasmic sperm injection (ICSI) and preimplantation genetic testing (PGT), these innovations offer new hope to those seeking to build a family. These 21st-century infertility treatments provide a broad spectrum of options tailored to the severity and underlying causes of infertility. Current chapter introduces, how these treatments address both male and female infertility, while acknowledging the socio-economic and cultural factors that influence access and outcomes.

For women with ovulatory disorders or irregular cycles, ovulation induction remains a first-line treatment. Medications like gonadotropins are used to stimulate the ovaries to release eggs, addressing mild to moderate cases of hormonal imbalances or unexplained infertility (Palomba et al., 2021). When these treatments are ineffective or underlying issues are more severe, such as blocked fallopian tubes or advanced endometriosis, In Vitro Fertilization (IVF) is often recommended. IVF involves retrieving mature eggs, fertilizing them outside the body, and transferring the resulting embryos to the uterus, bypassing issues related to tubal damage (Ma et al., 2023).

For women who experience premature ovarian failure or who have no viable eggs due to age-related decline, donor egg cycles provide an effective solution (Donnez - Dolmans, 2017). Eggs from a healthy donor are fertilized, and the resulting embryos are transferred to the recipient's uterus. In cases where a woman cannot carry a pregnancy due to uterine abnormalities or medical conditions, gestational surrogacy is a viable option, allowing the intended mother's or donor's embryo to be carried by a surrogate (Manvelyan et al., 2024). For those wishing to delay childbearing for personal or medical reasons, egg freezing (oocyte cryopreservation) allows women to preserve their fertility by storing eggs at a younger age for future use, with success rates improving due to advancements in vitrification techniques (Cobo et al., 2021).

Male infertility treatments have also evolved significantly in the 21st century. For men with mild infertility factors such as low sperm motility or cervical issues in the female partner, Intrauterine Insemination (IUI) is a common approach. This method involves placing washed sperm directly into the uterus to increase the chances of fertilization (Esteves et al., 2018). For moderate to severe cases, such as low sperm count or poor sperm morphology, In Vitro Fertilization (IVF) combined with Intracytoplasmic Sperm Injection (ICSI) is highly effective. ICSI involves injecting a single healthy sperm directly into an egg, overcoming many male infertility barriers by facilitating fertilization regardless of sperm quality or quantity (Alasmari et al., 2018).

For men who have non-obstructive azoospermia (a condition where no sperm are present in the ejaculate), surgical techniques like testicular sperm extraction (TESE) can retrieve viable sperm directly from the testes for use in ICSI (Qi et al., 2021). In cases where the male partner has no viable sperm due to genetic factors, prior surgeries, or medical conditions, donor sperm offers a solution, allowing couples to proceed with IUI or IVF using sperm from a donor (Gekowitz et al., 2018).

Some modern infertility treatments are applicable to both men and women and address underlying causes affecting either partner. For example, preimplantation genetic testing (PGT) is used alongside IVF to screen embryos for genetic abnormalities, increasing the likelihood of a successful pregnancy, particularly for older couples or those with a history of recurrent miscarriages (Olcay - Ergun – Basar, 2023). Additionally, lifestyle and environmental interventions have become an integral part of fertility care, with recommendations to address factors such as diet, exercise, and exposure to pollutants, which can impact reproductive health in both men and women (Osadchuk - Osadchuk, 2023).

4 Affordability of infertility treatments

Infertility treatments, while offering hope to individuals and couples unable to conceive naturally, come at a significant financial cost (Njagi et al., 2023). This expense varies widely depending on the type of treatment, the severity of infertility, and the geographic location where the treatment is sought. In the United States, where healthcare costs are notoriously high, assisted reproductive technologies (ART) such as In Vitro Fertilization (IVF) can pose a daunting financial burden (Conrad, Grifo, 2023). Prices for a single IVF cycle in the U.S. range from \$20,000 to \$40,000. This figure typically does not include the additional costs for medications, diagnostic tests, genetic screening, or multiple cycles that are often necessary for success. When considering that most individuals require more than one cycle to achieve pregnancy, the cumulative expense can quickly become overwhelming, placing ART out of reach for many people without substantial insurance coverage or personal savings.

The high cost of infertility treatment in the U.S. highlights a significant barrier to accessibility. Unlike other medical treatments, infertility care is often not fully covered by health insurance, leaving patients to pay out-of-pocket. Public funding options are limited, and private grants are highly competitive. This situation creates disparities, where only those with financial resources or employer-provided insurance plans can afford comprehensive fertility care. As a result, financial constraints frequently dictate who can and cannot pursue parenthood through ART, exacerbating existing inequalities within the healthcare system.

Country	Avg IVF Cost/ Cycle (USD)	GDP/Capita (USD)	Avg. monthly net salary	Infertility Prevalence (%)
Hungary	\$2100 – \$4500	17881	1652	15
India	\$3000 – \$6500	2389,1	212	15
Costa Rica	\$3000 – \$7500	13198,8	1154	14
Turkey	\$4000 – \$7000	10655	971	10
Mexico	\$4000 – \$7300	10045	1008	15
Greece	\$4000 – \$7700	22812	1882	15
UAE	\$4000 – \$8000	48950	4441	10
Cyprus	\$5000 – \$7000	30000	598	12
Dominican Republic	\$5000 – \$8000	10716	557	17
Thailand	\$5000 – \$10000	7233	1040	16
Georgia	\$5000 – \$15000	6000	929	15
UK	\$15000 – \$30000	47334	3983	12,5
USA	\$20000 – \$40000	76399	6676	12,5

Table 1. Average costs of IVF and other macroeconomic indicators across various nations

Source: Own compilation on the basis of WHO (2023) and World Bank (2023) data

When comparing these costs to those in other countries, the disparities in affordability become even more apparent. Table 1 provides a comparative view of IVF costs, GDP per capita, and average monthly salaries across different regions, illustrating how these factors intersect to shape access to fertility care. For example, in Hungary, the cost of an IVF cycle ranges from \$2,100 to \$4,500. This is significantly lower than in the U.S., yet when viewed in the context of Hungary’s average monthly net salary of \$1,652 and a GDP per capita of \$17,881, these treatments still represent a substantial financial burden. Similarly, in Greece, where IVF costs between \$4,000 and \$7,700, the average monthly salary of \$1,882 means that a single cycle can consume several months of income, making fertility care challenging to afford despite lower treatment costs.

In middle-income countries like Mexico and Turkey, the costs of IVF are slightly lower but still pose affordability challenges. In Mexico, an IVF cycle costs between \$4,000 and \$7,300, while the average monthly salary is \$1,008. In Turkey, the cost ranges from \$4,000 to \$7,000, against an average monthly salary of \$971. For many individuals in these regions, paying for fertility treatments can mean exhausting their entire savings or incurring significant debt. The situation is similar in countries like Thailand and Georgia, where IVF prices range between \$5,000 and \$15,000, and monthly salaries hover around \$1,040 and \$929, respectively. In these contexts, infertility treatments remain a luxury that only a small segment of the population can afford.

On the other hand, some high-income countries offer more favorable conditions for accessing ART. In the United Arab Emirates, for instance, the cost of an IVF cycle is between \$4,000 and \$8,000, while the average monthly salary is \$4,441, and GDP per capita stands at \$48,950. These figures suggest that fertility treatments are relatively more accessible in the UAE compared to the U.S. or many European countries. The same is true for Cyprus, where IVF costs between \$5,000 and \$7,000, but the average monthly salary is lower at \$598, making affordability a challenge despite the moderate cost of treatment.

In the Dominican Republic, where infertility prevalence is among the highest at 17%, IVF costs between \$5,000 and \$8,000, while the average monthly salary is \$557. This creates a stark affordability gap, where access to fertility care is limited to the wealthiest individuals. In India, the situation is similarly challenging, with IVF costs ranging from \$3,000 to \$6,500, but the average monthly salary is just \$212. Despite lower treatment costs compared to Western nations, the financial burden remains severe for the majority of the population.

The data from Table 1 highlights that while IVF treatments are less expensive in many countries outside the United States, affordability is still a significant issue due to lower incomes and GDP per capita. Even in regions where medical costs are reduced, the relative expense of infertility treatments compared to average earnings poses a substantial barrier. These disparities underscore the need for innovative solutions, such as government subsidies, insurance coverage, and international cooperation to make infertility care more accessible and equitable.

The analysis of infertility treatment costs and their affordability (displayed by Figure 1.) across various countries also reveals several distinct patterns. In high-income countries such as the United Arab Emirates and the United States, we see a contrast in the affordability of assisted reproductive technologies (ART). In the UAE, despite moderate IVF costs, higher salaries make these treatments significantly more accessible, as reflected in the low IVF price-to-salary ratio. In contrast, the United States, though similarly high in GDP per capita, suffers from exorbitant treatment costs, resulting in a higher IVF price-to-salary ratio. This disparity indicates that the financial burden of infertility treatments is not solely determined by income levels but is also heavily influenced by healthcare policies, insurance coverage, and public funding.

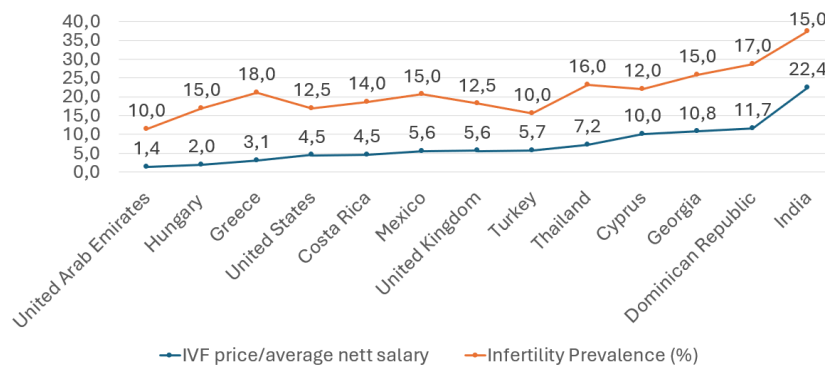


Figure 1. The affordability of IVF treatments and their prevalence across nations
 Source: Own compilation on the basis of WHO (2023) and World Bank (2023) data

In middle-income countries such as Hungary, Greece, Mexico, and Turkey, a pattern of moderate treatment costs combined with relatively low average salaries emerges. In these regions, the IVF price-to-salary ratios are higher, making ART less affordable despite treatment prices being lower than in the United States. This suggests that even when costs are reduced, limited disposable income and economic challenges pose significant barriers to accessing infertility care. Greece, in particular, highlights the impact of economic instability on healthcare affordability, with one of the highest ratios and a relatively high infertility prevalence rate.

In developing countries such as India, Georgia, and the Dominican Republic, a stark pattern of severe affordability challenges is evident. The IVF price-to-salary ratios are extremely high, reflecting a situation where the cost of a single IVF cycle can far exceed several months' worth of income. In these regions, even though treatment costs are comparatively low, the financial burden remains insurmountable for most individuals due to low wages and minimal healthcare support. This pattern highlights the compounded challenges faced by developing countries, where limited access to quality healthcare, cultural pressures, and economic constraints intersect to create significant barriers to infertility treatment.

Another interesting pattern is the relationship between infertility prevalence and affordability. Countries with higher infertility rates, such as the Dominican Republic and India, often face the greatest challenges in accessing ART due to financial constraints. In contrast, countries with lower infertility prevalence, like Turkey and the UAE, tend to show better affordability or more favorable conditions for treatment. This disparity underscores the urgent need for targeted policy interventions and international support to address the regions where the need for infertility care is most acute.

Conclusions

The affordability of infertility treatments is shaped by a complex interplay of economic, healthcare, and societal factors, creating significant disparities in access to assisted reproductive technologies (ART) across different regions. In high-income countries, such as the United Arab Emirates and the United States, the financial burden of ART varies widely. The UAE's relatively affordable IVF price-to-salary ratio reflects a healthcare system where higher average salaries make fertility treatments more accessible. In contrast, the United States, despite high GDP per capita, suffers from exorbitant treatment costs and limited insurance coverage, making ART unaffordable for many individuals.

In middle-income countries like Hungary, Greece, Mexico, and Turkey, the cost of IVF is moderate, yet the affordability remains limited due to lower average salaries. The IVF price-to-salary ratios in these regions demonstrate that, even when treatment costs are reduced, financial constraints and economic challenges still act as significant barriers to access. This reality underscores the need for comprehensive healthcare policies, including public funding and subsidies, to support those seeking fertility care.

In developing countries such as India, Georgia, and the Dominican Republic, the financial burden of ART is particularly severe. Low average incomes result in IVF price-to-salary ratios that far exceed several months' worth of earnings. Despite lower treatment costs compared to high-income nations, the lack of affordable healthcare options and minimal governmental support make ART inaccessible for the majority of the population. These disparities highlight the compounded challenges faced by developing regions, where cultural stigma, inadequate healthcare infrastructure, and economic hardships intersect to limit access to infertility treatments.

Another key pattern is the relationship between infertility prevalence and the affordability of ART. Countries with higher infertility rates, such as the Dominican Republic and India, often face the greatest challenges in accessing fertility treatments due to financial barriers. In contrast, regions with lower infertility prevalence, such as Turkey and the UAE, tend to have more favorable conditions for treatment affordability. This discrepancy emphasizes the urgent need for targeted policy interventions, including government subsidies, NGO support, and international cooperation, to address the regions with the highest need for infertility care.

Bridging these disparities requires innovative global strategies that prioritize equity and inclusivity in reproductive healthcare. Government-funded programs, insurance coverage, and affordable treatment initiatives are crucial for ensuring that ART is accessible to all, regardless of economic status or geographic location. By fostering international collaboration and addressing systemic barriers, we can

create a more inclusive framework for infertility care, offering hope and support to individuals and couples worldwide.

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More Developed, Less Fertile

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Abstract: The paradox of declining fertility rates in developed nations underscores the unintended consequences of modernization on reproductive health. Women in these societies often prioritize education, career advancement, and financial stability, leading to delayed childbearing. However, many are unaware of the rapid decline in fertility after age 35, coupled with increased risks of complications like miscarriage and chromosomal abnormalities. This fertility awareness gap is exacerbated by an overreliance on assisted reproductive technologies (ART), such as in vitro fertilization (IVF), which may create a false sense of security about postponing parenthood. Cultural norms and economic pressures further perpetuate this delay, with societal emphasis on personal achievements and inadequate family-friendly policies deterring early motherhood. While developed countries offer significant opportunities for women, these benefits come at the cost of rising infertility rates, emotional strain, and a growing dependency on expensive healthcare interventions. Addressing this issue requires better education about fertility, supportive workplace structures, and a cultural shift toward balancing ambitions with biological realities. Without these changes, the phenomenon of "more developed, less fertile" may continue to challenge the sustainability of populations and the well-being of individuals.

Keywords: infertility, assisted reproduction, in vitro fertilisation

1 Introduction

Infertility is a significant public health issue, affecting millions of individuals and couples worldwide (WHO, 2021). Infertility is influenced by a combination of biological, environmental, and societal factors, making it a complex issue that

requires understanding from multiple perspectives. Age plays a significant role, particularly for women, as fertility declines after 35, while environmental pollutants, lifestyle choices, and genetic predispositions also contribute. Geographical disparities mean that individuals' experiences with infertility differ vastly depending on where they live. In regions with advanced healthcare systems, patients may benefit from early diagnoses and modern treatments, while in less-developed areas, a lack of infrastructure can lead to untreated conditions causing permanent infertility. Cultural perceptions further shape how infertility is viewed, with childlessness carrying a heavy stigma in many societies. In some regions, social exclusion and emotional distress can accompany infertility, particularly for women. On top of this, financial barriers can delay or prevent access to assisted reproductive technologies (ART), making public funding or insurance coverage essential. Addressing these disparities requires a multifaceted approach, combining subsidies, NGO initiatives, awareness campaigns, and innovative solutions like fertility tourism. Current article endeavours to provide some metrics on the basis of which access to treatment can be assessed and equal opportunities can be initiated.

2 Infertility and its patterns

The World Health Organization (WHO) defines infertility as the inability to conceive after 12 months or more of regular, unprotected sexual intercourse (WHO, 2021). This definition encompasses both primary infertility, where conception has never occurred, and secondary infertility, where individuals struggle to conceive following a previous pregnancy. The condition is not confined to women alone; male infertility contributes to approximately 50% of all infertility cases (Agarwal et al., 2015). As scientific understanding grows, the perception of infertility has shifted from being solely a female issue to a complex medical condition affecting both genders.

Infertility is perceived differently across cultures and regions, influenced by social, religious, and economic contexts. In high-income countries, infertility is increasingly viewed as a medical condition that can often be treated through assisted reproductive technologies (ART) such as in vitro fertilization (IVF) (Mascarenhas et al., 2012). However, infertility treatment is oftentimes only accessible to those who can afford it or who have insurance coverage.

In contrast, the perception of infertility in low- and middle-income countries is often shaped by cultural and societal expectations. In many African, Middle Eastern, and South Asian societies, parenthood is viewed as a cornerstone of identity, marriage, and social status (Dyer, 2007). Childlessness can lead to social stigma, emotional distress, and even ostracism, particularly for women (Ombelet et al., 2008). In regions such as sub-Saharan Africa, where infertility rates exceed

20%, the pressure to conceive is immense (Larsen, 2000). These cultural perceptions are compounded by a lack of access to quality healthcare, delayed treatment for sexually transmitted infections (STIs), and limited availability of ART.

The prevalence of infertility varies significantly across different age groups and geographical locations. Globally, an estimated 17.5% of adults experience infertility during their lifetime (WHO, 2021). However, age remains one of the most critical factors influencing fertility outcomes. Female fertility declines significantly after the age of 35, with a marked decrease in ovarian reserve and egg quality (Broekmans et al., 2009). This trend is particularly pronounced in developed countries, where educational and career aspirations often lead to delayed childbearing (Van der Heijde et al., 2020).

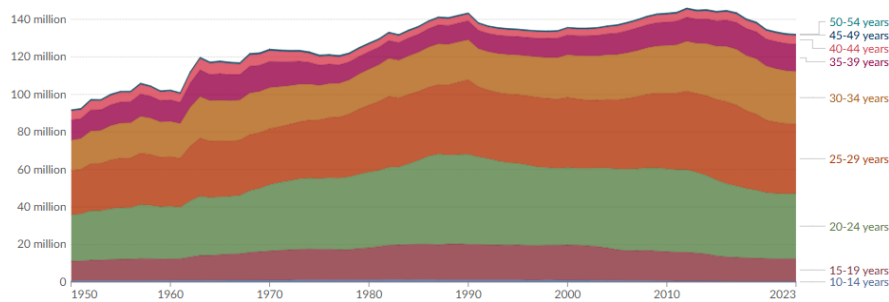


Figure 1. Births by age of mother
Source: Our World in Data (2024)

As a result, women in their late 30s and early 40s increasingly rely on ART, such as IVF and egg freezing, to achieve pregnancy. In the United States, according to the Centers for Disease Control and Prevention (CDC) the use of ART has more than doubled over the past two decades, with women over 35 representing a substantial proportion of patients (Nugent – Chandra, 2024).

As Figure 2 and 3 indicate, the parental age has significant positive correlation with the percentage of ART in the North European population.

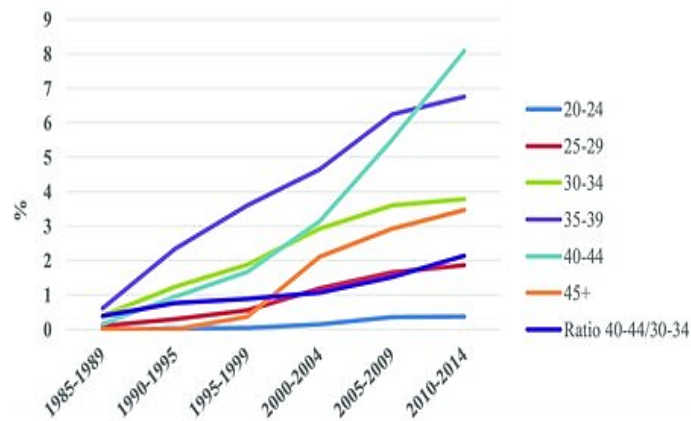


Figure 2. Percentage of ART births by maternal age
Source: Goisis et al. (2020)

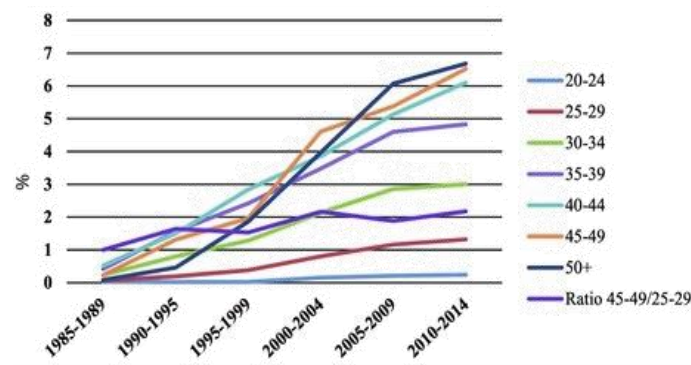


Figure 3. Percentage of ART births by paternal age
Source: Goisis et al. (2020)

The data from Figures 2 and 3 illustrate the percentage of assisted reproductive technology (ART) births by maternal and paternal age categories over the period from 1985 to 2014. When viewed together, these figures reveal clear trends and patterns, highlighting the relationship between age and the use of ART for both mothers and fathers.

In the maternal age data, there is a significant increase in the percentage of ART births among older age groups, particularly for women aged 30-34 and 35-39. This trend becomes more pronounced over time, with the percentage for the 30-34 age group rising from about 2% in 1985-1989 to over 7% in 2010-2014. Similarly, the

percentage for the 35-39 age group increases from under 1% to around 5.5% in the same period. These trends suggest that more women are delaying childbearing and relying on ART to achieve pregnancy as they age. Contrary to this, the percentage of ART births among younger maternal age groups, such as 20-24 and 25-29, remains relatively low and even shows a slight decline or stagnation. For example, the 20-24 age group starts at 0.4% and decreases to 0.3% by the end of the period. The 25-29 age group increases modestly but plateaus at around 2.5% by 2010-2014. This reflects a broader societal trend where younger women are less likely to need ART, possibly because they experience fewer fertility challenges compared to older age groups.

The paternal graph shows a similar pattern of increasing ART usage among older men. The 30-34 and 35-39 age groups show significant growth, with the percentage of ART births for the 30-34 age group increasing from about 2% to nearly 6% by 2010-2014. The 35-39 age group also rises consistently, reaching around 4.2% by the end of the period. This indicates that ART is being increasingly utilized by men who are in their 30s and late 30s. For older paternal age groups, such as 40-44 and 45-49, the percentage of ART births also increases, though at a slower rate. The 40-44 age group rises from 0.6% to 1.8%, and the 45-49 age group climbs gradually from 0.2% to 0.9%. The 50+ age group remains low, increasing slightly from 0.1% to 0.5%. These trends suggest that while older paternal age is associated with increased fertility challenges, ART is helping older men achieve fatherhood.

When comparing maternal and paternal age trends, several key patterns emerge. The increase in ART usage is more pronounced for women aged 30-39 compared to men in the same age range. For example, by 2010-2014, the percentage of ART births for women aged 30-34 is around 7.1%, while for men of the same age group, it is 5.8%. This discrepancy may reflect the greater impact of maternal age on fertility outcomes and the increased likelihood that women in their 30s seek ART due to age-related fertility decline. In contrast, younger paternal age groups, such as 20-24 and 25-29, show higher percentages of ART births compared to their maternal counterparts. For example, the 25-29 paternal age group reaches 5% by 2010-2014, while the corresponding maternal age group remains at 2.6%. This suggests that younger men are more likely to be involved in ART births compared to younger women, possibly due to male fertility being less affected by age in this range.

Another notable observation is the ratio of older to younger age groups. The ratio of ART births for men aged 45-49 compared to those aged 25-29 (shown as the Ratio 45/25) indicates that older paternal age groups are increasingly represented in ART births. This trend parallels the increasing ratio of ART births for women aged 40-44 compared to those aged 30-34 (Ratio 40/30), reinforcing the pattern that couples are turning to ART at older ages.

3 Disparities in infertility

In developing countries, infertility tends to affect an even broader range of age groups, often due to untreated infections, poor reproductive health services, and inadequate maternal care (van Gorkom, 2021). In regions such as South Asia and sub-Saharan Africa, STIs, postpartum complications, and unsafe abortions are leading causes of infertility (Ombelet, 2015). The lack of early screening and treatment options exacerbates these issues, leading to higher rates of infertility among younger women compared to their counterparts in developed nations. Additionally, male infertility due to infections, malnutrition, and environmental factors is more prevalent in these regions (Agarwal et al., 2015).

The perception of infertility is further influenced by the availability of innovative solutions and ethical considerations. In recent years, fertility tourism has emerged as a viable option for individuals seeking affordable treatment abroad. Countries such as the Czech Republic, and Greece have become popular destinations for fertility tourism due to lower costs and high-quality services (Inhorn & Patrizio, 2009). However, ethical concerns surrounding the exploitation of patients and donors in less-regulated markets remain a challenge (Whittaker et al., 2024). Additionally, awareness campaigns and NGO initiatives play a crucial role in destigmatizing infertility and promoting equitable access to treatment. Programs that provide education on reproductive health, early screening, and affordable ART options are essential in bridging the gap between developed and developing contexts (Ombelet et al., 2008).

Geographically, infertility rates also differ based on socioeconomic and healthcare infrastructure. In high-income countries such as Japan, Germany, and the United Kingdom, infertility rates are often below 10% (Mascarenhas et al., 2012). These countries benefit from advanced healthcare systems, early intervention programs, and widespread availability of ART. However, financial constraints and varying levels of public support influence access to these treatments. For example, in Germany, where certain ART procedures are partially covered by insurance, access remains more equitable compared to the United States (Kleyner, 2023). In contrast, in countries like India and Nigeria, infertility rates are higher, ranging from 15% to 20% (WHO, 2021). The combination of limited healthcare access, cultural stigma, and inadequate public health infrastructure contributes to these elevated rates.

Figure 3 displays the fertility rates of the different continents, which is already showing some disparities despite such high level aggregate data inevitably hiding the variability of infertility rates on a country or specific demographic group level.

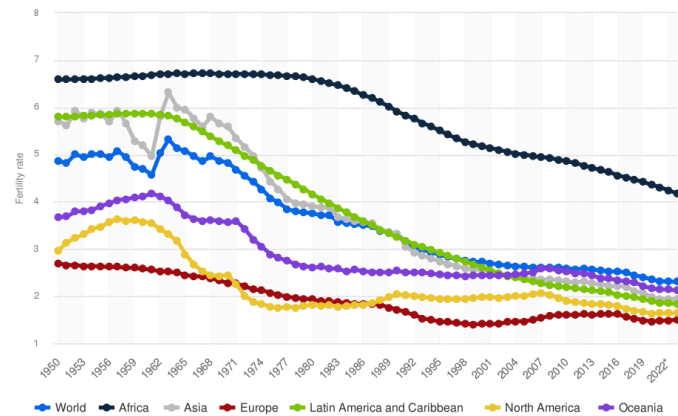


Figure 4. Fertility rates by continents
Source: Statista (2024)

Figure 4 indicates a clear global decline in fertility rates, which is particularly pronounced in regions like Europe and North America. For instance, Europe has experienced one of the steepest declines, now well below the replacement rate of 2.1 children per woman.

In contrast, regions such as Africa still maintain relatively high fertility rates, although they too are gradually declining. This stark difference highlights the demographic divide between developed and developing regions. The trends underscore the impact of modernization, education, and access to healthcare on family planning decisions.

It's also worth noting that while developing regions face challenges related to overpopulation, developed countries are grappling with aging populations and potential workforce shortages due to these declining fertility rates.

However, it is not only between countries and regions that disparities in infertility and access to/use of ART is significantly different. Even within a given country different demographic groups have different patterns.

According to Goisis and his coworkers' (2020) findings there is a growing reliance on ART among both older women and men over the past few decades. The trends suggest that as more individuals delay parenthood, ART becomes an essential tool for overcoming age-related fertility challenges.

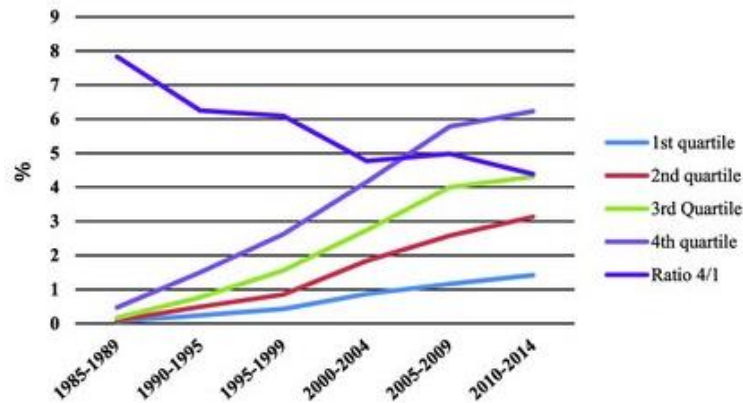


Figure 5. The trajectory tracking
Source: Goisis et al. (2020)

Figure 5 illustrates the distribution of assisted reproductive technology (ART) births across different income quartiles from 1985 to 2014. The graph clearly shows that higher-income groups, represented by the fourth quartile, consistently account for the largest percentage of ART births. Although the percentage of ART births in this group shows a slight decline over the years, it remains significantly higher compared to the other income groups. This trend underscores the financial barriers that restrict access to ART, making it more feasible for wealthier families who can afford the high costs of treatments like IVF.

In contrast, middle-income groups, represented by the second and third quartiles, show a gradual increase in ART births over the observed period. This upward trend suggests that more families in these income brackets are accessing ART services, possibly due to improvements in insurance coverage, financial assistance programs, or a reduction in treatment costs. However, despite this increase, their levels remain far below those of the highest-income group, reflecting the ongoing financial challenges they face.

The lowest-income group, represented by the first quartile, consistently shows the smallest percentage of ART births throughout the entire period. The minimal increase over time indicates that significant financial and systemic barriers remain for this group. ART services continue to be largely inaccessible to families with lower incomes, highlighting a critical disparity in reproductive healthcare.

The ratio comparing the fourth quartile to the first quartile (4/1) further emphasizes this disparity. Although there is a slight decline in this ratio, it remains high, indicating that the gap in ART accessibility between the wealthiest and the poorest has persisted over the decades. This disparity points to a systemic issue where access to reproductive technologies is heavily influenced by financial status.

The implications of data on Figure 5 are significant. The persistent dominance of higher-income groups in ART usage suggests that financial resources play a decisive role in determining access to fertility treatments. Despite technological advancements and increasing awareness of infertility, lower-income families face

insurmountable challenges, such as the high cost of treatment, lack of comprehensive insurance coverage, and limited availability of specialized clinics.

Addressing these disparities requires targeted policy interventions. Government subsidies, improved insurance coverage for infertility treatments, and the expansion of publicly funded ART services are potential solutions to reduce financial barriers. Without these changes, ART will continue to be an option primarily for those who are economically privileged, perpetuating inequalities in reproductive healthcare. Hence, while there has been some progress in making ART more accessible to middle-income families, the data highlight the urgent need for policies aimed at bridging the socioeconomic gap. Ensuring equitable access to ART means creating a system where financial status does not determine one's ability to pursue parenthood through these technologies.

Conclusions

The analysis of infertility trends highlights a pressing paradox in modern developed societies: as education, career opportunities, and financial stability for women increase, fertility rates decline. This phenomenon is exacerbated by delayed childbearing, where individuals often underestimate the rapid decline in fertility after age 35. The reliance on assisted reproductive technologies (ART), such as in vitro fertilization (IVF), provides a viable path to parenthood but remains financially burdensome and emotionally taxing. The disparities in ART access, influenced by socioeconomic status and geographic location, further complicate the landscape of infertility care.

Developed nations grapple with the challenge of balancing personal ambition with biological realities, while developing countries face cultural stigmas, healthcare limitations, and economic barriers that hinder access to infertility treatments. The data reflect an increasing reliance on ART among older age groups and higher-income families, underscoring the need for systemic change to bridge these inequalities. Effective solutions require comprehensive education on fertility awareness, supportive workplace policies, government subsidies, and expanded access to ART. Only through these multifaceted interventions can we address the disparities that persist across socioeconomic and geographical contexts. By promoting equitable access to reproductive care, societies can better support individuals and couples in achieving their family aspirations, ensuring that financial status or cultural barriers do not dictate one's ability to pursue parenthood. The sustainability of populations and the emotional well-being of individuals depend on our willingness to confront these challenges head-on and create a more inclusive framework for infertility care.

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Left The Threat of AI-Generated Fake News to Critical Infrastructures: Case Studies and Defensive Strategies

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Abstract: The proliferation of artificial intelligence (AI)-generated fake news poses a significant threat to critical infrastructures by disseminating misinformation that can disrupt essential services and erode public trust. This paper aims to analyze the impact of AI-generated disinformation (fakenews, -photos, -videos) on critical infrastructure sectors, including energy, transportation, and healthcare. Through detailed case studies of real-world incidents, such as the 2007 Aurora Generator Test, which demonstrated how cyberattacks could physically damage power grid components, we examine the mechanisms by which AI-generated fake news has been employed to compromise infrastructure integrity. The study employs a qualitative methodology, analyzing documented instances where AI-generated disinformation campaigns have targeted critical infrastructure, leading to operational disruptions or public misinformation. The findings highlight the vulnerabilities of critical infrastructure to AI-driven fake news and underscore the necessity for robust defense mechanisms. In response, the paper proposes a comprehensive set of countermeasures, including the implementation of advanced AI detection systems, the development of rapid response protocols, and the establishment of public awareness programs to mitigate the impact of disinformation. By synthesizing these strategies, the study offers a framework for enhancing the resilience of critical infrastructures against the evolving threat of AI-generated fake news.

Keywords: AI-generated disinformation, Critical infrastructure, Misinformation impact, Case studies, Defensive strategies

1 Introduction

Critical infrastructures such as electricity generation, transmission and distribution; telecommunications; water supply; public institutions; public services; financial services are increasingly under attack. One type of hybrid warfare attack is deception through fake news. There are various forms of these, such as fake websites, spam or SMS notifications, phone calls. All of these are supported by a seemingly credible composition and structure of content, which is then shared between people through different channels, for example verbally, on social media or in forwarded emails. People are not prepared to be victims of viral pseudo-news on seemingly innocuous platforms. So the question rightly arises: who is responsible for fact-checking and how? These are the questions and dilemmas addressed in my research and presentation. Greater media awareness, fact-checking and good quality media education can play a key role in countering attacks on critical infrastructure through fake news.

To illustrate these vulnerabilities, I will now present three case studies demonstrating how fake news threatens critical infrastructures.

2 Theoretical framework

2.1 Critical Infrastructure Framework

In this chapter, I review possible definitions of critical infrastructures.

In the publication *Methodology for Defining Critical Information Infrastructures* published in 2009, the authors emphasize that there is no uniform definition and framework, but that there are significant similarities between the definitions of different countries. Thus, they review the definition frameworks of several countries or international organizations, such as the United States of America, the United Kingdom, Germany, France, Russia, Austria, the European Union or even NATO. Finally, they discuss the critical infrastructure framework applied in Hungary at that time, which includes the following. According to Government Decision 2112/2004. (V.7.)¹ on the current tasks of combating terrorism, the following areas are classified as critical infrastructures: energy supply; public works; transport and transportation; telecommunications, electronic data traffic

¹ 2112/2004. (V. 7.) Government Resolution on the current tasks of combating terrorism

and IT networks; banking system; services; media; basic drinking water and food supply; health insurance. However, they differ from those defined by both the EU and other states, as they do not include public administration, emergency services and defense and emergency organizations. Later, in 2008, the Government Resolution 2080/2008. (VI.30.) on the National Program for Critical Infrastructure Protection made a proposal for possible sectors. Such as Energy; Infocommunication technologies; transport; water; food; healthcare; finance; industry; law and order – government; public safety – defense.

The authors of the 2019 edition of the book *Critical Infrastructure Protection I.*² (Balázs Bognár, Tünde Bonnyai, and Zoltán Vámosi) emphasize the importance of protecting critical infrastructures, highlighting those infrastructures that are essential for the safe and uninterrupted functioning of society. Infrastructure is interpreted from several perspectives, taking into account the assets, institutions, and facilities that are indispensable for production and service processes. According to the book, critical infrastructures include elements in the energy sector, such as electricity generation, transmission and distribution networks, the petroleum industry, and natural gas transportation and production. These infrastructures are key to the security of the national economy and the daily lives of citizens, so their protection is critical for national security. In the case of electricity generation, for example, those elements are considered critical whose failure would cause a significant reduction in domestic electricity production. In the transmission network, elements are considered critical whose failure would irreparably reduce the available power. The distribution network, the petroleum industry, and natural gas transportation and production also contain elements whose failure would have a serious impact on the country's energy supply and economic stability. Overall, the work discusses a wide range of critical infrastructures, with particular attention to those infrastructures that are essential for maintaining the country's economic stability and the security of its citizens. According to the authors, the Hungarian interpretation of critical infrastructure is most accurately described by those formulated in the Hungarian Green Book, I quote:

“critical infrastructure is defined as those networks, resources, services, products, physical or information technology systems, equipment, devices and their components, the failure, disruption, loss or destruction of which could have a serious impact, directly or indirectly, temporarily or in the long term, on the

² Bognár B. – Bonnyai T. (2019): *Kritikus infrastruktúrák védelme I.* Dialóg Campus Kiadó, pp. 36, 42.

economic and social well-being of citizens, public health, public safety, national security, the functioning of the national economy and government”³

Robert Mikac, in his book *European Critical Infrastructure Protection*, discusses in detail the protection of critical infrastructure in the European Union (EU). Mikac's analysis focuses on how the EU seeks to protect infrastructure that is essential to the security, economic stability and well-being of its member states. The following critical infrastructures are generally considered critical in the EU:

- Energy infrastructure, including electricity grids, gas pipelines and oil pipelines, is essential for daily life, the functioning of the economy and the security of energy supplies between countries.
- Transport infrastructure, such as airports, ports, rail and road networks, is crucial for the movement of people and goods, and for internal and external trade within the EU. Information and Communication Technology (ICT) infrastructure, including the internet, telecommunications networks and data centres, is essential for the functioning of modern society, the flow of information and the maintenance of critical services.
- Water supply and treatment infrastructure, including water purification and distribution systems, is essential for human health, hygiene and the protection of ecosystems.
- The food supply chain, including agricultural production, processing and distribution, is crucial for ensuring food security and the nutrition of citizens.
- Health infrastructure, including hospitals, laboratories and pharmaceutical supply chains, is vital for protecting human life and combating disease.

2.2 Communication techniques and tactics that qualify as weapons, or fake news

There is no established, unified concept in terms of the terminology of fake news, but this is a natural part of every new phenomenon. Of course, public discourse and scientific language also distinguish different types from each other, but there is no consensus on what we call fake news. That is why I will now focus on the main trends and my own grouping.

³ Green Paper on the National Programme for the Protection of Critical Infrastructures. Annex 1 to Government Decision 2080/2008 (VI. 30.) on the National Programme for the Protection of Critical Infrastructures.

We can mention the study published by Vian Bakir et al.⁴ and the organized persuasive communication (OPC) introduced therein as a collective term. OPC actually defines organized persuasive communication forms within the broad framework of types of influence, as it includes, in addition to the colloquially understood “fake news”, propaganda, PR or marketing, for example, in the conceptual framework. On one side, there is consensual (consent-based) organized persuasive communication, which is essentially based on whether the recipient agrees to be a part of this type of communication and acts freely during the reception. Two other types of this are known: dialogic (or dialogue-based) consensual communication and strategic (one-way) consensual persuasion. Another large category of this organized persuasive communication is non-consensual or propagandistic communication, which the authors divide into four further subcategories: deception, encouragement, coercion and deceptive coercion.

We can also talk about the types of information disorder as a definitional framework. This includes disinformation, misinformation and malicious distortion. The three concepts are fundamentally distinguished from each other by one important factor, and this is the motivation for spreading the given information. Of the three, disinformation is the easiest to define. The European Commission has defined disinformation as “verifiably false or misleading information that is created, published and disseminated for economic gain or deliberate deception, and that may harm the public interest. Misinformation does not include errors in reporting, satire and parody, or news and commentary that can be clearly identified as being linked to political parties.”⁵ Analyzing the motivations, the next important concept is misinformation. There is no official, commonly used translation for this yet. Misinformation is “false information that is disseminated regardless of the intention to mislead.” Malicious distortion (malinformation) is one of the most harmful in terms of motivation, since in this case it is the dissemination of real information with malicious intent. Perhaps it can be translated as malicious fake news, although this is not accurate in that it would assume the existence of benign fake news, for which we cannot give examples (possibly pages created for satirical or parodistic purposes, although these are created more for entertainment purposes).

⁴ Bakir, V., Herring, E., Miller, D., Robinson, P. (2019): Organized Persuasive Communication: A new conceptual framework for research on public relations, propaganda and promotional culture. In: *Critical Sociology*, Vol. 45, No. 3, May 2019, pp. 1–18.

⁵ European Commission (2018): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM (2018) 236 final. European Commission. Available at: [<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0236>].

3 Case Studies

3.1 How the Colonial Pipeline ransomware attack caused a false buyout panic

In the energy sector, fake news about energy shortages or disasters can influence energy prices or cause panic buying. When Colonial Pipeline⁶ was hit by a cyberattack, a so-called ransomware attack in 2021, it was one of the most significant cyberattacks on US energy infrastructure in history. During the attack by the DarkSide ransomware group, a Colonial Pipeline employee discovered a ransomware virus that caused the company to shut down fuel deliveries, affecting more than 2.5 million barrels of refined gasoline per day. News of this incident caused long fuel lines and panic buying on the East Coast of the United States, resulting in significant fuel shortages and price increases. But this also includes the spread of false information about renewable energy in general. Misrepresentation of the potential of renewable energy sources such as solar and wind power is a common target of disinformation campaigns, which claim that these technologies alone cannot sustain energy supply. These false claims can influence public opinion and policy-making processes, potentially hindering the development of green energy. Disinformation campaigns also exist about hydropower projects. False news can be spread about some large hydropower projects that are said to have harmful effects on the environment and local communities. This misinformation can trigger strong opposition, which can affect the progress of the projects and the associated political support.

3.2 The Donbas Water Poisoning Conspiracy: Fake News and Psychological Warfare

The 2018 Donbas water poisoning conspiracy⁷ is a prime example of the power of fake news and the use of disinformation campaigns for geopolitical purposes. During the conflict in eastern Ukraine, a pro-Russian hacker group known as Cyberberkut spread a story that claimed that the Ukrainian government and US intelligence agencies were jointly planning to deliberately poison the water supply of the Donbas region with nuclear waste. The goal, it was claimed, was to destabilize the population of the region and cripple local communities. The central claim of the conspiracy theory, that Ukraine intended to deposit nuclear waste in

⁶ DataProt (2023): Critical Infrastructure Cyber Attacks: A New Form of Warfare. Available at: <https://dataprot.net/articles/critical-infrastructure-cyber-attacks/>.

⁷ StopFake (2018): Fake: Kyiv to Poison Donbas Water Supply and Blame Russia. Available at: [<https://www.stopfake.org/en/fake-kyiv-to-poison-donbas-water-supply-and-blame-russia/>].

the water sources of the Donbas region, was widely disseminated through various Russian media outlets.

These stories:

- Repeated on television channels, such as Russia Today.
- Appeared on online portals, where visually manipulated images and dramatized narratives made the claims more credible.
- Spread on social media platforms, where troll farms and automated bots significantly amplified their impact.

The story was intended not only to intimidate the population of Donbass, but also to undermine international trust in Ukraine and its allies, especially the United States. The following effects can be observed:

- Social panic: Growing fear and loss of trust among the local population regarding the security of water supplies.
- Political pressure: Reducing the credibility of the Ukrainian government in the international arena.
- Social destabilization: Further divisions among people living in the conflict zone.

The baselessness of the story quickly came to light after independent international and local investigations determined that, there was no evidence to support the intent or attempt to poison. And the claims were based on manipulated information and falsified documents. In reality, the story was used solely for psychological warfare and disinformation purposes to paint the Ukrainian government and its Western allies in a negative light.

3.3 Causing social uncertainty towards the postal service provider

Phishing attacks have increasingly exploited the trusted reputation of the Hungarian Postal Service (Magyar Posta) by disseminating fraudulent emails and SMS messages to steal users' personal data. These attacks often intensify during holiday seasons, capitalizing on the surge in postal communications and online shopping. Cybercriminals craft messages that appear to originate from the postal service, prompting recipients to click on malicious links or provide sensitive information under the guise of parcel tracking or delivery issues. The Hungarian

⁸ Magyar Posta (n.d.): figyelem! Továbbra is adathalász levelet és sms-t vagy közösségi médiában álfelhívásokat küldenek a magyar posta nevével visszaélve. Available at: [https://www.posta.hu/aktualitasok/adathalasz_levelet_es_smst_kuldenek_a_magyar_posta_neveben].

Post has issued alerts to warn customers about these phishing scams, emphasizing the importance of vigilance and verifying the authenticity of communications. Despite these warnings, the prevalence of such attacks highlights the necessity for heightened public cybersecurity awareness and proactive measures by organizations to mitigate fraud. Social media platforms play a significant role in amplifying these scams. Attackers utilize these platforms to spread fraudulent messages more broadly, exploiting the trust users place in social media communications. This underscores the critical need for users to exercise caution and for platforms to implement robust security measures to detect and prevent the dissemination of fake news and phishing attempts. In summary, the exploitation of the Hungarian Postal Service's reputation through phishing scams, especially during peak seasons, demonstrates the ongoing challenges in cybersecurity. It calls for continuous public education on recognizing and avoiding such scams, as well as concerted efforts from organizations and social media platforms to protect users from fraudulent activities.

4 Resilience and conscious content consumption

4.1 The institutional system for combating fake news

Despite the fact that fake news has only begun to become a more serious, new source of danger in recent years with the rise of the media, there are already institutional efforts to curb it. Point 68 of the Hungarian National Security Strategy states: “The number, variety and effectiveness of strategies aimed at influencing political, economic and social processes sponsored by state and non-state actors are increasing. One means of influence can be the organized and methodical instigation of international public opinion against Hungary. The effectiveness of information operations is increased by the fact that social media makes the spread of fake news and disinformation extremely rapid. Overt influence can also appear in the exercise of political and economic pressure, during which international actors with opposing interests may try to limit our country’s ability to act.”⁹ Since 2018, NATO has also paid special attention to fake news, which can be identified among hybrid threats. It has established an appropriate institutional system for researching and countering hostile information and disinformation operations, including:

⁹ Government of Hungary (2020): 1163/2020. (IV.21.) Government Decree on Hungary’s National Security Strategy. *Magyar Közlöny*, April 21, 2020, No. 81, pp. 2101–2118, p. 2107.

- The European Centre of Excellence for Countering Hybrid Threats, established in Helsinki, non-NATO member Finland, and operated jointly with the European Union;
- Strategic Communications Centre of Excellence, based in Riga, Latvia;
- Cooperative Cyber Defence Centre of Excellence, based in Tallinn, Estonia.¹⁰

The European Union (EU) approaches the protection of critical infrastructures, including risk management, resilience building and cooperation between Member States, through the following policies and measures:

- **Legislation and Regulations:** The EU has adopted various laws and regulations to strengthen the protection of critical infrastructures. These include the Critical Infrastructure Protection Directive, which requires Member States to identify and protect infrastructure that is essential to society and the economy.
- **Risk Management:** The EU emphasizes the use of risk management strategies, which include assessing threats, vulnerabilities and potential impacts. The aim is to reduce the likelihood and impact of attacks on infrastructure or natural disasters.
- **Building Resilience:** The EU prioritizes building resilience, which means increasing the resilience of critical infrastructure to unexpected events. This includes developing reconstruction and recovery plans, and ensuring redundancy and diversity in infrastructure components.
- **Common Response Mechanisms:** The EU encourages cooperation between Member States in developing common response mechanisms, which help to address cross-border threats. This includes sharing information, exchanging best practices and conducting joint exercises.
- **Awareness and Training:** The EU attaches importance to raising awareness and training in the field of critical infrastructure protection. This includes informing stakeholders about the latest threats and training those responsible for protecting critical infrastructure.
- **International Cooperation:** While the EU encourages cooperation between Member States, it also stresses the importance of international cooperation, in particular with countries and organisations with which it has a common interest in protecting critical infrastructure.

¹⁰ NATO (n.d.): NATO's Response to Hybrid Threats. Available at: [https://www.nato.int/cps/en/natohq/topics_156338.htm].

4.2 Individual defense against fake news

Fighting against fake news is not an easy task, neither for ordinary people in terms of filtering nor for experts in curbing it. According to the recommendation of the European Parliamentary Research Service (EPRS)¹¹, it is important to check the content, author, sources and images. Before sharing, it is worth thinking about the veracity of the news and considering our own personal bias, i.e. how much it arouses emotions and how much we support or oppose the news related to the given topic.

The National Media and Communications Authority (NMHH) has published several research studies and articles on the subject. Among their most important findings is that “the more someone uses the Internet, the greater the chance of stumbling upon fake news”. Moreover, a critical approach to sources does not always provide a clear defense, as it is also helpless against misleading information that it does not matter where and how one searches for the source of the news.¹² In addition, in an article¹³ by the NMHH, it also formulates recommendations and suggestions for individuals on how and based on what aspects fake news can be recognized, based on which one can defend against it:

- “the title of an article is intended to get people to click with a claim that contradicts common sense,
- if a clearly fake or old photo is used for a recent news item,
- the news item is on an unknown, never-heard-of or too general website,
- the text contains spelling errors, multiple punctuation marks, and personal opinions,
- the content appears anonymously or under a pseudonym that does not appear anywhere else,
- it supports its claims without sources or with false, untraceable sources,

¹¹ European Parliament (2019): How to Recognize Fake News? European Parliament. Available at: [\[https://www.europarl.europa.eu/RegData/etudes/ATAG/2017/599386/EPRS_ATA\(2017\)599386_HU.pdf\]](https://www.europarl.europa.eu/RegData/etudes/ATAG/2017/599386/EPRS_ATA(2017)599386_HU.pdf).

¹² NMHH (2021): Védekeznénk az álhírekkel szemben, de ez nem mindig sikerül. Nemzeti Média- és Hírközlési Hatóság. Available at: https://nmhh.hu/cikk/224768/NMHHkutatas_Vedekeznenk_az_alhirekkel_szemben_de_ez_nem_mindig_sikerul

¹³ NMHH (2022): Élesedik az álhírek elleni küzdelem: mi sem maradhatunk ki belőle. Nemzeti Média- és Hírközlési Hatóság. Available at: https://nmhh.hu/cikk/229831/Elesedik_az_alhirek_elleni_kuzdelem_mi_sem_maradhatunk_ki_belole.

- the page contains a striking number of advertisements or advertisements that are closely related to the article.”

The European Union has set a strategic agenda for the period 2019-2024, which is committed to protecting societies, citizens and freedoms from hybrid threats. In their concrete steps on combating disinformation, they declare their main goal: to enhance cooperation in preventing and responding to threats, and to strengthen resilience.

5 The Role of Artificial Intelligence in Enhancing Cyberattacks, Phishing, and Fake News Production and Dissemination

5.1 Enhancing Phishing Attacks

AI significantly improves the effectiveness of phishing campaigns in the following ways. Personalized attacks, when AI analyzes user behavior, social media activity, and email patterns to craft highly convincing and personalized phishing messages. Automation, couse generative language models, such as GPT, enable the mass production of varied phishing emails or messages that evade security filters. Voice imitation and deepfake technology, so AI can mimic voices, enabling “vishing” (voice phishing) attacks where attackers deceive victims over the phone by imitating trusted figures.

5.2 Creation and Dissemination of Fake News

AI is a powerful tool for generating and spreading fake news across various platforms: Automated text generation by generative language models can create believable fake news articles in journalistic styles, lending false credibility to the content. Image manipulation by Generative Adversarial Networks (GANs) produce realistic images, including entirely fabricated ones, that can mislead public opinion. Deepfake videos, when AI can produce hyper-realistic videos where individuals appear to say or do things they never did, often used for political disinformation or character attacks.

5.3 Advancing Cyberattacks

AI can bolsters cyberattacks. AI scans networks to identify weak points that attackers can exploit. AI-driven malware can dynamically adapt to evade antivirus systems. AI algorithms analyze victim behavior and usage patterns, enabling precise, tailored attacks.

5.4 Amplifying Disinformation Campaigns

AI enhances disinformation campaigns through social media bots, when AI-powered bots automate posting, commenting, and sharing on social media, accelerating the spread of fake news. Targeted advertisements causes AI analyzes user data to deliver fake news through personalized ads, increasing persuasion among target audiences. Visual content distribution could AI-generated images and videos make disinformation campaigns more visually compelling and believable.

Conclusions

Importance of Protecting Critical Infrastructure from AI-Generated Fake News

Critical infrastructure forms the backbone of modern societies, encompassing essential systems such as energy, water supply, healthcare, transportation, and telecommunications. The protection of these infrastructures against AI-generated fake news in textual, visual, or video formats is of paramount importance for several key reasons:

1. **Disruption of Essential Services:** AI-generated fake news can cause widespread panic or confusion, disrupting the normal functioning of critical systems. For instance, false information about energy shortages or contaminated water supplies can lead to panic buying, overloading infrastructure, and causing service interruptions.
2. **Erosion of Public Trust:** Fake news, especially when amplified by AI technologies, undermines public trust in critical services. Misleading information about healthcare systems or emergency response capabilities can result in people disregarding official guidelines or losing confidence in government institutions.
3. **Exploitation of Vulnerabilities:** Critical infrastructures are already vulnerable to cyberattacks. When combined with AI-generated fake news, these attacks can have a compounding effect by diverting attention, creating chaos, or facilitating secondary attacks that exploit the confusion.
4. **Escalation of Geopolitical Conflicts:** AI-generated disinformation can be weaponized to destabilize regions or escalate conflicts. False narratives targeting critical infrastructure, such as allegations of sabotage or contamination, can intensify political tensions or undermine international relations.
5. **Hindrance to Policy and Public Awareness:** Disinformation campaigns about infrastructure projects, such as renewable energy developments, can mislead public opinion and obstruct policy-making processes. AI-generated fake news about the inefficacy of sustainable technologies can delay critical advancements in energy transition. ### Conclusion Protecting critical

infrastructure from AI-generated fake news is essential to ensure societal stability, maintain public trust, and prevent malicious exploitation. Governments, organizations, and technology developers must collaborate to deploy advanced detection systems, strengthen public awareness, and establish robust protocols to counter these evolving threats.

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Decision-Making Under Uncertainty: Exploring Behavioural Adaptations in Unknown Probabilistic Contexts

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Abstract: In decision-making scenarios characterised by uncertainty, players often navigate choices without prior knowledge of the distribution of correct and incorrect outcomes. This study investigates such environments, analysing behavioural adaptations when individuals engage with tasks devoid of explicit probabilistic cues. By withholding information regarding the ratios of correct answers, the game ensures independence across choices, thereby emulating the ambiguous appeal of mechanisms such as "gacha" systems and real-world phenomena, including repeated lottery participation following a win. Through the comprehensive tracking of key behavioural parameters, this research aims to deepen the understanding of user behaviour within simulated environments. Unlike traditional self-report questionnaires, this approach systematically captures nuanced user interactions, enabling an exploration of the underlying decision-making processes rather than focusing solely on outcome-specific data. Grounded in decision theory and game psychology, this study elucidates how individuals develop strategies and make choices in the face of unpredictability. By examining the interplay of risk, reward and randomness, it offers novel insights into the cognitive mechanisms that govern decision-making in uncertain contexts.

Keywords: Probabilistic ambiguity, Game psychology, Independent events, Dependent events, Gacha mechanics

1 Introduction

Decision-making under uncertainty is a core aspect of human cognition, influencing behaviours in everyday scenarios and high-stakes decisions alike. From trivial choices, such as selecting a new restaurant without recommendations, to significant ones like financial investments or gambling, individuals frequently operate in environments where explicit probabilistic cues are absent. These

contexts demand the use of heuristics, intuition and adaptive strategies to navigate ambiguity, often relying on limited or anecdotal observations to infer potential outcomes.

This study focuses on decision-making in environments where probabilities are undefined or unknown, mirroring scenarios found in both digital and real-world contexts. Modern "gacha" game mechanics exemplify this uncertainty, where players make repeated draws for randomized rewards without knowing the underlying probability distribution. Similarly, behaviours like purchasing lottery tickets despite statistically poor odds reflect broader tendencies to engage with uncertainty, driven by cognitive biases and emotional responses. By exploring these ambiguous probabilistic contexts, this research aims to uncover how individuals adapt, persist and refine decision-making strategies in the absence of clear information.

Traditional decision theory highlights the suboptimality of human reasoning under uncertainty, pointing to reliance on biases such as the Gambler's Fallacy and the representativeness heuristic. However, recent findings suggest a dynamic interplay between risk perception, strategy refinement and experiential learning, where individuals demonstrate adaptive behaviour over time. This research synthesizes these insights, focusing on how key behavioural parameters evolve in response to ambiguity, how initial heuristics influence decisions, and how risk preferences shift with accumulated experience.

Unlike conventional approaches that emphasize self-reported intentions or isolated outcomes, this study adopts a granular perspective, examining the processes by which individuals adapt and refine their strategies. By analyzing the evolution of choices in uncertain contexts, it aims to provide deeper insights into the cognitive and emotional mechanisms underlying decision-making. Grounded in decision theory, game psychology and behavioural analysis, this research addresses critical questions: How do individuals develop heuristics when probabilities are unknown? What cognitive adaptations occur in response to persistent uncertainty? And how do these processes inform broader tendencies in human decision-making? By illuminating the strategies individuals employ to navigate unpredictability, this research contributes to a nuanced understanding of the intersections of risk, reward and randomness. These findings have implications not only for theoretical advancements but also for practical applications in system design and behavioural interventions aimed at mitigating risk-related biases.

2 Literature Review

Decision-making in uncertain environments has been extensively explored in psychological and economic research, particularly in contexts where explicit

probabilistic cues are absent. Studies in areas such as gacha mechanics, lottery participation and randomness-based decision-making reveal how uncertainty drives engagement, fosters cognitive biases and shapes long-term behavioral patterns.

Gacha systems, a core feature of many mobile and online games, sustain user participation through randomized rewards that mimic gambling mechanics. The appeal of these systems stems from their ability to provide potentially high-value rewards, even when probabilities are hidden or low. This mechanism encourages repeated participation, with players aiming to "beat the odds" (Rentia et al., 2022) (Chen et al., 2023) (Zendle et al., 2019). Rao et al. (2023) highlight the role of biases, such as the Gambler's Fallacy, in sustaining engagement. This fallacy arises when individuals mistakenly believe that past outcomes influence future independent events. For example, players may assume a high-value reward is "due" after a series of low-value results. This is closely tied to the representativeness heuristic, which causes individuals to perceive patterns in randomness, often leading to flawed expectations.

Lotteries provide another lens for understanding decision-making under uncertainty. Kong et al. (2020) found that individuals often overestimate their chances of winning due to the promise of life-changing rewards. Near-miss experiences, as described by Dillon et al. (2024), further reinforce this behavior by creating an illusion of progress, which fosters persistence. For instance, a lottery ticket with numbers close to the winning combination can amplify the belief that a win is within reach. Minor wins, as noted by Crack (2024), also reinforce repeated participation, as they are perceived as validation of strategy or luck. Combined with a lack of probabilistic transparency, these factors create a reinforcement loop that encourages continued engagement in lottery-like systems.

Heuristic-based decision-making is a recurring theme in uncertain environments. Tversky and Kahneman (1974) introduced foundational concepts such as the availability heuristic, where individuals rely on easily recalled events and the representativeness heuristic, where patterns are overemphasized in random sequences. For example, players in gacha systems or lotteries often use anecdotal evidence or personal experiences to guide their decisions, even when such information lacks statistical validity. While these heuristics simplify decision-making, they frequently result in systematic biases that skew outcomes.

The absence of explicit probabilistic cues in gacha systems and lotteries limits the role of feedback, which is essential for refining strategies and adapting behavior. Research by Wong (2019) shows that environments without immediate feedback hinder adaptive decision-making, as individuals struggle to evaluate the success or failure of their strategies. Conversely, environments that provide feedback enable users to develop structured heuristics, facilitating adjustments based on prior outcomes.

The interplay of risk, reward and randomness in these systems has profound psychological effects. Studies by Schüll (2012) and Murch (2020) highlight how randomized reward systems induce a state of flow, where individuals lose track of time and persist in decision-making despite diminishing returns. This phenomenon is reinforced by intermittent rewards, which activate neural pathways associated with pleasure and anticipation. Neuroimaging studies, such as those by Clark et al. (2019), provide evidence that the unpredictability of rewards heightens engagement, creating a cycle of repeated participation.

Decision-making in uncertain environments differs fundamentally from decision-making in contexts of certainty. Under uncertainty, individuals often rely on heuristics, intuition and biases to navigate choices where probabilities or outcomes are ambiguous or unknown (Dhimi et al., 2018) (Muñoz et al., 2022). These mechanisms simplify complex decisions but frequently result in systematic errors. For example, players in games with randomized rewards may overestimate their chances of success, relying on past patterns that are statistically irrelevant (Benjamin, 2019). This reliance on cognitive shortcuts like the representativeness heuristic highlights the challenges of operating without reliable information.

In contrast, decision-making under certainty benefits from structured, rational strategies. When information is clear and probabilities are defined, individuals can make deliberate, calculated decisions that minimize risk (Cokely et al., 2018) (Lee et al., 2022). For instance, selecting a savings account with a guaranteed return allows for predictable outcomes, fostering confidence and reducing cognitive load. The contrast between these contexts underscores how the availability of information shapes the decision-making process, influencing both outcomes and the cognitive effort required.

Feedback plays a pivotal role in shaping decision-making processes, particularly in environments characterized by uncertainty. When feedback is present, it provides immediate validation or correction of decisions, enabling individuals to refine strategies and build more accurate heuristics (Zellweger & Zenger, 2023) (Lee et al., 2023) (Gupta et al., 2024). This learning loop reduces ambiguity, allowing participants to adapt their behavior based on observed outcomes. For instance, in educational settings, timely feedback on performance fosters rapid adjustments and improved results. Conversely, the absence of feedback creates significant challenges. Without validation, individuals must rely on initial heuristics, which may be flawed, and cannot assess the effectiveness of their decisions (Lieder et al., 2018) (Ensign et al., 2017). This perpetuates uncertainty and can lead to the persistence of ineffective strategies. In contexts like gacha mechanics or lotteries, the lack of feedback regarding probabilistic outcomes often sustains engagement but limits meaningful learning. The presence or absence of feedback thus serves as a critical determinant of how effectively individuals navigate decision-making scenarios.

Time constraints significantly influence decision-making by heightening cognitive pressure and prioritizing speed over depth. In time-limited environments, individuals tend to focus on exploiting known strategies rather than exploring new ones, as efficiency becomes paramount (Chen et al., 2024) (Del et al., 2018). Feedback in such contexts provides critical guidance, enabling rapid adjustments that improve short-term performance. For instance, in timed problem-solving tasks, immediate feedback allows participants to correct errors without extensive reflection. However, in the absence of feedback, time constraints exacerbate ambiguity and cognitive load. Participants are forced to make rushed decisions with little opportunity to evaluate their effectiveness, leading to reliance on heuristics or random exploration (Corbet, 2024). This can result in higher rates of error and ineffective adaptation. The interplay of feedback and time pressure reveals the delicate balance between speed and accuracy, emphasizing the importance of clear guidance in high-pressure decision-making scenarios.

3 Methods

This study adopts a theoretical and simulation-based approach to investigate decision-making processes in environments characterized by uncertainty. Building upon a comprehensive review of scholarly works in decision theory, behavioral economics and game psychology, the methodology critically analyzes existing literature to identify patterns in how individuals navigate ambiguity and develop strategies in the absence of explicit probabilistic cues. Key concepts, such as choice independence and the psychological appeal of randomness in "gacha" systems and lottery participation, form the foundation of the analysis. This framework facilitates a systematic exploration of behavioral adaptations and decision-making strategies.

4 Results and Discussion

Decision-making is a multifaceted process that is influenced by various contextual factors, such as the level of certainty, the availability of feedback and the presence of time constraints. This section explores how these factors shape cognitive processes, strategies and outcomes through a comparative analysis of three key scenarios. Each subsection examines the unique challenges and adaptations required in these conditions, providing insights into how decision-makers navigate complexity and pressure to achieve their goals.

4.1 Difference Between Uncertainty and Certainty

Decision-making is a process deeply influenced by the conditions under which it occurs, whether dominated by uncertainty or supported by certainty. These contrasting conditions significantly affect how information is processed, strategies are formed and risks are managed.

Aspect	Decision-Making Under Uncertainty	Decision-Making Under Certainty
Information Availability	Limited or ambiguous information	Clear and reliable information
Outcome Prediction	Uncertain outcomes with unknown probabilities	Predictable outcomes with known probabilities
Decision Strategies	Relies on heuristics, intuition and biases	Uses rational, optimized strategies
Risk Level	Higher risk due to ambiguity and unpredictability	Lower risk due to clear outcome knowledge
Examples	Gambling, investments with uncertain returns	Choosing a well-reviewed product, savings account
Cognitive Process	Intuitive, experience-based learning, biases	Deliberate, analytical and calculated
Adaptation	Adapt through feedback and heuristic development	Less need for adaptation due to certainty
Role of Biases	Significant, as biases help in simplifying decisions	Minimal, as information is clear

Table 1. Comparison of Decision-Making Under Uncertainty and Certainty

Source: Based on literature, edited by Author

Under uncertainty, decision-making is shaped by limited or ambiguous information, making it challenging to predict outcomes with accuracy. Individuals often rely on heuristics, intuition, and biases as tools to simplify complexity in the absence of clear data. For example, gambling or investing in volatile markets requires decisions based on incomplete or probabilistic information. This reliance on mental shortcuts increases the risk level, as ambiguity and unpredictability elevate the chances of unfavorable outcomes. The cognitive process under uncertainty is largely intuitive, influenced by past experiences and the development of adaptive strategies based on feedback. While biases can aid in

simplifying decisions, they also carry the risk of systematic errors that may lead to suboptimal outcomes.

In contrast, decision-making under certainty benefits from clear and reliable information, allowing for predictable outcomes and the application of rational, optimized strategies. For instance, choosing a savings account with a fixed interest rate offers guaranteed results, eliminating the uncertainty inherent in riskier options. Here, the cognitive process is deliberate, analytical, and calculated, emphasizing a structured approach that minimizes the influence of biases. Since the environment is predictable, there is less need for constant adaptation, allowing individuals to focus on executing well-thought-out decisions without frequent recalibration.

The role of biases marks a stark difference between these two contexts. Under uncertainty, biases are significant, as they help simplify decision-making in the face of complexity and limited information. However, this simplification often comes at the expense of accuracy. Under certainty, the role of biases is minimal, as the availability of clear information enables objective analysis and reduces the reliance on mental shortcuts.

In essence, decision-making under uncertainty requires flexibility, quick thinking and the ability to adapt, while decision-making under certainty rewards thorough analysis, careful planning and methodical execution. These differences highlight the importance of context in shaping how individuals approach choices, with each condition presenting unique challenges and opportunities.

4.2 The Role of Feedback in Decision-Making

The presence or absence of feedback fundamentally shapes the way individuals learn, adapt and refine their decision-making processes. When feedback is provided, it acts as a learning amplifier, enabling participants to understand the consequences of their actions and adjust their heuristics accordingly. This reinforcement mechanism not only solidifies correct strategies but also highlights errors, reducing ambiguity and building confidence in future decisions. For instance, in a game where players receive immediate feedback on their choices, they can quickly adapt, refining their approach to achieve better results. Feedback provides clarity by confirming correctness, which in turn lowers cognitive load—individuals no longer expend mental energy on guessing outcomes and can instead focus on optimizing their strategies. This clarity encourages a shift from random exploration to strategic exploitation, where participants prioritize refining effective approaches over trial-and-error experimentation.

In contrast, the absence of feedback creates a more challenging decision-making environment. Without knowing the consequences of their actions, individuals are forced to rely solely on initial heuristics, which may be flawed or incomplete.

Ambiguity remains high, leaving participants unsure whether their choices are effective or counterproductive. This uncertainty perpetuates a trial-and-error approach, where strategies are often chosen at random rather than being purposefully refined. Additionally, the lack of validation or correction hinders learning and adaptation, as participants are unable to identify and address their mistakes. Cognitive load increases significantly in this scenario, the mental stress of repeatedly guessing and reassessing without clear guidance can lead to frustration and fatigue.

The distinction between feedback and its absence becomes particularly evident in terms of adaptation. Feedback accelerates the process by offering a continuous learning loop, participants observe the results of their actions, adjust their behavior and improve their performance over time. For example, a student receiving detailed corrections on an assignment can quickly refine their understanding and avoid repeating the same errors. In contrast, without feedback, adaptation is slow and often ineffective, as participants lack the necessary information to make meaningful changes to their approach.

Aspect	Feedback Provided	No Feedback Provided
Learning Enhancement	Reinforces learning, helps adjust heuristics	No learning reinforcement, relies on initial heuristics
Ambiguity Reduction	Reduces ambiguity by confirming correctness	High ambiguity, participants unsure of correctness
Strategy Development	Strategies are refined based on accurate feedback	Persistence of flawed strategies due to lack of correction
Cognitive Load	Lower cognitive load due to knowledge of outcomes	Higher cognitive load, guessing leads to increased mental stress
Exploration vs. Exploitation	Encourages strategic exploitation and refinement	Encourages random exploration without clear direction
Adaptation	Participants adapt quickly by learning from feedback	Adaptation is hindered, participants struggle to adjust effectively

Table 2. Comparison of Decision-Making With and Without Feedback

Source: Based on literature, edited by Author

Ultimately, feedback transforms decision-making into a structured and efficient process, enabling individuals to learn, adapt and achieve their goals with greater precision. Its absence, however, forces individuals into a state of perpetual uncertainty, where the lack of direction limits growth and fosters a reliance on chance rather than strategy. The interplay between feedback and decision-making underscores the importance of clarity and guidance in shaping successful outcomes.

4.3 The Impact of Time Constraints on Decision-Making

The interplay of feedback and time constraints dramatically affects decision-making processes, shaping how individuals learn, adapt and handle ambiguity.

Aspect	Feedback Provided With Time Constraints	No Feedback Provided With Time Constraints
Learning Enhancement	Reinforces learning, but limited time reduces depth of reflection	No learning reinforcement, rushed decisions reduce learning opportunities
Ambiguity Reduction	Limited clarity due to time pressure, feedback helps reduce some ambiguity	High ambiguity remains, time pressure worsens uncertainty
Strategy Development	Strategies develop under pressure, focusing on efficiency rather than accuracy	Flawed strategies persist, and time pressure prevents careful strategy formulation
Cognitive Load	Increased due to time pressure, feedback somewhat mitigates stress	Extremely high cognitive load due to time pressure and lack of validation
Exploration vs. Exploitation	Focus on exploiting known strategies due to limited time, guided by feedback	Random exploration increases, lack of feedback leads to unstructured, reactive decisions
Adaptation	Adaptation occurs quickly, but under stress, limiting long-term effectiveness	Poor adaptation due to high pressure and no feedback loop to learn from

Table 3. Comparison of Decision-Making With and Without Time Constraints

Source: Based on literature, edited by Author

When feedback is available, even under time constraints, it provides a critical reference point for decision-making. While the limited time reduces opportunities

for deep reflection, feedback still reinforces learning by highlighting correct and incorrect decisions. This helps reduce ambiguity to some extent, offering clarity in a high-pressure situation. For instance, in a timed exam where students receive immediate feedback on answers, they can make quicker adjustments, although the fast pace limits deeper understanding. Time constraints also push individuals to focus on exploiting known strategies rather than exploring alternatives, as efficiency becomes the priority. Feedback, in this context, serves as a guidepost, helping individuals streamline their approach despite the pressure. However, the cognitive load remains elevated due to the combined stress of limited time and the need for rapid decision-making.

In the absence of feedback, time constraints compound the challenges. Without validation or correction, learning is minimal, as individuals have no way to confirm or refine their strategies. Ambiguity remains high, as participants cannot be sure whether their decisions are effective or appropriate. The lack of clarity forces reliance on initial heuristics or random exploration, often resulting in unstructured, reactive behavior. Under these conditions, flawed strategies are likely to persist, as time pressure prevents the careful formulation or adjustment of approaches. Cognitive load becomes extremely high, with the stress of guessing and the urgency to act overwhelming the decision-making process.

Adaptation, a key element of learning, also differs significantly between these scenarios. Feedback, even under time constraints, enables quick but surface-level adjustments, allowing participants to adapt rapidly in the short term. However, the stress of time pressure often limits the depth of this adaptation, reducing its long-term effectiveness. Without feedback, adaptation is severely hindered. The absence of a feedback loop leaves individuals without the tools to learn from their actions, resulting in repeated errors and ineffective adjustments.

In summary, time constraints heighten the intensity of decision-making, amplifying the importance of feedback. While feedback under pressure allows for some clarity and adaptation, its absence leads to heightened ambiguity, poor learning opportunities, and increased mental strain. These dynamics illustrate how time and feedback interact to influence the effectiveness of decisions in high-pressure environments.

4.4 Comprehensive Framework for Decision-Making

Decision-making under uncertainty can be understood through the interaction of feedback and time constraints, with each combination leading to distinct behaviors and outcomes. For example, when feedback and time constraints are both present, as in an online exam with immediate grading, individuals rely on heuristics to quickly adapt and solve problems under pressure. Conversely, if feedback is available but time is not constrained, like when analyzing monthly sales data, there is more room to refine strategies and make long-term adjustments.

In situations without feedback, decision-making becomes more challenging. With time constraints, such as troubleshooting a technical issue during a live broadcast, decisions tend to be reactive and prone to errors. Without time pressure, like experimenting with cooking recipes, decision-making evolves through trial-and-error, gradually identifying what works best.

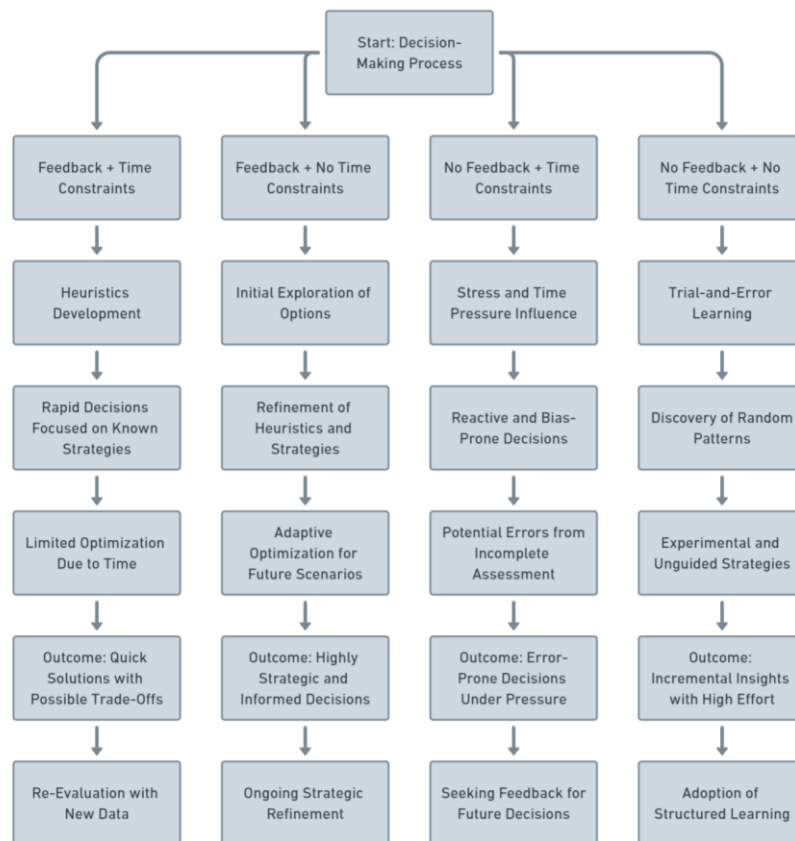


Figure 1. Decision-Making Framework
 Source: Based on literature, edited by Author

This framework highlights how feedback and time constraints interact to influence decision-making strategies and outcomes, offering insights into optimizing decision processes in uncertain environments.

Conclusions

This study highlights the intricate dynamics of decision-making under various conditions, emphasizing the roles of uncertainty, feedback and time constraints. Each of these factors profoundly influences how individuals process information, develop strategies and adapt to their environments, shaping outcomes in both predictable and ambiguous scenarios.

Decision-making under uncertainty is marked by the reliance on heuristics and intuition, as limited or ambiguous information makes accurate predictions difficult. This environment amplifies the role of biases, which, while useful for simplifying complexity, often lead to suboptimal strategies. In contrast, decision-making under certainty benefits from reliable information, enabling rational, calculated approaches that minimize risk and reduce cognitive load. The availability of clear information fosters structured learning and consistent strategy refinement, highlighting the stark contrast between these two conditions.

The presence or absence of feedback significantly shapes decision-making, particularly in terms of learning and adaptation. Feedback serves as a critical mechanism for reinforcing learning and refining strategies, offering clarity and reducing ambiguity. Even under time constraints, feedback enables rapid adjustments, albeit at the cost of deeper reflection and long-term strategy development. In its absence, participants are left to navigate high levels of uncertainty without validation, perpetuating flawed strategies and increasing cognitive load. This results in slower adaptation and reduced learning opportunities, underscoring the importance of feedback as a guiding force in decision-making.

Time constraints further complicate decision-making, magnifying the need for efficient strategies while limiting the capacity for exploration and reflection. When combined with feedback, time pressure can drive rapid adaptation and the exploitation of known strategies. However, the absence of feedback under such constraints creates an environment of heightened ambiguity, where random exploration dominates and cognitive stress peaks. These findings illustrate the delicate balance between time, feedback, and the decision-making process, where the interplay of these factors determines the effectiveness of choices made under pressure.

In conclusion, decision-making is a multidimensional process heavily influenced by context. Uncertainty, feedback and time constraints each exert distinct yet interconnected effects, shaping the strategies, cognitive processes and outcomes of decision-making. These insights underscore the need for tailored approaches to decision-making frameworks, particularly in high-stakes environments where the interplay of these factors can significantly impact performance and outcomes. Future research could explore how these dynamics interact over longer timeframes

or in team-based decision-making scenarios, offering further opportunities to optimize strategies in complex, real-world contexts.

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Development of an endogenous and exogenous factor based personalized risk assessment system of infertility

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Abstract: Female infertility is an increasingly significant societal and medical challenge, exerting profound psychological and economic impacts. The objective of our research is to conduct a comprehensive analysis of exogenous and endogenous factors influencing female fertility and to develop an IT-based analytical system to support personalized risk assessment. Present paper endeavours to explain and introduce how exogenous factors, including lifestyle habits, environmental exposures, stress levels, nutrition, physical activity, socioeconomic background, partner-related factors, and sexually transmitted infections affect the female reproductive system. Additionally, it also examines the influence of endogenous, biological and hormonal factors, such as age, ovulatory function regularity, hormonal markers (AMH, FSH, Prolactin, TSH), endometriosis, polycystic ovary syndrome (PCOS), structural abnormalities, and ovarian reserve on fertility outcomes. As part of this research, we propose a preliminary potential IT solution that integrates weighted scores and value ranges, categories of these factors to compute a fertility score, enabling the creation of risk profiles. This system could facilitate the development of personalized intervention strategies. The interdisciplinary approach we advocate aims to contribute to the early detection and more effective management of fertility-related issues.

Keywords: infertility, exogenous, exogenous, factors, IT-based system

1 Introduction

The issue of female infertility has become a subject of ever-growing concern. While its medical implications are significant, its broader economic and social impacts are equally noteworthy. As defined by the World Health Organization (WHO, 2024), infertility occurs when a couple is unable to conceive naturally after engaging in regular, unprotected sexual activity for a period of 12 months (Nik Hazlina et al. 2022). Beyond the direct health implications, infertility can profoundly affect the social and emotional well-being of individuals, families and communities, creating psychological challenges that stem from the inability to have children. These effects ripple outward, influencing the quality of life and social dynamics of those involved. Additionally, the process of seeking medical treatment for infertility is often both expensive and time-consuming, further intensifying the emotional and physiological strain on affected couples.

This study aims to delve into the various exogenous as well as endogenous factors that influence female fertility, organizing these insights into a systematic framework, which is then applied as the base of an IT-based risk assessment system. By offering a system that enhances the precision of individual risk assessments, the research aspires to assist patients in approaching their state from an outer perspective as well as provide possible ways of prevention and treatment.

2 Literature review

Various factors influence female infertility, broadly categorized into external (exogenous) and internal (endogenous) influences. Exogenous factors, such as lifestyle choices, environmental exposures, stress levels, nutrition, and socioeconomic conditions, can directly or indirectly affect the reproductive system (Hruska et al. 2000). Conversely, endogenous factors encompass biological and physiological processes, including age, ovarian reserve, ovulatory function, hormonal balance, and reproductive health conditions, all of which play a critical role in determining fertility. Together, these interconnected elements highlight the multifaceted nature of infertility and the need for a comprehensive understanding of both external and internal influences.

2.1 Exogenous factors

Lifestyle choices, such as smoking, alcohol consumption, and excessive caffeine intake, have been shown to disrupt hormonal balance and reduce the quality of oocytes (female egg) (Nik Hazlina et al. 2022; Hruska et al. 2000). Research indicates that women who smoke are 1.6 times more likely to experience infertility (Augood et al. 1998). Alcohol consumption has been linked to

menstrual irregularities and hormonal disturbances (Noorbala et al. 2009; Klemetti et al. 2010), while high caffeine intake may decrease the likelihood of conception, especially in individuals undergoing assisted reproductive techniques (Ramezanzadeh et al. 2004; Biringer et al. 2015; Augood et al. 1998).

On the other hand, a balanced diet can enhance hormonal equilibrium and improve egg quality (Kohil et al. 2022; Olooto et al. 2012). Nutrients such as omega-3 fatty acids, B vitamins, and adequate iron intake are particularly important for fertility (Kohil et al. 2022; Ramezanzadeh et al. 2004; Bakhtiyar et al. 2019; Biringer et al. 2015). In contrast, consuming trans fats and processed foods has been associated with reduced fertility rates (Noorbala et al. 2009). Regular physical activity also positively affects fertility by supporting hormonal stability (Biringer et al. 2015; Bakhtiyar et al. 2019) and maintaining a healthy body mass index (BMI). However, excessive, or high-intensity exercise can disrupt the menstrual cycle, particularly when body fat levels become critically low (Bala et al. 2021). Extreme athletic activity may lower estrogen levels, potentially causing anovulation (lack of ovulation) and making conception more difficult (Aarts et al. 2011; Klemetti et al. 2010; Nik Hazlina et al. 2022; Aggarwal et al. 2013). Therefore, a moderate exercise routine combined with a nutritious diet is essential for supporting reproductive health.

Environmental exposures also play a crucial role in the likelihood of infertility. Air pollution, heavy metals (e.g., lead and mercury), and pesticides can impair ovarian function and damage egg quality (Augood et al. 1998; Nik Hazlina et al. 2022; Lee et al. 2020; Aggarwal et al. 2013). Persistent organic pollutants, such as dioxins and PCBs, are known to disrupt hormonal processes, thereby adversely affecting fertility (Augood et al. 1998; Bala et al. 2021; Noorbala et al. 2009).

Chronic stress is another critical factor, as it negatively influences the hypothalamic-pituitary-ovarian (HPO) axis, which regulates the menstrual cycle (Noorbala et al. 2009; Klemetti et al. 2010; Nik Hazlina et al. 2022). Elevated cortisol and prolactin levels can interfere with ovulation, reducing the chances of conception (Aarts et al. 2011). Relaxation techniques like yoga and meditation are effective methods to manage stress-related fertility challenges (Bala et al. 2021; Biringer et al. 2015; Klemetti et al. 2010). Interestingly, reproductive outcomes are influenced not only by individual stress but also by broader socioeconomic status. Low income, limited access to healthcare, and lower educational attainment have been associated with increased infertility risk (Aarts et al. 2011; Biringer et al. 2015; Bakhtiyar et al. 2019; Sudha- Reddy, 2013). Furthermore, in many countries, women with lower incomes face significant barriers to accessing adequate fertility treatments (Bakhtiyar et al. 2019).

Fertility is also shaped by factors associated with the partner. Male fertility issues, such as reduced sperm count, decreased motility, or genetic abnormalities, play a

substantial role in a couple's overall reproductive success (Barbieri, 2019; Aarts et al. 2011; Noorbala et al. 2009).

Infections, particularly sexually transmitted diseases like chlamydia and gonorrhea, pose a significant risk to female fertility by causing chronic inflammation in reproductive organs (Direkvand-Moghadam et al. 2013; Nik Hazlina et al. 2022; Klemetti et al. 2010). These infections can damage the fallopian tubes, leading to blockages and infertility (Noorbala et al. 2009; Biringer et al. 2015). The resulting scar tissue and adhesions may hinder the fertilization and implantation of eggs in the uterus (Aarts et al. 2011; Abrao et al. 2013). Early detection and treatment of such infections are crucial for preserving reproductive health.

2.2 Endogenous factors

Age is among the most critical factors influencing fertility in women. Fertility naturally declines with age due to the progressive reduction in the number and quality of oocytes (Barbieri, 2019). Studies indicate that female fertility peaks in the mid-20s and begins a gradual decline in the early 30s (Nik Hazlina et al. 2022). After the age of 40, this decline accelerates sharply, with a significant decrease in oocyte quality and an increased risk of chromosomal abnormalities (Klemetti et al. 2010). Advanced maternal age is also associated with higher risks of miscarriage and genetic disorders in offspring (Aarts et al. 2011). As women age, hormonal shifts occur as well, with estrogen and progesterone levels dropping as menopause approaches. This hormonal decline leads to less frequent ovulation and eventually its cessation (Aggarwal et al. 2013).

The ovarian reserve, which refers to the quantity and quality of immature oocytes within the ovaries, is another key determinant of fertility. Monitoring ovarian reserve involves measuring levels of anti-Müllerian hormone (AMH) and follicle-stimulating hormone (FSH) (Nik Hazlina et al. 2022; Klemetti et al. 2010; Practice Committee of the American Society for Reproductive Medicine, 2015). AMH levels are higher in younger women but decrease over time, with low AMH levels indicating diminished ovarian reserve and reduced fertility potential (Aarts et al. 2011). Conversely, FSH levels rise as ovarian reserve diminishes, reflecting the body's effort to stimulate the ovaries (Aggarwal et al. 2013). Elevated FSH levels are a marker of reduced ovarian reserve and are linked to the onset of menopause (Biringer et al. 2015). Measuring AMH and FSH is therefore crucial in fertility evaluations and treatment planning, offering insights into reproductive capacity (Ramezanzadeh et al. 2004). A significant concern is premature ovarian failure (POF), where ovarian function ceases prematurely, potentially in a woman's 30s, resulting in an early loss of fertility (Aggarwal et al. 2013).

Ovulatory functions and the regularity of the menstrual cycle are also fundamental to natural conception. Ovulation involves the release of mature oocytes from the

ovaries for potential fertilization. Disruptions to this process, such as irregular menstrual cycles, anovulation (lack of ovulation), or luteal phase deficiencies, can hinder fertility (Aarts et al. 2011; Nik Hazlina et al. 2022; Klemetti et al. 2010). Hormonal imbalances, including elevated prolactin or thyroid hormone levels, are additional contributors to ovulatory issues (Biringer et al. 2015; Noorbala et al. 2009; Bakhtiyar et al. 2019).

Polycystic ovary syndrome (PCOS) is one of the most prevalent endocrine disorders affecting female fertility (Rosenfield- Ehrmann, 2016; Sharma et al. 2011). PCOS disrupts hormonal balance and metabolism, often resulting in irregular ovulation and increased insulin resistance (Aggarwal et al. 2013; Klemetti et al. 2010). Women with PCOS frequently experience irregular menstrual cycles and anovulation, making conception challenging (Aarts et al. 2011).

Another common condition, endometriosis, involves the abnormal growth of endometrial tissue outside the uterus. This condition can cause painful menstruation and complications (Abrao et al. 2013). Chronic inflammation due to endometriosis can lead to the formation of scar tissue in reproductive organs, impairing the function of the fallopian tubes and ovaries (Biringer et al. 2015; Sharma et al. 2011). This not only reduces fertility but also increases the risk of miscarriage (Sharma et al. 2011; Bakhtiyar et al. 2019; Biringer et al. 2015). Similarly, uterine abnormalities, such as fibroids or structural defects, can interfere with pregnancy by preventing proper embryo implantation (Aarts et al. 2011; Biringer et al. 2015).

3 Methodology: Defining and Systematizing Fertility Indicators

The previous chapter focused on identifying the most important external and internal factors of infertility. In this chapter we are going to introduce our process with which we tried to import these factors into our systematisation, which became the base of our IT system.

The systematization process involved the identification and classification of factors influencing female fertility into exogenous and endogenous categories. Within each category, specific indicators were defined, enabling these factors to be quantified and analysed. These indicators were assigned measurable ranges, which were divided into categorical values to facilitate interpretation and integration into an IT-based analytical system. The categorical values were associated with fertility probability categories, such as high, medium, and low fertility probabilities. Furthermore, each category was assigned a quantitative score, ranging from 5 (optimal fertility conditions) to 1 (least favourable

conditions). The scoring system provided a numerical framework to evaluate and compare the impact of each factor or indicator on fertility.

The methodology varied between exogenous and endogenous factors: while exogenous indicators were often meaningful independently, endogenous indicators typically required combined analysis to provide significant insights into fertility probabilities. For instance, within the lifestyle habits factor, the negative impact of high weekly alcohol consumption can be assessed independently of other indicators, such as caffeine intake or smoking. Specifically, consuming more than five glasses of wine per week can be evaluated as a standalone determinant of reduced fertility, without requiring consideration of the values for other lifestyle habits.

Unlike in the case of exogenous factors, however, the indicators for endogenous factors often required a combined analysis to provide meaningful fertility insights. For instance, assessing Premature Ovarian Failure (POF) necessitated the simultaneous consideration of both low anti-Müllerian hormone (AMH) levels and high follicle-stimulating hormone (FSH) levels. Individually, neither low AMH nor high FSH levels alone would conclusively indicate POF. The combined presence of these indicators was essential to determine the probability of infertility associated with POF. This integrated approach was applied consistently across other endogenous factors, where the interplay of multiple indicators defined the overall impact on fertility. This holistic evaluation ensured greater accuracy in diagnosing and categorizing fertility probabilities.

The list of the indicators for the exogenous and endogenous factors can be seen in Table 1 and 2.

The ultimate goal of this systematic categorization was its implementation within an IT-based analytical platform. This system aims to facilitate personalized fertility assessments by integrating indicator data, scores, and categories into a cohesive framework. By allowing mostly the independent analysis of exogenous indicators and mostly the combined evaluation of endogenous indicators, the system provides nuanced insights into individual fertility probabilities.

Factor	Indicator
Lifestyle	Number of cigarettes
	Weekly alcohol consumption
	Caffeine intake
Environment	AQI
	Proximity to industrial areas
	Biomarkers (e.g. BPA)
Stress	Psychological stress scale
	Cortisol levels
Nutrition	Calorie intake
	Micronutrients (e.g. vitamin D)
Activeness	Weekly exercise time or daily steps
Socio-Economy	Income
	Education
	Healthcare
Partner	Sperm count
	Motility
	Morphology
Infections	STI test results (e.g. Chlamydia)

Table 1: Exogen factors and their indicators

Factor	Indicator
Age	Chronological age
Ovarian reserve	AMH level
	FSH level
Ovulatory function	Cycle length, regularity
Body mass index	BMI value
Polycystic ovarian syndrome	Ultrasound/MRI examination
	Testosterone; AMH
	Insulin resistance
Premature Ovarian Failure	AMH level
	FSH level
Hormonal Balance	Prolactin level
	TSH level
Endometriosis	Endometrial biopsy
Uterine Health	Ultrasound, MRI
Egg Quality	Day 3 FSH test
	AMH level

Table 2: Endogen factors and their indicators

4 System design

The goal of this research was to develop a system capable of assessing the factors influencing female fertility, supporting the infertility diagnostic process. The system is structured as outlined in Figure 2.

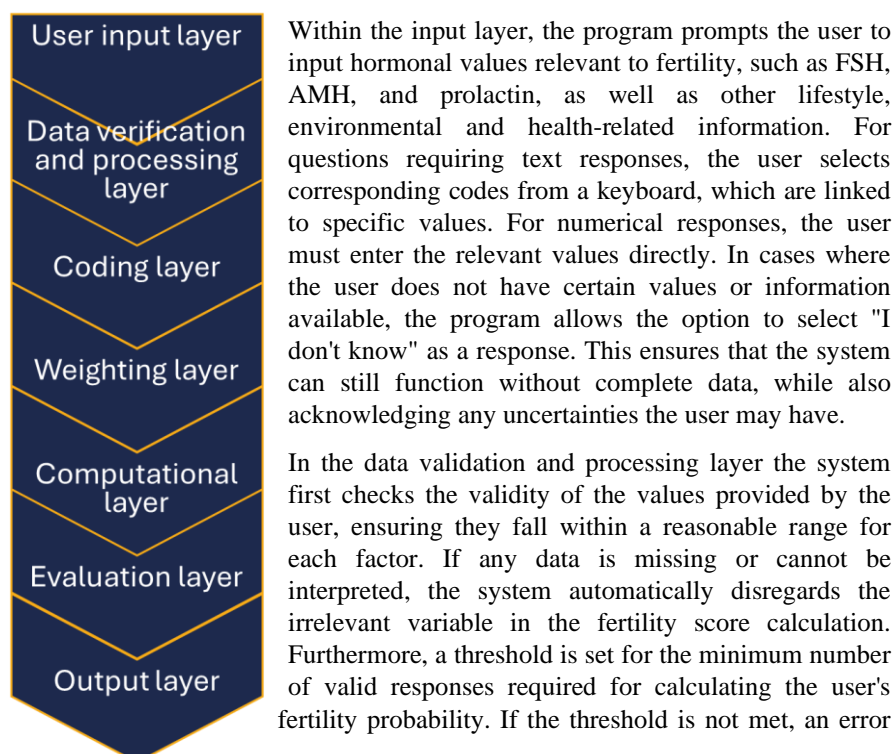


Figure 1: The logical structure of the system

message is displayed to the user, additionally, the program terminates and the next layers are not executed.

In the coding layer, the user's answers are assigned predefined fertility scores based on established ranges. Each factor and its corresponding responses are mapped to specific scores, ranging from 0 (least favourable) to 5 (most favourable). The system compares the user's input to these predefined categories and assigns the appropriate score for each answer.

Each indicator is assigned a weight to reflect its significance in the overall fertility assessment. For example, responses related to lifestyle factors may have less impact than answers concerning biological or hormonal aspects. In the weighting layer, these predefined weights are applied to the user's responses. Currently, all

weights are set to 1, as precise statistical data to determine the exact importance of each factor is not yet available. These weights will be refined in the future based on further research.

The computational layer is responsible for summing the weighted scores to compute the final fertility score. This score reflects the user's fertility level based on the given factors. In the evaluation layer, the system categorizes the final fertility score based on pre-established probability ranges. These ranges are created using the maximum possible score, for example, a score above 80% corresponds to a high probability of conception. As noted earlier, during the validation phase, factors with invalid or "I don't know" responses are excluded, meaning the maximum possible score may be lower for some users. Finally, in the output layer, the system presents the fertility score and the likelihood of conception based on the user's responses and the predefined evaluation ranges.

Future plans include identifying and highlighting specific factors or groups of factors in the output layer whose individual or combined values automatically indicate a very high probability of infertility. Additionally, to provide meaningful support to users, we aim to display variables where "improvement" could serve as a critical turning point in reducing the likelihood of infertility.

5 Interrelationships of Fertility Factors

In the context of our research, we discovered that that the factors influencing fertility are not isolated but interconnected, forming a complex network of interactions. Both endogenous factors, such as hormone levels, and exogenous factors, such as lifestyle choices, influence each other, either amplifying or mitigating their individual effects. This intricate interplay necessitates analysing not only each factor's direct impact on fertility but also the relationships and dependencies among the factors themselves.

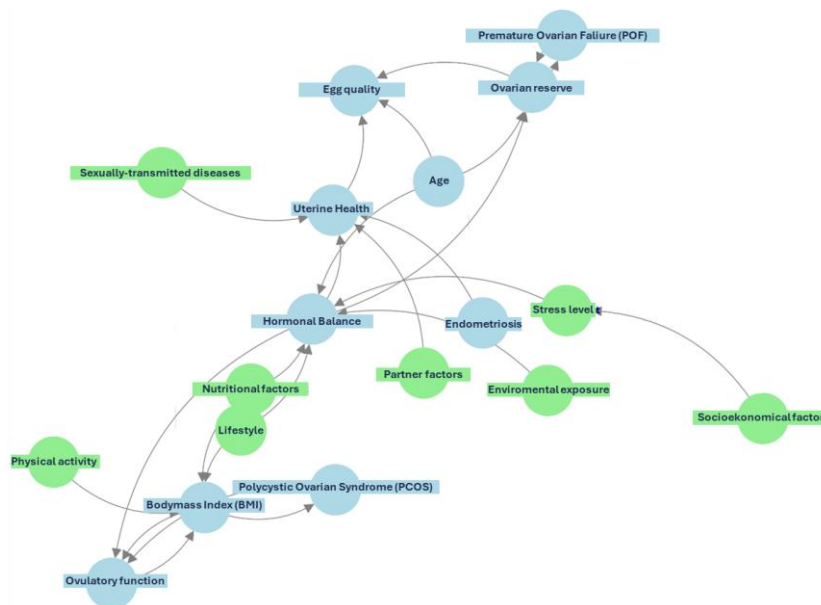


Figure 2: Interrelation of infertility factors

As visualized in the graph presented in Figure 2, certain exogenous (green) or endogenous (blue) factors do not operate in isolation but are interlinked on multiple levels. Examining these connections has revealed how factors contributing to fertility risk can strengthen or weaken one another's impact. Exploring these relationships allows for a deeper understanding of infertility's underlying causes and paves the way for developing more targeted diagnostic tools and treatments.

To refine the weighting layer in our system, future work will investigate the ways in which these factors interact and influence each other. Two key complexities in this analysis include common indicators and the casual overlaps. The ultimate goal is to assign weights that accurately reflect each factor's relative importance in the broader fertility framework. These refined weights will consider not only the independent impact of each factor on fertility but also the effects of their interactions with other variables. By addressing these complexities and incorporating more nuanced statistical analyses, we aim to enhance the accuracy and reliability of fertility assessments, providing a more comprehensive understanding of fertility-related risks and facilitating tailored interventions.

Conclusion

This research aimed to provide a comprehensive overview of the factors contributing to female infertility, encompassing both exogenous and endogenous aspects. The analysis underscored the significant impact of lifestyle habits,

environmental exposures, stress, and nutrition on fertility. At the same time, internal biological factors were found to play a fundamental role in determining reproductive potential. A deeper understanding of these elements not only facilitates more accurate diagnosis but also opens opportunities for prevention and personalized treatment strategies.

Another key aspect of the study was the development of an IT-based analytical system designed to predict fertility outcomes through weighted analysis of various factors. While this system is still under development and requires further refinement, we believe that this approach has the potential to aid in the early identification of fertility issues.

Acknowledgement

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The challenges of the sustainability of pension security

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Abstract: The deteriorating demographic situation is typical of the countries of the European Union, including our country. The current operating principle of the pension system, the pay-as-you-go system, is difficult to sustain in its current form and the future of its operation is questionable. Long-term demographic processes affect not only the active-age population, but also future retirees. There are currently 1,998,000 old-age pensioners in Hungary, and this number will increase greatly in the coming years. In the next 20 years, approximately 2,600,000 people will pass the current retirement age of 65, while no more than 1,900,000 people will enter the labor market. Thus, in twenty years, there will be at least 700,000 fewer people of economically active age in Hungary, if the current retirement age is still in effect. Thus, employment will decrease by 530,000 people. In order for Hungary to have an economy that adapts to the inevitable demographic processes, a more serious paradigm shift is needed in terms of the sustainability of the economic environment and pension security.

Keywords: pension security, demographic effects, sustainability and modeling of state pension systems, pension savings

1 Introduction

The defining issues of social security – issues related to pension security – have been and are being addressed by countless domestic and international organizations and experts today. The aging of developed societies and the decline in the proportion of the working-age population place a huge burden on welfare systems and the states that operate them. Payments to be made to groups in need of pension benefits place a significant burden on budgets, thereby generating financing problems and can also appear as a crisis factor. For this reason, the reform of pension systems has become increasingly urgent, for which numerous attempts, plans and concepts have been born in recent years. The Hungarian pension system is also affected by this issue in many ways, as it is based on

Bismarckian traditions, like the social security systems of most countries, and is based on the pay-as-you-go (PAYG) principle, where the current payments (contributions) create the basis for the current payments (benefits) (Igazné, 2006). This method ensures risk sharing between generations and income groups with different situations. The money entering the system is distributed among those pensioners who created their entitlement by paying contributions during their active life. The system is safe and sustainable if the income covers the expenses (Augusztinovics, 2014). Paul Samuelson's 1958 study (Samuelson, 1958) provides a kind of theoretical basis for the pay-as-you-go system, which is widespread around the world, and its long-term sustainability has now become questionable not only in the post-socialist European Union member states, but almost everywhere (Domonkos – Simonovits, 2018).

2 Pension systems and their challenges

Social security is an unquestionable value of modern history. The social security system (tb system) can consist of pension insurance, health insurance, and a social welfare system (Balogh, 1996). The first state social welfare system was born after the organization of the unified Kingdom of Prussia in 1871. The development of the concept is associated with Chancellor Otto von Bismarck. The reason for the pension reform at that time was the poverty of the rapidly growing urban proletariat due to the rapidly industrializing society. The Bismarckian system tried to protect people who were already integrated into society and the division of labor against risks that threatened their status. The basic idea of the social system was the logic of private insurance of civil law. The burden of the risk must be borne by those belonging to the risk community, and the amount of benefits and compensation received is determined by the degree of burden-bearing. The retirement age in Bismarck's time was 70 years. Contributions had to be paid for at least 30 years, only two percent of the salary, and the pension only reached 18 percent of the average salary. The system was considered profitable, since pension expenditure did not reach even one percent of the state revenues at that time. The condition for eligibility for benefits was that the worker could not work due to a reason related to one of the insurance branches: illness, accident, old age, unemployment. The laws created an institutional structure that provided effective protection for the growing layers of employees.

The Bismarckian model was adopted and developed further by many countries from the late 1800s (Novoszách, 2014). The aim of modern pension security and the pension systems related to it is to provide financial security in old age at the highest possible level, so that the transition from work to retirement life involves the smallest possible decrease in living standards and is predictable for the entire retirement years. In my thesis, I use the following definition: pension security

deals with the protection of the pension system, its aim is to establish a transparent and adequate pension level, and to reduce the risks to the pension system by applying economic, legal or technical means (Bartha, – Tóth, 2013). A pension system is a system designed according to a specific system, which ensures the livelihood of an individual who has left the workforce due to old age (or disability) by providing him with regular financial support (pension benefits). Pension systems can be grouped, compared or contrasted according to their systems, sources and regulations. According to the Green Paper (Towards adequate, sustainable and safe European pension systems) (European Commission, 2010) prepared by the European Commission in 2010 and the White Paper (An Agenda for adequate, safe and sustainable European pensions) (European Commission, 2012) adopted in 2012, the fundamental objective of pension systems is to provide adequate retirement incomes and to ensure that older people live in decent conditions and in economic independence, and that pensions also play an automatic stabilising role. The role of the pension system is to provide income security in old age or in the event of the death of a close relative. In a state pension system, entitlement to benefits is based on the payment of pension contributions. The state guarantees the payment of pensions and ensures that the real value of pension benefits is preserved (Matits, 2016). According to the 2015 European Commission report on pension adequacy (European Commission, 2015), EU pension systems can only be expected to provide an adequate level of pensions for future generations if Member States implement sufficiently strong policies to ensure that as many workers as possible remain active until they reach the official retirement age. Employment policies should offer more opportunities for older workers to remain in the labour market for longer. At the same time, pension systems should also protect those who are unable to remain in the labour market long enough to build up sufficient pension rights.

In addition to the conceptual definition of pension security and pension systems, it is important for further studies to define what we mean by pension income, or pension for short. There are countless definitions of pension in the literature, which I will describe later in the chapter on pension income and its problems. I will begin my thesis with the following definition of Act LXXXI of 1997 on social security pensions: old-age pension: pension payable upon reaching a specified age and completing a specified period of service. To explain the conceptual definition of pension, some concepts need to be clarified. Redistribution, also known as redistribution (whether in a state or private funded system), is a means of ensuring pensions. Smoothing consumption (redistribution between the life cycles spent in work and in retirement). Ensuring social justice (solidarity). The purpose of old-age pensions is not to ensure livelihood in old age through the social assistance system. The payment of social security pension benefits is covered by the Pension Insurance Fund, and its revenues are formed by pension contributions paid by natural persons, public charges paid by employers for this purpose, sources

provided from the central budget and other revenues specified in the law [26]. In the following, I will clarify the models and grouping methods necessary for comparing pension systems. There are several options for grouping pension systems and preparing a paradigm system based on the suggestions of experts and the related literature.

3 Pension systems in OECD countries

The Organization for Economic Co-operation and Development (OECD) is an international economic organization based in Paris, of which Hungary has been a member since 1996. In the development and evaluation of social policy. According to the OECD, pension systems usually consist of "three pillars" (see Figure 1).

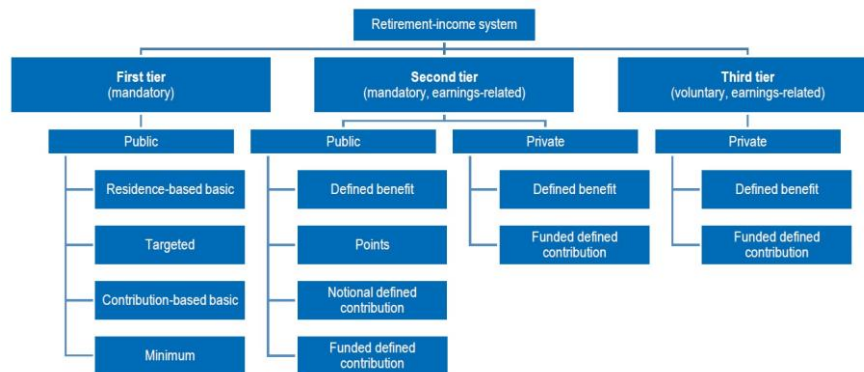


Figure 1. Summary framework of the various pension financing systems (OECD, 2021, own editing, 2024)

The "first pillar" (state) pensions are legal state pensions managed by the state, usually financed from social security contributions and/or general tax revenues on a pay-as-you-go (PAYG) basis. In some countries, individual plans financed by law have been introduced alongside the first pillar. "Second pillar" (employer) pensions are private supplementary programs related to the employment relationship. Finally, "third pillar" (personal) pensions are personal pensions, i.e. pre-financed private voluntary supplementary programs in which contributions are invested in an individual account managed by a pension fund or financial institution.

	<i>Pension System</i>		<i>Private Pension Coverage</i>	
	<i>Public</i>	<i>Private</i>	<i>Mandatory</i>	<i>Voluntary</i>
	<i>Type</i>	<i>Type</i>	%	%
Australia		DC	85	18
Austria	DB			13.9
Belgium	DB			55.6
Canada	DB			39.4
Denmark	DB+DC	DC	>90	
Finland	DB			8.7
France	DB+points			15
Germany	Points			64
Hungary	DB	DC	74	31
Iceland		DB	>90	
Ireland	DB			42.9
Italy	NDC			10.6
Japan	DB			45
Mexico		DC	34.5	
Netherlands		DB	>90	
New Zealand				32.6
Norway	Points		>90	60
Poland	NDC	DC	71.7	1
Slovak Republic	Points		65.8	
Spain	DB			8.7
Sweden	NDC	DB+DC	>90	
Switzerland	DB	d.credit	>90	
United Kingdom	DB			47.1
United States	DB			46

Figure 2. Funding and operating principles of pension systems (OECD, 2021, own editing, 2024)

Pension systems can be grouped based on the principle of financing and the principle of operation. Regarding the financing of pension systems, there are three main types based on the principle of current financing and capital coverage: pay-as-you-go, capital coverage and expectation coverage systems. Based on the form of financing, there are also two types: the pay-as-you-go (PAYG), otherwise known as the financing system, and the funded system. In terms of the operating principle of the pension system, there are two types: the defined benefit (DB) and the defined contribution (DC) pension system. In time, DB pension financing

systems based on the principle of capital coverage were formed first, and the consequences and experiences of the Second World War led to the transition to DB systems based on the pay-as-you-go principle. Later, in parallel with the strengthening of the capital markets, DC systems based on the principle of capital coverage were formed and developed, and starting from the 1990s - in developed countries - the transformation of the systems into DC systems with current financing can be observed more and more. The pay-as-you-go pension system is based on the solidarity of the successive generations, while the essence of the capital protection system is self-care. During the 1950s, no distinction was made between defined benefit (DB) and defined contribution (DC) pension systems. Sometime later, when they recognized the difference between these two systems, they believed that annuity-based financing was synonymous with pay-as-you-go financing, and that contribution-based financing was equivalent to equity financing. However, in the mid-1990s, Sweden reconsidered the previously pay-as-you-go pension system, and as a result of the reform, a notional defined contribution (NDC) system was introduced, and this highlighted the need to treat the endowment system as synonymous with defined contribution - if not necessarily incorrect - but definitely an oversimplification (Dezse, 2022). The points system and the basic pension system (DB+Ponts) differ from the pure points system (Ponts) in that a part of the total pension, say half, goes equally to all old-age pensioners, and only the other half is distributed in proportion to the earned pension points (Simonovits , 2019).

The Figure 1 summarizes the financing and operating principles of pension systems in OECD countries. In Hungary, the state pension system is DB-based and accounts for 74% of the pension benefits, which means that there is a high dependence on the state pension system. Based on the OECD's recommendation, it would be important to put more emphasis on self-care, which could reduce the high dependence on the state pension system. Occupational pension schemes are not present in all OECD countries, and when they are, they may be voluntary or compulsory, while some countries have both. Along these lines, structural differences in pension systems and various reforms have led to different pension systems in individual countries. The vast majority of pension systems are public. At the same time, several countries have introduced occupational pension systems and/or private mandatory and voluntary systems (European Commission, 2021). In most countries, earnings-related old-age state pension systems are the main type of insurance, except for example Denmark, Greece, Ireland and the Netherlands (European Commission, 2021). The vast majority of European countries also provide a minimum guaranteed pension, which is usually means-tested, to ensure minimum adequacy for all pensioners. In contrast, in some other countries, such as Denmark, Ireland, the Netherlands and the United Kingdom, the minimum guaranteed pension is provided by a flat-rate pension that pays the same amount to all pensioners (European Commission. 2021). Most pension systems rely on a state (earnings-based) pension system. The basic indicator of the generosity of the

pension system is the replacement rate, i.e. the percentage of employees' pre-retirement monthly income that they receive after monthly retirement. Recent evidence shows that the theoretical net substitution rate from mandatory schemes averages 59% and ranges from almost 30% in Lithuania and the UK to almost 90% in Austria, Italy and Portugal (OECD, 2019). Therefore, it becomes essential to examine whether enough information is provided to people to understand whether they are aware of how the pension system works in their own country.

4 Investigation of the sustainability of public pension systems

The sustainability and adequacy of social security systems primarily depends on how the level of employment and contributions deducted from the income of the employed, taxes and savings set aside for pension purposes develop and what influence they have on it (Augusztinovics, 2014). The sustainability and adequacy of social security systems primarily depends on how the level of employment and contributions deducted from the income of the employed, taxes and savings set aside for pension purposes develop and what influence they have on it (NYIKA, 2010, Mészáros, 2014, Banyár, 2016). The financing rules, eligibility conditions and labor market conditions must be adjusted in such a way that there is a balanced relationship between contributions and entitlements, the number of actively contributing employees and retired beneficiaries (Novoszáth, 2017).

Figure 1 summarizes the summary framework of the various pension financing systems based on the OECD. The Hungarian pension system currently consists of two pillars, the mandatory social security system ("giant") and the voluntary private pension system ("dwarf") (NYIKA, 2010, ONYF, 2015). Of the 30 OECD countries, only Hungary, New Zealand and Ireland do not have a mandatory second pillar, which includes community and private systems (Novoszáth, 2014). The previously mentioned demographic pressure can be modeled with economic-social impact assessments. In European countries, including in Hungary, the state pension system operates on a pay-as-you-go basis based on different financing principles and pre-calculations are made for the sustainability of the pension system. The essence of the pay-as-you-go principle is that it is tax-free: the pension contribution is paid out (imposed) on active employees, and it is distributive: the pension contributions collected from the employees are distributed among the current pensioners as a pension benefit. In pay-as-you-go systems, current pension expenses are covered from the contributions of economically active employees (Samuelson, 1958).

The European Union published its report on the change in the number of people living in the Union on its official website (Eurostat, 2015). The contents of the

report are not very positive for Hungary. Considering the rate of population decline, the population of Hungary in 1995 was still 2.1% of the European Union, by 2015 only 1.9% of the population of the Union could call themselves Hungarian citizens. The basis of the sustainability of the pay-as-you-go pension system is that there are far more people of working age than people of retirement age, otherwise the balance of the system will be upset (Holtzer 2010). Based on his precalculations, the ratio of employed and retired people in OECD countries will change in an inappropriate direction, as the number of elderly people will increase and the number of people of working age will decrease, which are summarized in Figure 3.

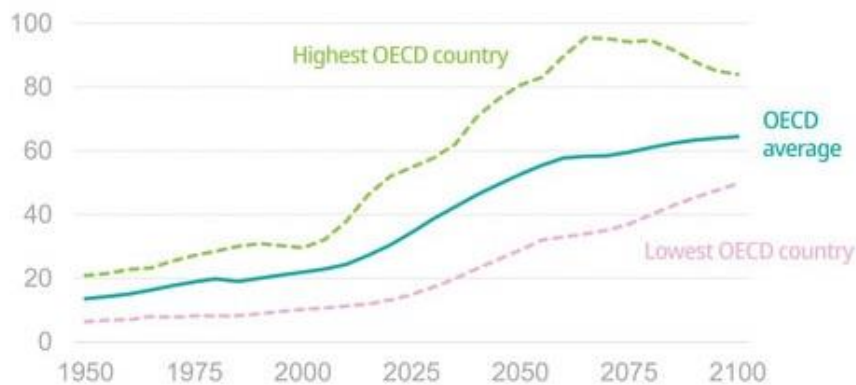


Figure 3. Old age ratio pensions (OECD, 2021, own editing, 2024)

In Hungary KSH projections show that the proportion of pensioners and those of working age rose slightly from 22.4% in 1970 to 22.4% in 2000, but could rise to 47.7% by 2050. This means that in 1970 one pensioner was supported by five workers, while in 2050 one pensioner will be supported by the contributions of two workers (Simonovits, 2002). According to the medium-term macroeconomic forecast of the Ministry of Finance at the end of 2019, economic growth is expected to remain around 4 percent, and inflation will remain around the 3 percent target. In addition, until 2023, they forecast a confident reduction in the budget deficit, a decreasing state debt and limited budget room for maneuver. According to the PM, the labor market processes between 2019 and 2023 are likely to continue their favorable trend, as employment growth is associated with low unemployment. Average earnings may increase by 10.8% in 2019 and 9.3% in 2020. In addition, inflation may reach 3.4% in 2019, 2.8% in 2020, and 3% thereafter. The economic protection measures already in place and planned will probably contribute to protecting the achieved results and maintaining growth above the EU average (PM, 2019). According to forecasts, the state pension and the corresponding pension level will remain mostly unchanged in the short term,

which still justifies the need to strengthen self-care in order to achieve an adequate pension in the long term.

5 Self-care as an option for pension security

Based on the forecasts, the number of pensioners will increase drastically, this cannot be changed in the short term. The Hungarian pension system currently relies on two pillars. Pillar I: the state pension system operates on a pay-as-you-go basis and Pillar II. pillar, which operates on the principle of capital coverage (Novosz ath, 2014). In the current pension system, choosing a voluntary pension fund can be an additional element of ensuring a living in old age. The voluntary pension fund can enable us to maintain the standard of living we were accustomed to during our active years upon retirement. These institutions supplement other retirement savings, such as pension insurance. In the general public perception, a pension is the pension that the elderly citizens of a country receive on a subjective basis, i.e. not on the basis of need. Its amount depends on the length of service, i.e. the number of years spent working (earning) and previous income (Matits, 2016). This definition reflects public opinion, according to which the concept of pension is exclusively related to social security benefits. However, any regular old-age income to which we are entitled during our active years can be considered a pension. Thus, our retirement income from some retirement savings can or could be a pension. It should be made aware that there is not and cannot be a form of state care that could promise an adequate pension for everyone, in all cases. In other words, if we really want to be safe in our old age, we must do a lot ourselves. In addition to raising taxes and contributions and pushing the retirement age further, there is also a more efficient and sustainable solution, which is called self-care. This means that people create for themselves the private pension fund that allows them to live a full life in old age. This also relieves the burden on the state, because, although with state aid, money is being set aside privately. They manage their own assets and do not pay more into the joint.

There are many different ways to save for retirement. Before choosing the right savings product, we must decide in advance to what extent the time period and liquidity will matter in the selection of the savings form. The state supports three types of pre-saving solutions for retirement purposes: the voluntary pension fund, the pension pre-savings account and pension insurances. For these, it is worth thinking in terms of at least 10-20 years. Accumulated private pension capital can be withdrawn upon reaching retirement age, with certain restrictions it can also be accessed earlier.

Conclusion

The current pension systems, due to the high degree of aging of societies, and based on the forecasts, the drastic change in the ratio of active earners and pensioners will most likely cause social, economic and other problems globally and in our country in the future. Living in old age and preserving the sense of security of the retired society is a priority social interest. In most European Union countries, public systems play a central role in enabling people to reasonably maintain their standard of living during their working years and beyond retirement. The challenge facing the pension policies of the member states is to create systems that are financially sustainable in the long term and fulfill the basic purpose of the pension systems, namely to enable an adequate income and standard of living for the elderly, as well as to ensure their economic independence. They should create an institutional system that is able to create sufficient coverage in the long term to create the security of the retired society.

Due to the high rate of aging of society, the current pension system and, based on forecasts, the drastic change in the ratio of active earners and pensioners will most likely cause social, economic and other problems in the future globally and in our country as well. Experts argue in favor of a mixed system, but there is no accepted concept that everyone would like. Due to the mandatory nature of the state pension, there is no choice. Based on the literature review and research, we were not able to prove with certainty that a harmonious old age and pension security are possible even without material well-being, but we managed to clarify that in order to maintain our current standard of living in retirement, it is necessary to take care of ourselves in some financial form in the future. We already have three state-supported options for this, the choice is up to us as to which one or which ones we choose. When it comes to saving for retirement, the amount of our income and our emotional decisions determine which form or forms of savings we choose.

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Building Trust and Fostering Collaboration in Pro-Poor Tourism: A Cross-Cultural Psychological Analysis

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Abstract : This study investigates the optimization of pro-poor tourism efforts, a concept that ensures tourism activities benefit impoverished communities. Given the intricate balance required among the interests of visitors, local communities, and diverse stakeholders, this topic is crucial for policymakers, tourism practitioners, and scholars. The research emphasizes the role of trust as a foundational element for cross-cultural engagement, addressing a significant gap in current pro-poor tourism practices. The primary aim of the research is to enhance the effectiveness of pro-poor tourism initiatives. By examining how trust can serve as the foundation for cross-cultural engagement, the study seeks to provide practitioners with solutions to bridge the gap between visitors, local communities, and diverse stakeholders. Ultimately, the goal is to ensure that pro-poor tourism leads to sustainable and impactful initiatives that uplift local communities while providing visitors with memorable experiences. The methodology involves a comprehensive review of literature sourced primarily from Google Scholar, analyzed using a narrative approach. This method allows for a thorough synthesis of existing knowledge and insights into pro-poor tourism. The findings indicate that local control, cultural sensitivity, and transparency are essential in fostering trust among stakeholders, communities, and visitors. These elements are crucial for promoting cooperation and mutual benefit in pro-poor tourism activities. The research highlights how cultural values influence trust, providing a foundation for developing effective strategies to enhance cooperation among all parties involved. The study's theoretical contribution lies in its detailed exploration of trust as a critical factor in pro-poor tourism. By identifying cultural psychology-based trust-building tactics, the research offers a valuable roadmap for practitioners. These strategies not only

promote cooperation but also strengthen the social and economic fabric of local communities and enhance visitor experiences. In terms of originality and practical implications, this research adds significant value by offering actionable insights into trust-building in pro-poor tourism. The practical solutions proposed can lead to more sustainable and impactful tourism practices that align with the needs and values of local populations. By fostering a sense of ownership and participation among local communities, the study ensures that pro-poor tourism initiatives are ethically and socially responsible, ultimately achieving their full potential in contributing to equitable and inclusive growth.

Keywords: pro-poor tourism; cross-cultural; trust-building; local community empowerment; cultural sensitivity

1 Introduction

1.1 Background of the Study

Tourism has grown to be a significant economic force, particularly in developing countries, because of its ability to combat poverty and advance sustainable development. Anticipations of robust tourism growth in emerging countries—where poverty is rampant—have sparked a great deal of interest in tourism as a means of eliminating poverty. To grow this initiative, strong bureaucratic and commercial links have been established (Chok et al., 2007).

An increasing number of individuals are concentrating on pro-poor tourism development, which places an emphasis on optimizing benefits for neighboring communities in order to fight poverty and promote inclusive growth. Stakeholder interaction, or collaboration between various tourism sector actors, is necessary to achieve pro-poor tourism growth. National governments and donors have generally aimed to encourage private sector investment, macroeconomic growth, and foreign exchange profits in the tourism industry (a concept known as "pro-poor tourism"), without specifically taking into account the needs and possibilities of the poor in tourism development.

Infrastructure development, private investment encouragement, and attracting foreign tourists are the top priorities of donor-funded tourism master plans. Travel is very common over the world and has a significant impact on local populations, particularly in developing countries. Pro-poor tourism is travel aimed at maximizing benefits for the impoverished through improved living conditions, increased earnings, and job creation (Ashley et al., 2000).

The idea of pro-poor tourism (PPT) has become a potent force for good in the ever-changing world of international travel. PPT aims to produce a win-win

situation by helping underprivileged areas and encouraging long-term, sustainable economic growth. Fundamentally, PPT seeks to improve the lives of the most disadvantaged people on the planet while reducing adverse effects on regional landscapes and cultures. This article explores the vital significance that fostering trust and collaborating across cultural boundaries play in the context of pro-poor tourism. Through comprehension of the psychological processes involved, we can improve PPT projects' efficacy.

1.2 Problem Statement

Bridging the gap between different stakeholders, including visitors, local communities, government agencies, non-governmental organizations, and private businesses, is the main problem encountered by pro-poor tourism practitioners. How do we build mutual trust and promote cooperation across cultural divides? As we negotiate the complexity of cross-cultural relationships, we understand that trust is essential to productive teamwork. The potential of pro-poor tourism cannot be realized without trust since meaningful collaborations are impossible to establish without it.

1.3 Research Objectives

1. To identify how can trust be cultivated among diverse actors, including tourists, local entrepreneurs, and community members?
2. Explore how cultural psychology can inform strategies for fostering collaboration between tourists, local communities, and tourism stakeholders.

1.4 Significance of the Study

This study is very important in a number of ways. Understanding how cultural values affect relationships and cooperation in tourist projects that help marginalized groups is made easier with its insights into the intricate dynamics of trust and collaboration across cultural boundaries in the context of pro-poor tourism. By looking at these psychological aspects, the research can help stakeholders improve relationships, settle disputes, and encourage tolerance across different groups all of which will improve sustainable tourism practices. Furthermore, by emphasizing the significance of genuine community engagement and equitable benefit sharing in tourism development, it helps to promote social inclusion and empowerment.

The study also advocates for policies and training initiatives that place a high value on community involvement and respect for local knowledge, which helps to inform management practices and policy. The utilization of a cross-cultural approach yields significant insights into universal principles and culturally

particular behaviors that are pertinent to the success of pro-poor tourist efforts. This, in turn, contributes to the body of academic research in fields like community development, sustainable tourism, and cross-cultural psychology. In general, the research contributes to the advancement of pro-poor tourism knowledge and practices by highlighting the critical role that trust and cooperation play in developing inclusive, sustainable tourism models that are advantageous to both locals and visitors.

2 Literature Review

Pro-poor tourism, or PPT, is tourism that helps those who are poor. PPT is a methodology, not a specific travel product or niche. Rather than expanding the sector's size, PPT policies aim to give the poor opportunities for financial gain, other livelihood benefits, or involvement in decision-making (Ashley et al., 2000).

2.1 Trust-building Strategies

The concept of trust has been the subject of more and more selective and uncritical engagement by tourism researchers. Trust is always granted in certain circumstances and areas. This holds especially true for research on tourism, which "is still at the stage of developing research models to test its compatibility in selected industrial sectors and borrowing constructs from other established disciplines" (Wang et al. 2014, p. 1). Travelers' judgments of travel agents' competence can be influenced by cognitive trust, which is an evaluation of their professional performance, whereas affect trust, or the emotional worth of their services, was more influential in determining their perceived friendliness.

When it comes to the relationships between businesses, the scant tourism research that addresses trust largely adheres to the general body of literature on the subject. For instance, there were few results specifically related to tourism in Czernek and Czakon's (2016) study of the cooperation of tourism enterprises, which was based on Das and Teng's (2004) general work on the calculative character of trust. In a similar vein, important tourism specificities are not highlighted in the research on tourism stakeholders' trust in tourism policies and tourism policy bodies (Nunkoo and Ramkissoon 2012).

Following the groundbreaking study on the social embeddedness of economic activity (Granovetter, 1985), a number of social science concepts have been employed more frequently in management as explanatory factors. The idea of trust has been employed extensively by researchers among them (Bachmann, 2011). According to Doney and Cannon (1997), trust is commonly defined as the perception of the target of trust's goodness and credibility. Each of the parties is

exposed in the collaboration setting because of their dependency and the unpredictability surrounding the environment.

According to recent research, trust is a major factor in tourist partnership (Czernek, 2013; Nunkoo & Ramkisson, 2011). According to Sztompka (1999), one of the causes is that trust is the emotional basis of collaboration" or the lubricant facilitating collaboration.

Trust has a crucial role in enhancing collaborative performance by resolving conflicts, easing tensions between partners, and discouraging opportunistic behavior (Nielsen, 2011). It is abundantly evident from academic research that the formation of any partnership requires a minimum degree of trust (Das & Teng, 1998).

A thorough examination of trust challenges us to go beyond the idea that it is a micro-level occurrence that develops naturally between people (Bachmann, 2011). This is necessary in order to comprehend why actors have a tendency to put their faith in certain actors while withholding it from others. Put another way, trust becomes a tool that can be developed, molded, and affected, enabling productive collaboration with others. It is no longer merely a phenomenon. According to academics, the decision to start a relationship is influenced by a variety of evaluative processes that combine past experiences, current beliefs, and newly acquired information (Huang & Wilkinson, 2013).

Assuming that partners behave rationally and pursue what best serves their own interests, the first process for establishing trust is calculative (Nielsen, 2011). The trustor determines if working together would be more advantageous after weighing the benefits and costs of a target acting dishonestly.

The second mechanism is concerned with evaluating capability. This speaks to the target's capacity and availability to fulfill obligations (Doney & Cannon, 1997). Therefore, a partner's competence and capacity to carry out specific activities leads to the development of trust (Nielsen, 2011). According to empirical data, competences and resources are crucial elements that promote network collaboration in the tourism industry (Wang & Fesenmaier, 2007). Cooperation academics point out a conflict between trust and capabilities, stating that although choosing a capable partner is preferable for resource-based reasons, choosing a trustworthy partner who might not be the most capable is essential to prevent opportunistic behavior (Gnyawali & Park, 2009).

The third process for establishing trust is intentionality, which is based on the goals and attitude of the trustor (Doney & Cannon, 1997). Network cooperation is driven by the desire to diversify offerings and open up new markets in order to entice visitors to remain longer and bring benefits to all participating parties (Wang & Fesenmaier, 2007).

Prediction is the fourth mechanism that fosters trust. Its fundamental tenet is that actions taken in the past serve as premises for actions taken in the future, and vice versa. Actors use the more comprehensive and prolonged experience with a partner in order to do this (Doney & Cannon, 1997). However, knowledge of experience and credibility traits will only be known in advance if there is a history of previous contacts, a recall of when introductions were made by reliable third parties (Huang & Wilkinson, 2013).

In general, trust is thought to be a predictor of other people's behavior (Kumar & Das, 2007). It could result from a number of things, including the artist's qualifications, standing, degree of dependency, dedication, and previous connections (Wang & Fesenmaier, 2007).

2.2 Cross-cultural Collaboration

Numerous studies in a variety of fields, including anthropology, psychology, geography, education, political science, and marketing, have been conducted as a result of the increased interest in cross-cultural study (Ramkisson et al., 2011). It is regarded as a crucial area of study for marketing and consumer studies since it influences how individuals and groups behave while producing and consuming goods. People behave differently in different cultures because diverse groups have different beliefs and attitudes (Richardson and Crompton, 1988). As a result, it is widely believed that culture plays a major role in explaining human behavior, and cultural distinctions are valuable concepts in the context of global tourism marketing. These evaluations can offer precise standards for positioning and targeting travel locations and products (Reisinger and Turner, 2002).

Cross-cultural studies are carried out to identify and contrast the cultural traits of particular groups within a given nation or between several nations (Clark, 1990; Sussmann and Rashcovsky, 1997).

According to Master and Pierreux (2000), culture has two dimensions. One way to conceptualize culture is as non-material components of identity that include customs, norms, values, and activities. According to Kim et.al (2011), the second dimension is made up of material things, such as where to go, what to eat, what to buy, and how to act when traveling. However, the place of origin of a particular group of people shapes both the material and nonmaterial components of culture.

Actual tourists, prospective tourists, and other tourism sector practitioners are all involved in tourism activities. They behave differently as a result of having distinct psychological activities related to tourism (Skavronskaya et al., 2020c). In tourism activities, there are constant interactions and connections between visitors, tourism products, tourism service employees, and tourism enterprise management employees. These exchanges and interpersonal connections are reliant on individuals' psychological processes. The laws governing these individuals'

psychological processes and behaviors when engaging in tourism activities are studied by tourism psychology. Behaviours and psychological activity are interdependent. Behavior is determined by psychology, and psychology is reflected in behavior (Kesenheimer and Greitemeyer, 2021). A super utilitarian experience serves as the foundation for a holistic tourism experience. While taking in this experience, visitors can find aesthetic pleasure in taking in the surroundings, recognize a vibrant life through social interactions, actively explore and develop their own identities through role-playing, and also enjoy secular pleasures through tourism consumption.

2.3 The Need of Stakeholder Cooperation in the Favor of Pro-Poor Tourism

The identification and engagement of actual and legitimate stakeholders is a necessary condition for the successful development and implementation of effective collaboration and community participation in tourist planning (Eyisi et al, 2020).

2.4 Private Sector

The private sector is made up of several local tourism businesses and a complex web of links between national and multinational corporations. The private sector must be involved to guarantee excellent tourism management and draw investment to the area. Without a doubt, each tourism firm has its own set of guiding ideas and business procedures. While some may be ardent supporters of using tourism to combat poverty, others might not view this as a top concern for their business (Jamieson et al., 2004).

2.5 Government

Governments control the laws and regulations pertaining to tourism, influence the development of travel destinations, and provide financial incentives to help small companies, local jobs, and procurement. These elements are essential to pro-poor travel. In order to encourage commercial operators to commit to pro-poor principles, the government can offer the impoverished safe tenure over land or other assets utilized for tourism, as well as investment incentives and planning regulations. It can also consult with these individuals when making decisions about tourism. Additionally, encourage the growth of tourism in underserved areas by making marketing and infrastructural investments, changing regulations that prohibit the destitute from starting small enterprises or finding employment, and generally lending assistance to small businesses (Ashley et al, 2001; Roe, 2006).

2.6 Local Communities

Locals' involvement is necessary to support low-income tourism. Engaging in tourist efforts that aid the disadvantaged can positively influence social relationships, cultivate a feeling of community and belonging, and enhance local and regional pride. The degree to which locals participate in pro-poor tourism varies depending on the area, kind of community involvement, and content (Wen et al., 2021).

2.7 Non-government Organization

It is easier to involve the impoverished when civil society which consists of journalists, trade associations, NGOs, community-based organizations, and educational institutions of all kinds—supports them.

2.8 Tour Operators

International tour operators should urge tourists and groups to help lessen poverty in vacation destinations. Even if they would prefer not to forfeit their vacation fun, many customers increasingly expect tour operators to advocate for the impoverished on their behalf (Goodwin, 2006).

2.9 Tourism Enterprises

In order to obtain development opportunities that promote the economic growth of these areas and aid in the reduction of poverty, tourism businesses in rural, underdeveloped areas make use of their tourist resources. Enterprises implementing pro-poor tourism strategies present a fresh approach to mitigating poverty in developing nations and foster the development of a varied coalition of travelers who share the goal of eliminating poverty via tourism (Wen et al., 2021).

2.10 Tourists

Tourist awareness of environmental and sociocultural issues has to grow, and customers have to put pressure on tour operators to make the tourism sector more pro-poor (Cattarinich, 2001). More and more tourists would like to improve the environments in which they vacation. In addition to being taught about the opportunities available to enhance the quality of life for locals, visitors must be provided the opportunity to actively participate in the process of decreasing poverty.

3 Research Methodology

In order to conduct this study, the researchers used a qualitative research methodology and carefully analyzed secondary materials from Google Scholar and other relevant websites, including peer-reviewed studies, published papers, and online resources.

4 Results and Discussion

The study shows that trust is mostly dependent on open communication regarding perks and income sharing. This can entail making certain that local communities receive a fair portion of the money generated by tourism and that they are aware of how it is used.

It also indicates that educating visitors and locals alike about cultural sensitivity promotes trust. Locals can teach tourists about expectations and customs, and tourists can teach locals about the motivations and conduct of visitors.

The findings of this study emphasize how crucial it is to grant local communities ownership and control over tourist initiatives. This can entail giving people the opportunity to create experiences that are genuine and considerate of their culture, as well as include them in decision-making processes.

The study reveals how cultural values pertaining to power dynamics, in-group/out-group dynamics, and communication styles impact the establishment of trust. Using this information, tailored tactics for various cultural situations might be created.

It indicates that creating social bonds between visitors, residents, and stakeholders via common experiences can be an effective strategy for establishing trust. This can entail fostering social gatherings that go beyond strictly business dealings.

The study emphasizes how critical it is to pinpoint and highlight shared goals for all parties engaged in pro-poor tourism. This could be environmental sustainability, cultural preservation, or poverty reduction. Perhaps via the application of cross-cultural psychology-informed trust-building techniques, pro-poor tourist efforts can promote more productive cooperation amongst various stakeholders.

Conclusions

The study concludes by highlighting the importance of trust in fostering communication between travelers, locals, and other stakeholders in pro-poor tourism projects. Through the identification of the significance of equitable distribution, transparent communication, and cultural sensitivity training, the study

provides practitioners with tactics to foster trust among heterogeneous players. Furthermore, a fuller knowledge of cross-cultural cooperation can be attained by investigating how social relationships and cultural values affect trust-building. In the end, the study emphasizes that encouraging common objectives—like reducing poverty or promoting environmental sustainability can strengthen cooperation even more. These results open the door to further successful pro-poor tourism initiatives that could benefit local communities and visitors alike greatly.

Implications for Future Research

This study establishes the foundation for fascinating upcoming research projects. Future research might examine how these trust-building techniques result in sustained cooperation and beneficial effects for nearby communities in order to gauge the long-term effects. For a more comprehensive understanding of success, it is imperative to develop rigorous measures that take into account environmental sustainability, community empowerment, and cultural interchange in addition to economic indicators. The increasing impact of technology on the tourism industry necessitates a closer look at how it promotes communication, trust-building, and knowledge exchange among various stakeholders. Further research into context-specific tactics, such as looking at trust-building in certain cultural contexts or tourism models, may also yield more insightful results. Ultimately, a comprehensive knowledge would come from investigating the viewpoint of the tourist, comprehending how trust grows among visitors, and learning how tourism experiences might be planned to promote trust and responsible travel practices. Future studies can build on this foundation and improve our knowledge of how to design pro-poor tourism activities that are actually successful and sustainable by exploring these possibilities.

Limitations of the Study

The primary constraint of this research is its heavy reliance on a single database, which resulted in a small number of included studies. Larger database searches in future studies might yield additional proof and strong arguments in favor of differential analysis.

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Application of a hybrid BWM-EDAS-VIKOR method for analyzing ERP system adoption across different industries

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Abstract: Enterprise Resource Planning (ERP) systems are standardized software packages built upon industry “best practices”. They allow enterprises to automate and optimize their competitive processes and facilitate cross-functional transactions. Using ERP systems in different enterprises impacts success and enhances decision-making quality. Although they come ready-made, many companies tailor the software to fit their specific industries' business processes. Therefore, the study aims to rank different industries' intentions to use ERP systems by applying hybrid BWM-EDAS-VIKOR. Based on the empirical analysis conducted in Serbian companies, four industries (information and technology - IT, automobile industry, sales and distribution, and metal processing industry) were compared based on different criteria. The study indicates that the inclination to adopt ERP systems varies by industry type, serving as an initial step for a more in-depth examination of the reasons for the implementation of ERP systems.

Keywords: ERP systems; industries; BWM, EDAS, VIKOR.

1 Introduction

Recognizing the need for continuous access to information within organizations, there is an increasing drive towards automation, digitalization, and the creation of integrated cross-functional connections. To effectively manage these interconnected elements, deploying a comprehensive information system is essential, serving as a cornerstone for organizational success (Goumas et al., 2018). Consequently, the Enterprise Resource Planning (ERP) system has become a foundational pillar for modern business operations. ERP enables enterprises to streamline processes, enhance productivity, and make informed decisions based on real-time data (Hansen et al., 2023).

However, organizations in some industries remain hesitant to adopt ERP due to the significant risk of failure associated with such implementations. A study by Coşkun et al. (2022) identified the primary factors leading to ERP failures, examining various project stages of implementation. Their research found that a lack of user involvement in the post-implementation phase was one of the main reasons for failure. This underscores the importance of gathering feedback from ERP users.

As a result, it is essential to explore user acceptance of ERP systems (Andwika et al., 2020; Hancerliogullari Koksalmis & Damar, 2022). In the context of new technology acceptance, the Technology Acceptance Model (TAM) serves as a valuable framework (Jo & Bang, 2023). On the other hand, implementing an ERP system requires considering various influencing factors. This complexity necessitates a robust decision-making framework to effectively analyze and evaluate intentions related to ERP adoption (Thanh, 2022). Different industries exhibit varying preferences for adopting ERP systems, so it is valuable to explore which sectors demonstrate a stronger intention to implement these systems. Therefore, this paper examines users' attitudes toward ERP adoption across different industries in the Republic of Serbia, focusing on the most influential criteria driving these decisions. In the initial research phase, the criteria were assessed using the Best-Worst Method (BWM) to evaluate their relative impact. Subsequently, industries were ranked based on the EDAS and VIKOR multi-criteria decision-making methods. Additionally, a sensitivity analysis was performed to examine the effects of methodological variations, ultimately leading to the identification of the optimal solution.

The structure of this paper is as follows. The theoretical review section explains and discusses previous studies found in the literature. The methodology section provides a detailed explanation of the techniques used in this study. The results and discussion section presents the findings obtained from the research. Finally, the conclusion summarizes the key insights and offers suggestions for future research.

2 Theoretical Review

Business management systems have evolved significantly, making modern information systems, known as ERP, essential in today's business practices. These systems are crucial in standardizing, rationalizing, and automating companies' processes. By implementing an ERP system, companies can gain a competitive advantage and enhance their ability to process information or meet stakeholders' interests. Over the past decades, ERP systems have garnered considerable attention as companies search for new ways to achieve strategic and competitive advantages through technological advancements. Therefore, it is reflected in numerous academic papers concerning ERP systems.

Few studies examined the factors that influence the adoption of ERP systems within the healthcare sector (Damali et al., 2021; Bialas et al., 2023), banking sector (Ahmadzadeh et al., 2021; Jaradat et al., 2022; Shbail et al., 2024), construction (Boutros et al., 2024) etc. Some papers investigated using Multi-Criteria Decision-Making (MCDM) methods for ERP selection. Besides, Ayağ and Samanlıoğlu (2021) adopted a hybrid fuzzy approach that uses the Analytic Hierarchy Process (AHP) with a combination of the Technique for Order Performance by Similarity to the Ideal Solution (TOPSIS). In this regard, in the work of the author Jin (2024), the (srb. Višekriterijumsko KOmpromisno Rangiranje) VIKOR method was used to select adequate ERP software. Other studies used the MCDM approach to rank ERP failure factors. Yadav and Joseph (2020) used TOPSIS to prioritize critical failure factors for adopting an ERP system. In another study, such as Naveed et al. (2021), MCDM techniques are used to rank critical success factors for cloud ERP adoption.

Additionally, literature is available on topics related to using ERP systems in industries such as information technology (IT), the automobile industry, sales and distribution, and the metal processing sector. ERP systems play a crucial role in streamlining operations in the IT industry, which is primarily centred around the production and distribution of software to end users. During the software development phase, the emphasis is predominantly placed on modules that support project management and planning. These modules help IT companies manage resources effectively, track project progress, and ensure timely delivery of software products. In contrast, once the software reaches the distribution phase, the focus shifts to customer relationship management and sales management modules. These modules are essential for managing client interactions, understanding customer needs, and driving sales growth, as Grubić and Ratković (2012) highlighted. According to Lorenc and Szkoda (2015), the automotive industry often finds that standard transactions do not meet its specific needs effectively. The processes in this sector require the continuous flow of raw materials, semi-finished products, and finished goods (Lakshmanan et al., 2018). Overall, the manufacturing industry faces considerable challenges in managing operations efficiently due to the increasing complexity of supply chains and evolving market conditions (Wulan et al., 2024). This underscores the importance

of adopting ERP systems. In manufacturing, ERP systems enhance productivity and product quality by improving logistics, production planning, and reporting (Chopra et al., 2022). Hidalgo Nuchera et al. (2011) explored the selection of ERP systems in the metal processing sector, concentrating on the implementation of software. Furthermore, Braga Pereira et al. (2024) investigated the challenges encountered by users at different hierarchical levels during the ERP implementation process in a metal production company. The department manages key processes in sales and distribution, including marketing strategies, pricing strategies, contracts, distribution, and customer relations. In this context, the ERP system serves as a vital tool, providing comprehensive visibility into sales data and customer interactions, thus enabling organizations to make informed decisions that drive sales performance and enhance customer satisfaction (Worster et al., 2016).

Considering the growing interest in adopting ERP systems in emerging economies, this paper aims to explore attitudes towards implementing ERP systems across various industries in the Republic of Serbia. The MCDM approach proves to be very practical for achieving this. The literature review indicates that the use of MCDM methods in investigating ERP systems has not been extensively explored to examine key factors that influence ERP implementation. Therefore, this study applies BWM-EDAS-VIKOR, which presents an improved hybrid MCDM approach.

3 Methodology

The survey was distributed via a link on LinkedIn, specifically targeting individuals employed in organizations that utilize ERP systems in their operations. A total of 139 respondents participated, representing a diverse range of sectors, including IT, the automotive industry, sales and distribution, and metal processing. The defined research model is illustrated in Figure 1.

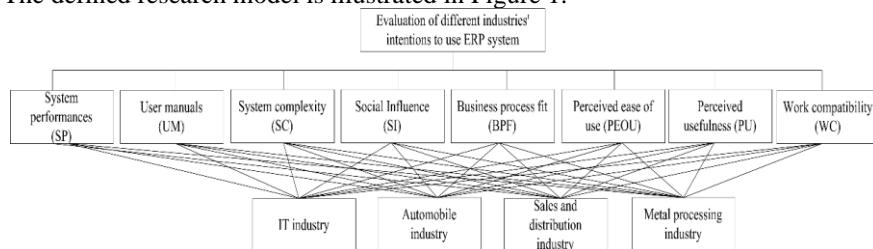


Figure 1. Multi-criteria model for selection industry based on implementation of ERP system¹

¹ Note: Criteria are adopted from Sternad Zabukovšek et al. (2019)

In the first phase of the research, the weight coefficients for each criterion were determined using the Best Worst Method. In the second phase, four industries (IT, automobile, sales and distribution, and metal processing) were ranked based on eight established criteria, utilizing both the EDAS and VIKOR methods. Figure 2 briefly explains the research process.

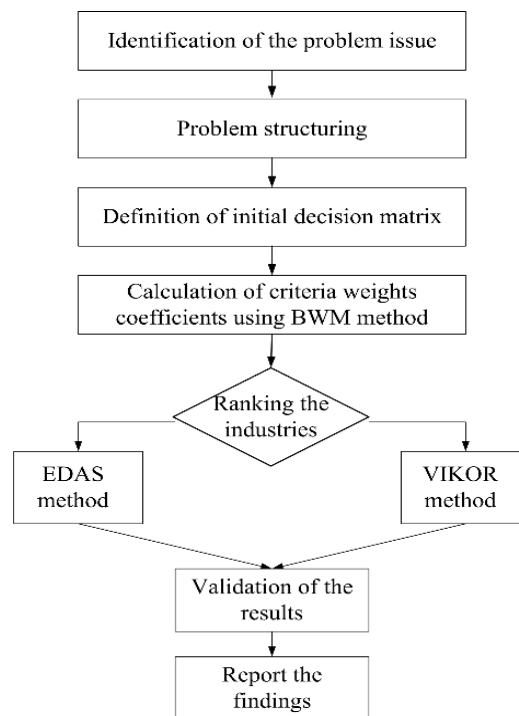


Figure 2. Research process flowchart

The following sections of the paper comprehensively explain the techniques employed.

3.1 Best Worst Method

The Best Worst Method (BWM) is a decision-making approach developed for solving multi-criteria decision-making (MCDM) problems (Rezaei, 2015, 2016) that relies on pairwise comparisons. BWM offers two key advantages over other MCDM methods: first, it requires significantly less pairwise comparison data than a full pairwise comparison matrix; second, it produces results that are more consistent than those generated by traditional methods that utilize a complete pairwise comparison matrix (Ahmadi et al., 2017; Mi et al., 2019). These benefits are the primary reasons for choosing BWM in this study. This method has already been widely used in numerous studies such as supplier selection, technology,

transportation, Industry 4.0 challenges, environmental performance evaluation (Liu et al., 2021; Wankhede & Vinodh, 2021; Varchandi et al., 2024).

According to Rezaei (2015), the Best Worst Method (BWM) employs a five-step process to determine the criteria weights. This same approach can also be applied to derive the weights of alternatives for each criterion. In this study, the focus will be on calculating the criteria weights. Below, the five steps of BWM presented by Rezaei (2015) are summarized.

Step 1: Determine a set of decision-making criteria. In this step, a collection of criteria $\{c_1, c_2, c_3, \dots, c_n\}$ is selected to guide the decision-making process.

Step 2: Select the *best* (most important) and *worst* (least important) criteria. In this step, the decision-maker or expert identifies the best criterion (most desirable or important) and the worst criterion (least desirable or important) from the set of decision criteria. If there are multiple criteria that could be considered the best or worst, they can be chosen arbitrarily.

Step 3: Conduct pairwise comparisons with the best criteria. In this step, pairwise comparisons are made between the best criteria and the other criteria. This process results in the Best-to-Others (BO) vector, which is established based on a preference score ranging from 1 to 9. A score of 1 indicates equal preference between the best criterion and another criterion, while a score of 9 signifies extreme preference for the best criterion over the others. Then, the BO vector could be established as:

$$BO = (a_{B1}, a_{B2}, a_{B3}, a_{B4}, \dots, a_{Bn}) \quad (1)$$

where a_{Bj} shows the preference of the best criterion B over criterion j , and it can be concluded that $a_{BB} = 1$.

Step 4: Conduct pairwise comparisons with the worst criteria. In this step, pairwise comparisons are made between the worst criteria and the other criteria. The Others to Worst (OW) vector can be established as follows:

$$OW = (a_{1W}, a_{2W}, a_{3W}, a_{jW}, \dots, a_{nW})^T \quad (2)$$

where a_{jW} explain the preference of the criteria j over the worst criteria W . It also can be deduced that $a_{WW} = 1$.

Step 5: The calculation of optimal weights. In this step, $w_1^*, w_2^*, w_3^*, \dots, w_n^*$ are calculated. Two distinct models for Best Worst Method (BWM) have been proposed. The first model (Rezaei, 2015) can result in multiple optimal solutions, while the second model (Rezaei, 2016) focuses on identifying unique weights.

The optimal weights for the linear model are those that minimize the maximum absolute difference in the following set: w_B / w_j and w_j / w_w . The ideal solution is where $w_B / w_j = a_{Bj}$ and $w_j / w_w = a_{jW}$. The weights must sum to 1, and none

can be negative. This constraint leads to Eq. (3) for determining the optimal solution.

$$\begin{aligned} & \min \max_j \{ |w_B - a_{Bj} w_j|, |w_j - a_{jW} w_W| \} \\ & \text{subject to} \\ & \sum_{j=1}^n w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \tag{3}$$

This problem can be equivalently transformed to the next linear programming problem.

$$\begin{aligned} & \min \xi^T \\ & \text{subject to} \\ & |w_B - a_{Bj} w_j| \leq \xi^T, \text{ for all } j; \\ & |w_j - a_{jW} w_w| \leq \xi^T, \text{ for all } j; \\ & \sum_{j=1}^n w_j = 1 \\ & w_j \geq 0, \text{ for all } j. \end{aligned} \tag{4}$$

After solving problem Eq. (4), the optimal weights $w_1^*, w_2^*, w_3^*, \dots, w_n^*$ and ξ^{T*} are derived. The value of ξ^{T*} serves as a direct indicator of the consistency within the comparison system. A value of ξ^{T*} closer to zero signifies greater consistency, which in turn enhances the reliability of the comparisons. This study utilized the linear model to determine the unique weights of the criteria for the actual use of the ERP system.

3.2 EDAS method

For the first time in the literature on MCDM methods, Keshavarz Ghorabae et al. (2015) introduced the EDAS method as a ranking tool designed to address complex decision-making challenges where multiple alternatives need to be prioritized based on various criteria (Stojanović et al., 2022). One key distinction of EDAS compared to traditional methods like TOPSIS and VIKOR is its normalization approach. While these conventional methods focus on identifying the best alternative based on ideal and anti-ideal solutions, real-world decision-making often reveals that simply minimizing the distance to the ideal solution and maximizing the distance from the anti-ideal solution does not always lead to the most appropriate choice. In contrast, EDAS aims to identify the best alternative using an average solution-based normalization technique. To assess each

alternative's score and establish their relative rankings, EDAS employs two measures: Positive Distance from Average (PDA) and Negative Distance from Average (NDA) (Torkayesh et al., 2023). For a complex, multi-faceted MCDM problem involving n criteria and m alternatives, EDAS can be implemented through the following steps.

Step 1: Construct the initial decision matrix using either real data or a qualitative scale provided by participants (decision-makers or experts). For a decision-making problem involving n criteria ($n = 1, 2, \dots, j$) and m alternatives ($m = 1, 2, \dots, i$), the initial decision matrix can be represented as follows:

$$\begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & \cdot \\ \cdot & \cdot & \dots & \cdot \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix} \quad (5)$$

Step 2: In the normalization process, the average solution is calculated by considering all criteria. The average value for each criterion j is determined using the formula presented in Eq. (6).

$$AV_j = \frac{\sum_{i=1}^n x_{ij}}{n} \quad (6)$$

Step 3: In this step, two key measures of the EDAS method, Positive Distance from Average (PDA) and Negative Distance from Average (NDA), are calculated based on the nature of the criteria involved. For *beneficial* criteria, the PDA and NDA values are derived using Eq. (7) and Eq. (8). Conversely, for *cost* criteria, the PDA and NDA values are calculated according to Eq. (9) and Eq. (10).

$$PDA_{ij} = \frac{\max(0, x_{ij} - AV_j)}{AV_j} \quad (7)$$

$$NDA_{ij} = \frac{\max(0, AV_j - x_{ij})}{AV_j} \quad (8)$$

$$PDA_{ij} = \frac{\max(0, AV_j - x_{ij})}{AV_j} \quad (9)$$

$$NDA_{ij} = \frac{\max(0, x_{ij} - AV_j)}{AV_j} \quad (10)$$

Step 4: The weight coefficient for each criterion (w_j), assigned by experts or determined through other methods, is utilized to calculate the weighted sums of the PDA and NDA values. This is done according to Eq. (11) and Eq. (12).

$$SP_i = \sum_{j=1}^n w_j PDA_{ij} \quad (11)$$

$$SN_i = \sum_{j=1}^n w_j NDA_{ij} \quad (12)$$

Step 5: Weighted sum values of PDA and NDA are normalized using Eq. (13) and Eq. (14).

$$NSP_i = \frac{SP_i}{\max_i(SP_i)} \quad (13)$$

$$NSN_i = 1 - \frac{SN_i}{\max_i(SN_i)} \quad (14)$$

Step 6: Finally, the compromise score for each alternative is calculated using Eq. (15). The alternatives are then ranked based on their compromise scores, from highest to lowest, with the alternative having the highest score deemed the best option.

$$AS_i = \frac{1}{2} (NSP_i + NSN_i) \quad (15)$$

3.3 VIKOR method

The VIKOR method (*srb.* VišeKriterijuska Optimizacija I Kompromisno Resenje) MCDM technique used to rank and select from alternatives characterized by conflicting criteria. The primary goal of this approach is to find a mutually acceptable resolution that maximizes the overall benefit for the group while minimizing the individual regret of the opposing party (Opricovic & Tzeng, 2004; Ahmed et al., 2024). To achieve this, we employ an aggregating function known as the L_p -metric, which evaluates how closely each alternative aligns with the ideal solution (Zeleny and Cochrane, 1982). The L_p -metric is based on assessments of each alternative against various criteria. The method for each criterion function begins with the following formulation of the L_p -metric:

$$Lp_j = \left\{ \sum_{i=1}^n \left[w_i (F_i^+ - F_{ij}) / (F_i^+ - F_{ij}^-) \right]^p \right\}^{\frac{1}{p}}, 1 \leq p \leq \infty; j = 1, 2, \dots, J. \quad (16)$$

The VIKOR approach generates a ranking list that reflects a compromise solution, incorporating weight stability intervals that indicate preference stability. This method involves evaluating the degree of closeness to the ideal alternative to determine the ranking of compromise options. The solution that minimizes group utility (S_j) represents a compromise that maximizes overall group benefit, as outlined in Eq. (17). Conversely, the solution that minimizes individual regret (R_j) signifies a compromise aimed at reducing personal dissatisfaction, illustrated in Eq. (18). The VIKOR technique is specifically designed to identify a compromise solution that is closest to the ideal while accounting for the trade-offs and concessions made by all stakeholders. The steps to derive the compromise solution are detailed below (Opricovic, 1998).

Step 1: Determine the best F_i^+ and worst F_i^- values, where $i = 1, 2, 3, \dots, n$ of all the criterion functions as: $F_i^+ = \max(F_{ij})$ and $F_i^- = \min(F_{ij})$.

Step 2: Normalization of S_j and R_j where $j = 1, 2, 3, \dots, n$ is computed with Eq. (17) and (18).

$$S_j = \sum_{i=1}^n \left[\frac{w_i (F_i^+ - F_{ij})}{F_i^+ - F_i^-} \right] \quad (17)$$

$$R_j = \max \left[\frac{w_i (F_i^+ - F_{ij})}{F_i^+ - F_i^-} \right] \quad (18)$$

Calculation of the value of Q_j where $j = 1, 2, 3, \dots, n$ is illustrated in Eq. (19).

$$Q_j = \frac{v(S_j - S^+)}{(S^- - S^+)} + (1-v) \left(\frac{R_j - R^+}{R^- - R^+} \right) \quad (19)$$

where, $S^+ = \min S_j$, $S^- = \max S_j$, $R^+ = \min R_j$, $R^- = \max R_j$ and v is the weight of the majority of criteria or the maximum group utility, here $v = 0.50$.

Step 3: The ranking of the alternatives is done after sorting the S , R and Q values in decreasing order, which gives three ranking lists.

Step 4: Analyzing the compromise function using the generated best-ranked alternative (A_2) involves measuring the minimum Q through two distinct conditions, which are:

Condition 1. $Q(A_2) - Q(A_1) \geq DQ$; where, A_2 is the second-place alternative in the ranking list sorted by Q ; $DQ = 1/(J-1)$; J is the number of alternatives.

Condition 2. The compromising function is chosen with a random decisionmaking process, where Q_j is chosen as the best choice from S and/or R with $v \geq 0.50$.

The best alternative in the compromise function is the one with the lowest Q value.

4 Results and discussion

This paper examined the ERP system's implementation in various industries in the Republic of Serbia based on more influential criteria. Initially, the importance of these criteria was evaluated using the Best Worst Method (BWM). Subsequently, the industries were ranked using multi-criteria decision-making methods. Following this, a sensitivity analysis was conducted to assess the impact of methodological changes, ultimately identifying the most effective solution

The decision problem included a set of eight criteria: SP(C₁) - system performance, UM(C₂) - user manuals, SC(C₃) - system complexity, SI(C₄) - social influence, BPF(C₅) - business process fit; PEOU(C₆) - perceived ease of use; PU(C₇) - perceived usefulness; WC(C₈) - work compatibility.

After defining a set of criteria, applying BWM determines the best (most important) and worst (least important) criteria. Based on the opinion of an industry expert, C₈ - work compatibility is chosen as the best, and C₅ - business process fit is chosen as the worst criterion. The best in relation to all other criteria is compared in pairs using Saaty's scale (Saaty, 1980). The comparison results placed in the appropriate vector are presented in Table 1.

Criteria	SP(C ₁)	UM(C ₂)	SC(C ₃)	SI(C ₄)	BPF(C ₅)	PEOU(C ₆)	PU(C ₇)	WC(C ₈)
Most important C ₈	1	4	2	4	5	3	3	1

Table 1. Best criterion preference over the other criteria

Based on the expert opinion shown in Table 2, it can be concluded that the system performance criterion is on the same rank as work compatibility (1). Furthermore, the work compatibility criterion has strong dominance in relation to business process fit (rating is 5). Furthermore, a comparison vector is formed for the worst criterion, C₅ - business process fit, the comparison results of which are shown in Table 2.

Criteria	<i>Least important criterion C₅ (Business Process Fit)</i>
SP (C1)	5
UM (C2)	2
SC (C3)	5
SI (C4)	2
BPF (C5)	1
PEOU (C6)	3
PU (C7)	3
WC (C8)	5

Table 2. Preference of all criteria over the Worst criterion

A simple weighted average is computed for each criterion to obtain a single weight vector. Figure 3 displays the optimal weights of the criteria. The result indicates that the average consistency ratio is close to zero (0.25), and the pairwise comparison consistency level is acceptable, demonstrating that the comparisons are highly consistent and reliable.

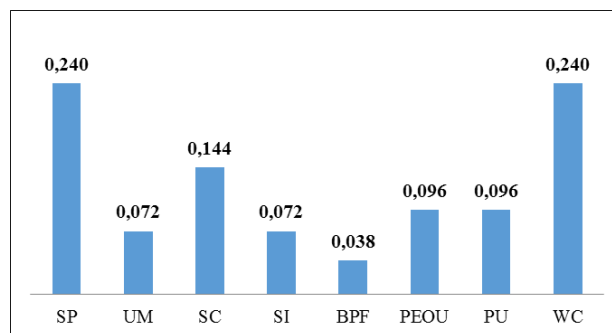


Figure 3. Results of BWM criteria weights

The results presented in Figure 3 provide insight into criteria weights. Namely, “SP(C1) - system performance” and „WC(C8) - work compatibility“ have the strongest influence on ERP implementation, with a criterion weight of 0.240. These criteria are the most important when organizations attempt to achieve ERP system actual use. This was followed by “SC(C3) - system complexity” with a criterion weight of 0.144. On the other hand, the lowest importance has BPF(C5) - business process fit (0.038), which, according to the opinion of experts, is singled out as the least influential.

Furthermore, the criteria evaluations derived from the Best-Worst Method (BWM) were employed to rank four distinct industries - IT, Automobile, Sales and Distribution, and Metal Processing Industry. The multi-criteria decision-making methods EDAS and VIKOR were applied to this ranking. Table 3 shows the initial

decision-making matrix formulated based on the average rates of respondents' answers for all industries and the weights of criteria obtained by the BWM method.

Industries	Criteria							
	SP(C ₁)	UM(C ₂)	SC(C ₃)	SI(C ₄)	BPF(C ₅)	PEOU(C ₆)	PU(C ₇)	WC(C ₈)
	<i>max</i>	<i>max</i>	<i>min</i>	<i>max</i>	<i>max</i>	<i>max</i>	<i>max</i>	<i>max</i>
IT industry	4.19	3.90	2.12	4.76	4.43	3.885	4.34	4.47
Automobile industry	4.33	3.66	1.91	4.62	4.39	3.950	4.48	4.28
Sales and distribution	4.02	3.53	2.43	4.60	4.26	3.700	4.03	4.22
Metal processing industry	4.43	4.05	1.82	4.51	4.25	4.035	4.35	4.20
Criteria weight	0.240	0.072	0.144	0.072	0.038	0.096	0.096	0.240

Table 3. Initial decision matrix

Following the formation of the initial decision-making matrix (Table 3), alternatives were ranked using EDAS and VIKOR methods, the calculation of which is presented in detail in the sequel.

Table 4 shows the positive distance from the average value (PDA) while Table 5 shows the negative distance from the average value of the NDA. Table 6 shows the ranking of the alternatives.

Industries	Criteria							
	SP(C ₁)	UM(C ₂)	SC(C ₃)	SI(C ₄)	BPF(C ₅)	PEOU(C ₆)	PU(C ₇)	WC(C ₈)
))))))))
IT industry	0.000	0.002	0.000	0.002	0.001	0.000	0.001	0.010
Automobile industry	0.005	0.000	0.011	0.000	0.001	0.001	0.004	0.000
Sales and distribution	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Metal processing industry	0.011	0.005	0.017	0.000	0.000	0.004	0.001	0.000

Table 4. The PDA of EDAS method

Industries	Criteria							
	SP(C ₁)	UM(C ₂)	SC(C ₃)	SI(C ₄)	BPF(C ₅)	PEOU(C ₆)	PU(C ₇)	WC(C ₈)
IT industry	0.003	0.000	0.003	0.000	0.000	0.000	0.000	0.000
Automobile industry	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.001
Sales and distribution	0.013	0.005	0.025	0.000	0.001	0.005	0.006	0.004
Metal processing industry	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.005

Table 5. The NDA of classical EDAS method

Alternatives	S ⁺	S ⁻	Si	Rank
IT industry	0.429	0.893	0.650	3
Automobile industry	0.581	0.943	0.738	2
Sales and distribution	0.000	0.000	0.422	4
Metal processing industry	1.000	0.874	0.790	1

Table 6 . Ranking of industries using the EDAS method

Based on the results of the ranking of the alternatives shown in Table 6, it can be seen that the industries are ranked as follows: Metal processing industry (0.790) > Automobile industry (0.738) > IT industry (0.650) > Sales and distribution (0.422). Compared with other industries, the metal processing industry has implemented the ERP system to the greatest extent. In contrast, while the automobile and IT industries also use ERP systems, their requirements and challenges differ, leading to lower implementation levels than the metal processing industry.

After the ranking of industries using the EDAS method, based on the initial data shown in Table 3, the ranking of industries was performed using the VIKOR method in order to compare the obtained results. Following the steps for the calculation of the VIKOR method, which are presented in detail in Section 3.3, the results shown in Table 7 were obtained.

Alternatives	S _j	R _j	Q _j	Rank
IT	0.3022	0.1389	0	1
Automobile industry	0.844	0.1743	0.2369	2
Sales and distribution	0.9602	0.2404	1	4
Metal processing industry	0.3795	0.2404	0.5587	3

Table 7. Ranking of industries using the VIKOR method

Ranking the defined industries by the VIKOR method, which is based on a compromise solution and for all the values of v , the alternative IT industry is the best, that is, it has a sufficient advantage and a sufficiently solid position. The alternative IT industry is the best ranked based on Q_j 's values. As this alternative is also ranked best by S_j and R_j , condition 1 and condition 2 are satisfied. The final rank of industries are as follows: IT industry (0) > Automobile industry (0.2369) > Metal processing industry (0.5587) > Sales and distribution (1).

Comparing the results obtained using the EDAS and VIKOR methods, it can be seen that there are differences in the first three positions, while sales and distribution are the industries that apply ERP systems to the smallest extent, according to the respondents' opinion. These results support the notion that the characteristics of the alternatives and the method employed influence the final choice. This highlights the necessity of reducing arbitrariness in the multi-decision-making (MDM) selection phase, emphasizing the importance of objectifying the method selection process.

To validate the EDAS and VIKOR methods, the ranks obtained using these methods need to be compared with the ranks suggested by models of multi-criteria decision-making that have already been developed and used in similar studies. Different studies are associated with ERP selection decisions, some of which use multi-criteria decision-making techniques. These include the evaluation of various ERP alternatives with the ANP method (Gürbüz et al., 2012), cloud-ERP selections using TOPSIS and PROMETHEE (Hansen et al., 2023), evaluate the ERP systems using the AHP method (Ziemba & Gago, 2022), and ERP selection problem at airline industry using FAHP method (Kilic et al., 2014).

Bearing in mind that the application of MCDM methods for the analysis of ERP system implementation has not yet been investigated to a greater extent, and COPRAS, TOPSIS and PROMETHEE have been applied in many other areas (Behzadian et al., 2012; Gigović et al., 2017; Pamučar et al., 2017; Sařabun et al., 2020; Goswami et al., 2021; Hezer et al., 2021; Simsek et al. al., 2022; Taherdoost & Madanchian, 2023), in the following phase these methods are used to compare the ranks obtained using the EDAS and VIKOR methods.

To be able to adequately compare the ranks of alternatives obtained by the different methods, it is necessary to apply the same method of normalizing the input data. For this reason, all of the methods used a linear method of normalizing the input data. In order to check the sensitivity of the results to a change in methodology for the same set of alternatives and criteria, the COPRAS, TOPSIS and PROMETHEE methods were applied, the results of which are shown in Table 8.

Alternatives	COPRAS		TOPSIS		PROMETHEE	
	Q	Rank	C_i	Rank	$\Phi(a)$	Rank
IT	0.2521	3	0.5164	3	0.0000	3
Automobile industry	0.2544	2	0.8392	2	0.0208	2
Sales and distribution	0.2359	4	0.0075	4	-0.0625	4
Metal processing industry	0.2577	1	0.9288	1	0.0416	1

Table 8. Alternative ranking according to the COPRAS, TOPSIS and PROMETHEE methods

The final result obtained by applying the EDAS method is the rank of alternatives: Metal processing industry > Automobile industry > IT industry > Sales and distribution (Table 7). The same rank is obtained by applying COPRAS, TOPSIS and PROMETHEE methods. The difference between EDAS and other applied method results is in the first three ranked alternatives, while sales and distributions are the last-ranked industry according to all methods.

The metal processing industry involves complex production processes that require precise management of materials, inventory, and production schedules. ERP systems streamline these processes, improving efficiency and reducing waste. This industry often faces strict regulatory requirements regarding quality control and safety standards. ERP systems help ensure compliance by providing robust tracking and reporting capabilities. In contrast, while the automobile and IT industries also use ERP systems, their requirements and challenges differ, leading to lower implementation levels than the metal processing industry.

Conclusion

Today, multi-criteria analysis and its methods have become indispensable in decision-making processes in all areas of human activity. Diversification of the problem and perceived shortcomings of various methods have led to the emergence of many new methods. Therefore, in this research, a combination of the BWM-EDAS-VIKOR hybrid model was implemented here for the first time to select the industries based on the implementation of ERP systems in business operations, and it is a model that can be applied to other sectors with similar characteristics. Firstly, the BWM technique was used to determine the weights, that is, the significance of each criterion, and the EDAS and VIKOR methods were used to identify the best-ranking industries. In the final phase of applying the model, its validation was performed by comparing its results with those obtained using the multi-criteria techniques of COPRAS, TOPSIS and PROMETHEE.

Applying the BWM-EDAS-VIKOR multi-criteria model involved constructing a model with eight evaluation criteria. The evaluation criteria reflected external factors (SP, SI, BPF, UM and SC) and elements of the TAM model (PU, PEOU) and WC. Based on the type of industries where empirical research was conducted, four industries were identified as the final result of the model. A ranking of the suitable alternatives was carried out using the EDAS and VIKOR methods.

Validation of the results for the ranks of the industries using the EDAS and VIKOR methods was carried out by comparing the results with those of the COPRAS, TOPSIS and PROMETHEE multi-criteria techniques and it demonstrates its credibility in its selection of metal processing industry as the industry in which ERP systems are implemented to the most considerable extent. These results reflect the perception of ERP systems in Serbia.

This model broadens the theoretical framework of knowledge in the field of ERP systems' application. It considers the existing problem using a new methodology, which creates the basis for further theoretical and practical improvement. In addition, this model highlights new and modified criteria and constraints that other models have not considered, which are significant to this issue. It is important to note that the criteria applied for selecting industries are defined based on the theoretical framework derived from the research of Sternad Zabukovšek et al. (2019). In future research, the criteria investigated can be grouped under personal, organizational and technological process characteristics. The practical significance of this model is the possibility of its application in other industries.

The main recommendations for further using this model are its accessible mathematical framework and the stability (consistency) of its solution. Additionally, it can be combined with other methods, particularly in the section related to determining weight criteria. Future enhancements to the BWM-EDAS-VIKOR model should focus on incorporating classical fuzzy sets and fuzzy number intervals when defining criteria parameters. This fuzzification process allows for better handling of uncertainties associated with these parameters. Additionally, grey theory presents a valuable approach for addressing uncertainty and ambiguity, making it suitable for future research and potential expansion of the model.

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Sustainability aspects of project success factors and project success criteria evaluated by managers of a given company

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Abstract: In the last few decades, the rate of spreading of project management has accelerated tremendously and project management has become an integral part of everyday work, as it has been recognized and acknowledged that using project management tools and methodologies preferred by the organization provides a range of benefits, from more effective planning, more flexible change management and more efficient resource management to better stakeholder and customer satisfaction. And if the project throughout its life cycle and throughout its entire process and beyond through the delivered results meets environmental, social, and economic criteria, it can also meet sustainability principles and sustainability success criteria to some extent. This research investigates whether the project success factors, and project success criteria identified and evaluated in my previous research correspond to some extent to the sustainable project management success factors and success criteria published in the relevant literature. Thus, it can be examined whether and to what extent sustainability and sustainable project management criteria can be validated in the previous assessment of senior managers. Most of the project success factors and project success criteria preferred by managers can also meet sustainability criteria.

Keywords: industry; pharmaceutical industry; project management; project success; success factor; success criterion; sustainability, sustainable project management

1 Introduction

The research covers a further examination of project success factors and project success criteria previously identified and evaluated by managers of a given company based on importance aspects (Balogh, 2024). According to prominent researches of the field of science of the project management, project success should no longer be examined and defined within the framework of the classic

project triangle (time frame, budget frame, quality/specification). The Sustainability School, as a new school of project management schools aims to research and examine the relationship and correlations between projects, project management and sustainability. The assumption during the research was that the success factors and success criteria previously identified and evaluated by managers can be matched to some extent to the sustainability factors and criteria found in the literature.

2 Literature review

The main goal of the literature review was to find and collect project success factors and project success criteria, as well as factors and criteria of sustainable project management, defined and published in domestic and international literature as the results of research in certain fields.

2.1 Project, project management, sustainable project management

Dancsecz examined that the definitions of the project found in the literature were not unified, but Dancsecz listed some common characteristics that are mainly found in the project definitions. These characteristics are the following (Dancsecz, 2008):

- one-time, complex task
- defined goal (product/service/outcome)
- defined start and end period
- unique, complex, and significant problem
- specialized knowledge and multiple resource requirements
- short to medium term, strategically important process
- change, creating something new or special
- multifunctional nature.

Blaskovics stated that the diversity in the definition of the project pointed out its interpretation went beyond the essential project triangle [according to Olsen (1971): time, cost, quality]. (Blaskovics, 2014); (Olsen, 1971 in Blaskovics, 2014)

According to professional standards, the project management:

- is the process by which a project is scoped, planned, monitored, controlled, executed, and implemented to achieve pre-defined outcomes (APM, 2008)
- is the application of knowledge, skills, tools, and methods during project activities in order to meet the project requirements. (PMI, 2012); (AIPM, 2008)

According to Görög, project management is „... a management function that focuses information, resources - especially the project team staff as the temporary project organization implementing the project - and project management tools to achieve a specific project outcome within a given timeframe and budget.” (Görög, 2013)

According to the authors Varga and Csiszárík-Kocsir, the importance of project management can be demonstrated in many areas and is more than a set of methodologies. Project management is a dynamic discipline in which complex tasks can be carried out along well-planned processes, thus reducing potential risks, and directing them towards a specific goal, focusing on the available resources and activities. (Varga, Csiszárík-Kocsir, 2024).

Horváth provides a visual summary of the overview of the different project management trends, schools, and their development over time, as previously presented by Turner at al. (Horváth, 2018); (Turner at al., 2013 in Horváth, 2018)

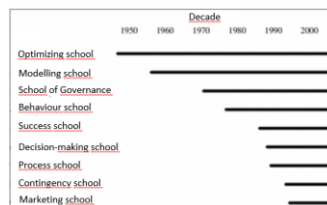


Figure 1. The nine schools of project management (Horváth, 2018; translated)

In terms of the field of previous research, the success school was highlighted. The two main areas of research of this school are examining the relationship between project goals and business, strategic objectives; and the research of the project success factors (which may contribute to some extent to the achievement of success) and the project success criteria (which allow the measurement of project success) and the possible relationships and correlations between them. (Turner et al., 2013)

From the perspective of this current research, it should be noted that the increasing amount of research and published results expectedly provide a suitable breeding ground for the development and fulfillment of a new potential school of project management, called the Sustainability School. (Silvius, 2017)

The new school is intended to research and examine the relationship and correlations between projects and project management, as well as sustainability. According to the Silvius-Schipper authors, sustainable project management is the planning, monitoring and control of project implementation and support processes, considering the resources planned and used during the entire project life cycle, the processes used, the outcomes/results produced and created by the project, and the environmental, economic, and social aspects of the impacts of all of these. Its aim is to involve stakeholders and encourage them to proactive participation, and to realize the benefits of the project and its outcomes/results for stakeholders in a transparent, fair, and ethical manner. (Silvius, G., Schipper, 2014)

2.2 Project success

The literature review naturally included the concept of project success in the following.

The most cited researchers in defining project success are Baker, Murphy, and Fischer, who stated that project success cannot be defined in its entirety/exhaustively as achieving quality/specification within a timeframe and budget. The perceived success of project was defined as the achievement of the defined quality/specification with a high level of satisfaction of the parent organization, client, user, and project team. It can be observed that the authors were the first in the literature to mention the importance of customer satisfaction. (Baker et al., 1983)

Görög formulated the following definition of project success: „a project is considered successful if the project outcome contributes to the achievement of the strategic objective of the initiating organization and both of the project delivery process and the project outcome are acceptable for the stakeholders involved.” (Görög, 2013)

According to Horváth, like the project, clearly defining the project success is a challenging task. „Defining the success of a project is difficult in itself, and understanding it is greatly aided by defining two related concepts, the success factor and the success criterion, and distinguishing between these two.” (Horváth, 2018)

According to Blaskovics, while success factors basically focus on the parameters that contribute to success, thus dealing with the input factors of success, success criteria allow the measurement of the achieved project success, i.e. they concern the output of success. (Blaskovics, 2014)

Blaskovics and colleagues have investigated the success factors along the differences between private and public sector projects (Blaskovics et al, 2023), and Khan and colleagues have conducted research on the topic among start-up projects (Khan et al, 2023).

In the following, based on the literature, success factors, success criteria and their sustainable equivalents of projects will be presented.

2.2.1 Success factors and sustainable success factors

As a result of their collection and aggregation work, Pinto-Slevin has identified 10 success factors that depend on internal organization:

- project goal,
- support of top management,
- project schedule,
- consultation with the stakeholders, identification of needs/requirements,
- team members,
- technical performance,
- acceptance of project deliverables by client,
- information flow (monitoring, feedback, control),
- communication,
- troubleshooting, problem solving. (Pinto-Slevin, 1988)

According to Verzuh, regardless of industry, all successful projects can have certain characteristics that are constant, so he summarized five success factors for projects:

- clearly defined goals/objectives agreed by all participants,
- an appropriate project plan (task plan, schedule plan, budget plan),
- constant and effective communication between stakeholders,
- well defined and controlled scope,
- support from senior management/management. (Verzuh, 2006)

Carden and Egan reviewed the literature from the 1970s, 1980s and 1990s and found that the following success factors were highlighted: project management competencies of management, communication and negotiation skills, project organization structure, and cooperation/collaboration between business units and senior management. (Carden and Egan, 2008)

Csiszárík-Kocsir and Varga also dealt with the measurement of project success, examining the success factors of global megaprojects from the perspective of stakeholders and end-users. These studies also stressed the importance of sustainability as a user expectation. (Csiszárík-Kocsir – Varga, 2023; Varga – Csiszárík-Kocsir, 2023).

El Khatib and his co-authors draw attention to the importance of emotional intelligence in their research. According to their opinion, the key to the success of a project is a project manager with high emotional intelligence, i.e. with appropriate social skills, motivation, empathy, and self-awareness and relationship-orientation. If the project manager is able to perceive, understand and effectively manage the feelings and emotions of the project team, it can have a positive influence on the performance of the project team and thus on the outcome of the project. (El Khatib et al., 2023)

It was an important moment in the history of science when scientific literature identified those success factors within the set of success factors that have significant and outstanding importance and weight for projects and project management. These factors are the critical success factors.

According to Earl, the critical success factors method is about identifying a small number of factors (preferably 3-7) during the project identification and planning processes that in themselves can ensure the success of the project. (Earl, 1989)

Rockart also stated that while success factors can contribute to some extent to success, critical success factors largely contribute (or to the greatest extent, in extreme cases up to 100%) to project success. (Rockart, 2002)

Similar observations are made by Fortune and White, who define critical success factors (key success factors) that make a major, outstanding contribution to the development of project success as defined by one of the criteria. (Fortune and White, 2006)

According to Cooper's complex, comprehensive, cross-industry study carried out during the Covid-19 pandemic, the key to success is accelerating development and innovation processes, which can also ensure the survival success of companies. The author highlighted the importance of project success factors, also identified in the literature, that could have greatly contributed to maintaining or increasing the performance of companies during the pandemic:

- an appropriate and realistic schedule plan,
- an adequate resource plan,
- known and appropriate processes,
- satisfaction of partner,
- satisfaction of client,
- satisfaction of colleagues,
- satisfaction of stakeholder,
- satisfaction of management,

- owner satisfaction,
- satisfaction of project manager,
- size of the project team,
- composition of the project team,
- commitment and satisfaction of the project team,
- communication within the project team,
- change management competence of the project manager and the project team,
- problem-solving ability of the project manager and project team,
- commitment of management, the project manager, and the project team,
- continuous monitoring, evaluation and feedback on the status and scope of the project. (Cooper, 2021)

The complex, domestic Project Management Overview 2022 survey highlights, among other things, that the human factor is prominent and primary among the factors influencing project success. Human factors related to competence were identified as the factors that most determine (help or hinder) project success. The research also states that the success of projects can be almost guaranteed if motivated, customer and user focused project managers with the appropriate competencies and willing to work in partnership with stakeholders and committed and motivated project teams with appropriate competencies are executing the given project. (Hungarian Project Management Association, 2022)

Kumar et al. identified proper planning, a good and partner relationship with the client, and properly trained human resources as the most important success factors in their research. (Kumar et al., 2023)

Tóth-Kaszás mentions that as result of recently published research, environmental and social sustainability has also become part of project success (extended success) and plays a significant role in its assessment. The author summarized the most important success factors of sustainable project management. These are the following:

- awareness, introduction, better known status, knowledge of sustainability,
- defined, specific and achievable goals,
- defined requirements, roles, and responsibilities,
- commitment of stakeholders to the project and sustainability also,
- continuous support by stakeholders,

- prioritizing the social, environmental, and economic interests of stakeholders,
- constructive relationships and information flow between stakeholders,
- availability of project manager and resources,
- the experience and expertise of the project manager,
- commitment of Management to the project and sustainability also,
- decision-making skills of the Management,
- ability and competence of the project team members,
- commitment and motivation of the project team,
- relationship and cooperation between the project manager and the project team,
- appropriate organizational culture,
- execution with proper quality,
- proper project monitoring and control, and proper feedback,
- management of health and safety risks during execution,
- keeping water and noise pollution on a minimum level during execution. (Tóth-Kaszás, 2021)

2.2.2 Success criteria and sustainable success criteria

Dancsecz summarized the results of research on the criteria of project success and concluded that, in addition to the elements of the magic triangle (time, cost, quality/specification), the contribution to the strategy and the satisfaction of different stakeholders/interested parties are the main elements that are repeatedly mentioned in the different studies. (Dancsecz, 2008)

The 6th edition of the Project Management Body of Knowledge (PMBOK), published by the Project Management Institute, has defined the following success criteria:

- the project's compliance with revenue/benefit plans,
- compliance with the financial indicators of the decision-preparation study that defined the business case for the project [net present value (NPV), return on investment (ROI), internal rate of return (IRR), payback period (PBP), and cost benefit ratio (BCR)],
- the fulfilment of the nonfinancial objectives of the decision-preparation study to determine the business case for the project,

- meeting the quality expectations/requirements of the project outcome,
- integration of project results into the operational environment of the organization,
- meeting contractual conditions,
- meeting organizational strategy and objectives,
- meeting organizational governance objectives,
- achieving desired positive changes in the organization,
- stakeholder satisfaction,
- customer/end-user satisfaction
- other criteria. (PMI, 2017)

Horváth categorized these criteria - in terms of their content - into the following four basic competence categories:

- business value-based criteria,
- criteria for meeting primary project objectives (schedule, resources, budget, and quality expectations/requirements),
- satisfaction of the project owner organization and compliance with organizational objectives,
- criteria addressing the satisfaction of relevant stakeholders. (Horváth, 2018)

According to Silvius-Schipper, companies are integrating sustainability into their processes, communications and operations, and sustainability is now linked to both projects and project management. The researchers conclude that the most important success criteria for sustainable project management are respecting and taking into account the potential interests of stakeholders and maintaining their satisfaction and commitment throughout the project life cycle. According to their opinion, sustainability is also ensured by risk management that is as comprehensive as possible, covering as many areas and processes as possible. A project can be considered sustainable if its process, execution, and results create and develop value, thereby preparing the involved organizations for the future and its challenges. (Silvius, G., Schipper, 2016).

According to the authors Iwko and Klaus-Rosinka, project managers and project team members involved in their research believe that the most important sustainability project success criteria are good collaboration/cooperation, timely delivery of project objectives, and the project outcome itself. (Iwko, Klaus-Rosinka, 2023)

2.2.3 Project success in the pharmaceutical industry

As the previous research was conducted in a pharmaceutical development and manufacturing company, I felt it important to include some of the more important success literature that has published on previous pharmaceutical success research findings.

According to Sara, the key to success is to involve management/leadership in the project from the very beginning to providing moral, financial, and business support. (Sara, 2012)

According to Pattanaik, critical success factors for a pharmaceutical project include: the role of the project manager and stakeholders, team communication, and business processes, operations. (Pattanaik, 2014)

According to Koka et al., project management itself, as a success factor, is one of the most effective management tools for influencing the entire process (from clinical research through production to market logistics) across the entire spectrum of drug development and routine production. (Koka et al., 2015)

According to Chomac-Pierzecka, the basics for sustainable drug development are compliance with environmental standards and regulations, the development and application of innovative and green technologies, the rational and efficient use/consumption of available resources, the creation and operation of green business models and green cooperation networks, the integration of advanced production, efficiency, and quality parameters into manufacturing technologies. (Chomac-Pierzecka, 2023)

More than 4 decades of research of success field have identified and appreciated the fact that, while the importance of the project triangle remains - almost perennial - the project success has a much greater number of elements contributing to project success as the complexity of projects increases. Overall, it can be concluded that the project success factors and project success criteria and the sustainable project success factors and sustainable project criteria found in the literature, largely overlap, so there is a high likelihood that the success factors and success criteria identified and evaluated in previous research, and the sustainability factors and criteria found in the research literature, will be mutually compatible and can be evaluated from a sustainability perspective.

3 Research methods

In my previous anonymous questionnaire primary research, the managers of a pharmaceutical company identified and evaluated project success factors and project success criteria based on their experiences and opinions and identified the factors and criteria that were preferred by them in terms of importance.

As part of secondary research, I conducted a literature review to identify and collect success factors and success criteria of sustainability project management identified and published in domestic and international literature.

The research investigates the implementation options for conscious sustainable project management by comparing the project success factors and project success criteria identified and evaluated in previous primary research with the success factors and success criteria of sustainability project management collected in the literature research and defining the necessary conclusions.

The research sought to answer the following questions:

- What are the project success factors that correspond to sustainable project management success factors?
- What are the project success criteria that correspond to sustainable project management success criteria?
- Is there a theoretical possibility to introduce conscious sustainable project management?

4 Results

In the framework of the previous primary research, the project success factors were sorted into logically and content-related groups based on the study of Tsiga et al. (2017), while the project success criteria were sorted into logically and content-related groups based on the research of Horváth (2018).

4.1 Success factors

The first set of success factors are the external and internal challenges. This group includes the environmental factors surrounding the company and its employees. Among the success factors in this group, the work environment was found to be the most important. This choice reflects the company's current strong and conscious HSE (health, safety, environment, and security protection) principles and commitment. The natural environment factor is also considered by managers to be equally important. The preservation of natural water, water used for production and the surrounding soil is also in the company's interest, and it naturally strives to comply with environmental regulations. Health and safety risk management and the continuous, conscious, and routine implementation of activities to reduce and minimize water, noise and waste pollution can have a positive impact on the future and are also sustainability factors.

Among the factors of the knowledge and experience group, the importance of knowledge management is well representing the long-term planning. Knowledge and implementation of previous experiences and lessons learned from a similar project into another project in the future helps project management and promotes sustainability. The factor of realistic, achievable plans was unanimously rated by managers as a critical success factor. A proper plan is a critical condition for the quality execution and thus for the effective achievement of the set objectives, and its absence can lead to failure or even premature demise of a project.

As regards the factors of the senior management support group, the most important factors according to the managers are the support of the project by the Management and the commitment of the Management to the project. A supportive, decisive, and committed Management can provide more effective control and guidance to the projects, and its decisions and feedback help to ensure proper project execution, which also contributes to sustainability.

In the group of institutionalized factors, both factors were found to be important for managers. The pharmaceutical industry is expected to research, develop, and produce pharmaceutical products that meet the requirements for efficacy, safety, and quality also. Availability and assuring quality specifications is essential. Ensuring adequate quality over long term also contributes sustainability. Defined and known processes can lead to transparency, and with such processes the project can be executed faster and more efficiently, thus maintaining competitiveness and market presence.

'Soft' factors within the competence of the project manager group are considered very important by managers. The team organization and leadership skills, problem-solving skills, decisiveness and assertiveness, planning and organization skills, expertise, change management skills, communication skills, conflict management skills, leadership techniques, leadership tools, leadership methods, leadership style, inspirational and motivational skills of the project manager all contribute to the project manager's ability to lead current projects and future projects also in an effective, efficient and sustainable way.

In the factors of the project-based organization group, the commitment of stakeholders to the project is more important for managers. Involving stakeholders as soon as possible, prioritizing their interests and incorporating their requirements into the project can result more willingness to cooperate and support of the stakeholders. By its importance, a defined schedule plan is also a highly preferred success factor by the managers. According to researchers of the sustainable project management literature, one of the most important sustainability factors and criteria is proper stakeholder management. Maintaining the commitment and motivation of stakeholders can contribute to successful completion of the project within the given and appropriate timeframe and can also lead to future strategic collaborations beyond projects relationships.

Active and flexible risk management, which is part of the project risk management factor group, was found to be the most important factor. The continuous identification, assessment and monitoring of risks is a crucial process throughout the project life cycle and beyond. Literature shows that good risk management is also an important sustainability factor. Properly preparing for and responding to a constantly and rapidly changing environment and challenges can lead to effective long-term operations.

The next and last group of factors is the requirements management group. A defined and achievable project goal that is aligned with the company's organizational and strategic objectives is unanimously and critically important to managers. The proper project objective can be achieved more effectively through appropriate time and resource management and appropriate managerial and strategic decisions. Managers also identified stakeholder satisfaction as an important factor, which, as mentioned above, is also an important sustainability factor.

The project success factors preferred by managers are also mostly consistent with the sustainability success factors. The result of analysis of the success factors helps to suggest that the theoretical possibility of introducing, consciously operating and maintaining sustainable project management as an extended project management methodology could be supported by managers. Continuous support by the management as a key stakeholder could lead to greater awareness, acceptance, and more effective application of sustainability.

4.2 Success criteria

The first set of success criteria examined is the set of business criteria. Among the criteria in this group, business and economic profit was considered as an important success criterion. In addition, the outcome of the project, the ability of the project to create value and its contribution to profit growth were also assessed as important criteria. It is important for the managers that the project should meet the business objectives and the project, and its outcomes should improve the economic indicators of the company. Therefore, the company can achieve greater market share, can survive, and grow, thus creating a positive and sustainable impact for itself and its environment, as well as creating value for its owners, its customers, for the society and the economy.

The evaluation of the criteria of the group of primary project criteria by managers resulted the preference for schedule performance and quality and specification performance in terms of their importance. According to the expectations of the managers the project should be delivered according to the previously defined schedule plan, and the execution of the project should comply with processes and requirements, and the outcome of the project should meet quality requirements.

Time-efficient and quality project execution and project outcomes can also contribute to sustainability.

Among the project ownership and organizational criteria, the criterion involving the project manager's skills, abilities and competences and the criterion of goal performance were highlighted as important criteria by the managers. During the evaluation of projects, the ability, skill, and competence performance of the project manager throughout the project is important as a basis for good collaboration with the project team and stakeholders. Effective achievement of the scope, time, cost, quality, and outcome goals, as well as good project manager performance can lead to stakeholder satisfaction, which is also a sustainability criterion. Managers identified the improvement of organizational effectiveness and organizational learning as important evaluation criteria. Managers also expect the improvement of the organization through the process of project execution and through the project outcome. This will enable the organization to be better prepared and to respond sustainably to future challenges.

Among the group of stakeholder criteria, the sustainability and reliability of the product/process, stakeholder satisfaction and individual learning and personal development were all rated as important criteria by managers. Sustainable pharmaceutical product development and process development are important for the company and its managers. According to the requirements, the developed and manufactured pharmaceutical drug product should be able to meet current patient needs and requirements, and as a sustainable solution and product, should also be able to meet market requirements and expectations according to future trends, and should also be able to prepare and respond to market requirements and expectations with appropriately developed and known and less risky processes and technologies. The learning and development of the individuals contributes to the development of the organization, generating long term, sustainable performance.

Most of the project success criteria preferred by managers may also correspond to sustainability criteria. The result of analysis of the success criteria suggests that there is a theoretical possibility for adding sustainability criteria to the current project evaluation requirements of managers.

Summary

Michaelides et al. stated that sustainability can only be integrated and enforceable in organizations if the project managers and the participants of the execution of the projects consider sustainability as a critical factor and define the achievement of environmental and social goals as success criteria in the same way as scope, cost, schedule, and economic and business goals of the project. (Michaelides et al., 2014).

According to Martens-Carvalho, integrating sustainability into project management can lead to a more efficient environment - resource - and cost

management, more effective risk management, more efficient innovation, additional productivity improvement, further strategic and competitive advantage, introduction of new and more advanced business models, and development of more fruitful strategic partnerships. (Martens-Carvalho, 2017)

The research examined the sustainable project management aspects of project success factors and project success criteria previously identified and evaluated by the managers of a company in my previous research. Overall, it can be concluded that the potential for the theoretical implementation of sustainable project management as an extended methodology is given and most likely the Management can be convinced by the benefits of this methodology, as the company is currently giving high attention and strategic importance to sustainable product development.

Further research opportunities are offered by practical project examples, case studies, and the examination of the practical applicability of sustainable project management.

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AI-Driven Real-Time Intelligence for Proactive Business Strategy

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AI-powered systems can provide real-time monitoring for organizations, continuously tracking key factors in the competitive landscape. These systems alert stakeholders to significant changes, such as shifts in competitor activities, market demand, or regulatory updates. By integrating AI with frameworks like Porter's Diamond and Five Forces models, companies gain deeper insights into external conditions. This enables faster identification of both emerging opportunities and potential threats. With timely information, decision-makers can act swiftly to adapt strategies, maintaining or improving their competitive edge. For example, AI might detect new entrants in the market or rising supplier costs and notify relevant departments immediately. These insights help organizations pivot resources and strategies as needed. AI's real-time data analysis reduces the delay between detecting changes and implementing responses. Overall, the system enhances strategic agility, enabling businesses to thrive in dynamic environments. The result is a proactive, rather than reactive, approach to business strategy.

Keywords: artificial intelligence, machine learning, business strategy, proactive forecasting, predictive analytics, predictive learning, strategic agility

1 Introduction

Business strategy is a comprehensive high-level plan aimed to determine how an organization intends to achieve its goals and gain competitive advantage in the long term. Regardless of the size, domain and target market of the organization, a successful business strategy should define how its mission, values and objectives align with existing market conditions and customer needs to ensure its survival in a competitive environment. Designing a business strategy encompasses setting clear, consistent and long-term goals for your organization, defining your competitive role on the market and identifying your resource requirements, availability and limitations (Grant, 2024). While strategic goals of an organization are usually set to support its mission as an integral part of the brand and therefore

may not require constant revision, competitive environment is subject to permanent change. Resource requirements of the organization also evolve over time with scale and diversification of the business. In strategic management, this volatility of internal and external environment of an organization is represented in contingency theories (Jamalnia et al., 2023; Moniz, 2010). Contingency theory states that different circumstances may require a different management approach. To address this volatility, entrepreneurs must adapt their business strategy to market trends and plan their investment in resources accordingly on a regular basis. In so doing, business owners can follow either a reactive or a proactive approach. Reactive approach requires entrepreneurs to respond to issues or changes as they arise. Proactive approach focuses on anticipating potential challenges and opportunities in advance and acting before the former have an adverse effect on the business, or the latter are missed.

However, designing a robust business strategy, let alone aligning it with the volatile market trends proves to be a challenge for many entrepreneurs. Scientific research shows that although roughly 10% of start-ups fail within the first year of their existence, 70% of start-ups manage to survive from two to five years, with 90% of start-ups failing eventually (Venczel et al., 2024). Aside from financial problems, reasons of start-up failure can also include wrong business decisions, scaling problems, lack of product-market fit and other strategic planning mistakes that can be avoided if an agile business strategy is in place. Large companies often have the budget to engage specialized consulting firms to help them design and improve their business strategy. Small businesses, on the other hand, are usually left alone before a wide variety of determinants that should be considered in respect of each factor of production. For instance, every entrepreneur needs to plan in advance whether they will be producing their goods or rendering their services by themselves, or they will be outsourcing production processes to one or several third-party companies. In case of outsourcing, organizations need to determine the available contractors on the market and select the most cost-effective option based on multiple criteria that can vary depending on the domain. Moreover, a strategic business partnership may be reasonable to protect exclusive intellectual property and avoid causing extra competition from potential contractors. If the entrepreneur prefers own manufacturing of their product, they need to consider production facilities, supply chains, storage, logistics, office facilities and numerous other factors before they can actually start the production process. Decision whether to rent the facilities or invest in property, plant and equipment can be the focal point of an organization's business strategy in the long run. Besides, both models are drastically different in terms of the necessary recruitment policy. Identifying the necessary workforce and skills to be involved in the production process, hiring employees or freelancers, hiring in your home country or abroad are the decisions that should be made beforehand and can lead to either success or failure if business strategy is not carefully considered. Funding your business venture properly is another area of uncertainty for many

entrepreneurs. Every business should decide whether it will be more efficient to apply for a bank loan, or find a grant, or pitch their project to a venture capital fund, or even aim to raise funds through initial coin offering or crowdfunding. As bank interest rates, tax rates and rebates, subsidies and fundraising options vary in different locations and industries, initial funding decisions can have a significant impact on survivability of the organization and should be also addressed in the business strategy. Apart from careful assessment of labour, land and capital requirements to start a business, entrepreneurs should also keep track of the volatile market to ensure that their business strategy is viable in the long run. Besides, although the connected business environment of Industry 4.0 encourages entrepreneurs to target customers globally, it also requires them to be proactive in business planning as they are getting more susceptible to global trends. New market entrants, substitute products or services, cross-border competition can pose a subtle threat for the business if the entrepreneur is unaware of growing market tendencies. Even patenting your trademarks and observing the market for potential copyright infringement can become a challenge of its own if the entrepreneur lacks proper skills and technology to facilitate the process. On the other hand, proactive strategic agility can empower entrepreneurs to leverage the opportunities of the connected world and stay ahead of the competition.

Traditionally, entrepreneurs tend to start their business venture without a carefully designed business strategy in place due to the scarcity of resources and tools for a comprehensive strategic analysis, as well as due to time constraints urging them to launch their innovative product or service onto the market as soon as possible after they identify an unoccupied niche (Kabir, 2019). At the same time, if an entrepreneur intends to apply for a bank loan to fund the business venture, they are often asked to submit a business plan that usually incorporates a section on market research, encouraging the entrepreneur to make a preliminary assessment of their competitive advantages and long-term goals. In a similar fashion, an organization applying for venture capital funding will be required to calculate unit economics to confirm their financial prospects to the fund and prove that their business model will remain profitable with scale. Therefore at least basic strategic planning is often essential for a business willing to attract early investment. However, even if the entrepreneur designs a strategic plan for fundraising purposes in the beginning, the incentives to revise it proactively can be limited due to the complexities outlined above. Prior research confirms that entrepreneurs tend to rely on feelings and intuition rather than careful strategic planning (Venczel et al., 2024). While this approach is understandable in view of resource scarcity, a subjective business strategy omitting the empirical analysis of market indicators can be detrimental to the organization in the long term.

In this respect, artificial intelligence (AI) can meet the needs of entrepreneurs, providing them with a consistent and comprehensive solution for proactive strategic business planning. Since AI is a general-purpose technology, its use is

not limited by any industry-specific boundaries. Therefore, any business domain can leverage AI-driven state-of-the-art tools to predict key market indicators, retrieve data insights on market trends, classify products, services and resources existing in the competitive environment, identify clusters of competitors and suppliers, as well as observe many other factors important for a competitive business strategy. AI has already been recognized as a powerful enabler for entrepreneurs in scientific research (Giuggioli – Pellegrini, 2023). Modern AI-driven predictive analytics models can be used to design an intelligence platform tracking diverse economic indicators and forecasting their expected values in real-time. Natural language processing capabilities of large language models (LLMs) can be combined with predictive analytics to deliver business strategy advice proactively based on the calculated forecasts. Such a platform can provide entrepreneurs with a cost-effective solution to make their business strategy more flexible and adaptable to market fluctuations, increasing their strategic agility and survivability on a dynamic market.

This paper aims to establish a conceptual framework for future design of an AI-driven real-time intelligence platform to empower entrepreneurs with a proactive approach towards definition and adaptation of their business strategy. The first section of this paper introduces the concept of proactive business strategy and highlights the necessity to model it in real-time with AI-enabled tools. The second section of this paper outlines the literature review conducted to identify the methodology that can be used to assess entrepreneurial requirements for proactive strategic agility, determine and structure business processes implementable in a real-time intelligence platform for strategic advice, as well as find where strategic competitive advantage theories overlap with AI-enabled entrepreneurial processes. The third section of this paper specifies the methodology proposed as the backbone for design of an AI-driven real-time intelligence platform for proactive business strategy advice. The fourth section provides the results and findings identified by the author as the conceptual framework for AI-driven real-time intelligence related to proactive business strategy. The fifth section aims to discuss the findings of this paper, defining the potential challenges and avenues for future research. The sixth section summarises the conclusions of this paper, highlighting the necessity of future research in the development of AI-driven platforms for proactive business strategy.

2 Literature Review

This section reviews the existing academic literature to provide a foundational understanding of the methodologies, frameworks, and theories relevant to the development of an AI-driven real-time intelligence platform for proactive business strategy. Conducted literature review focused on entrepreneurial needs,

competitive advantage theories and the potential implementation of AI technologies to bridge the gap between the former and the latter. For purposes of this research, literature review aimed to identify scientific articles that could be classified into three categories comprising the backbone of the conceptual framework for the platform: theoretical framework, practical framework and implementation framework. Theoretical framework is established to incorporate scientific literature important to design a structured taxonomy of economic factors and variables that should be considered by entrepreneurs to determine a comprehensive business strategy and keep it up to date with market trends and business requirements. Practical framework provides a selection of articles relevant for in-depth analysis of the theoretical layer and identification of measurable business processes that can be tracked by an AI-driven real-time intelligence platform. Implementation framework combines articles specifying machine learning (ML) and deep learning (DL) models, as well as AI-enabled business models that had been analysed and tested in similar cases in prior research and can be leveraged in model selection and fine-tuning for an AI-driven real-time intelligence system for proactive business strategy. Table 1 provides an overview of 25 scientific articles selected for the purposes of this study, indicating the assigned category, main topic of the article and the potential application of the article to expand the conceptual framework of the AI-driven real-time intelligence platform for proactive business strategy.

Porter's competitive advantage theories were selected as starting point axioms for the theoretical framework of this article. Porter's Five Forces model provides solid representation of the market landscape that should be considered by entrepreneurs designing their business strategy, as well as highlights why strategic agility is so crucial. According to Porter's Five Forces model, businesses must be aware of their competitive rivals, observe the threat of substitutes and new entrants potential, as well as evaluate the available customer and supplier powers to reach competitive advantage on the selected market (Porter, 1979). Porter's Diamond model dives deeper into the factor requirements, outlining the necessity to consider factor conditions, demand conditions, maturity of related and supporting industries, and firm strategy, structure and rivalry on the market, as well as the role of government policy and the potential of "chance" (i.e. force majeure) to either increase or hinder competitive advantage (Porter, 1990). For purposes of this paper, systematic literature review done by Giuggioli & Pellegrini was initially used to identify how entrepreneurs use AI for opportunity identification, decision-making, performance measurement and consistent education and research (Giuggioli – Pellegrini, 2023) and determine if competitive advantage theories specified above overlap with AI-enabled entrepreneurial frameworks. Additionally, this paper suggests incorporating other business strategies and competitive advantage theories into the theoretical framework to expand the taxonomy for AI-driven real-time intelligence platform for proactive business strategy. Entrepreneurship Ecosystem models can add a more detailed layer of

clustered variables that should be considered for proactive business strategy, grouped into the following segments: market conditions, human capital, finance, culture and media, support services and policy (Cavallo et al., 2018). Contemporary strategic analysis research can be explored further to establish a step-by-step process that should be followed in order to design a wholesome and adaptive business strategy and provide meaningful strategic advice if market conditions start to change (Grant, 2024). Blue Ocean strategy and knowledge-based entrepreneurial models can enhance the conceptual framework, identifying how entrepreneurs can shift their focus from oversaturated markets to niche markets and reach competitive advantage based on more sophisticated needs of the customers (Kabir, 2019). Contingency theories can enhance the proactive identification of strategic opportunities and market threats, recognizing the necessity to revise business strategies as the organization scales or as environmental shifts occur (Moniz, 2010). Apart from general theoretical research on business strategy, more specific opportunities and threats relevant to AI applications in entrepreneurship can be identified to capitalize on the predictive capabilities of AI tools without leaving the entrepreneur out of the decision-making process (Shepherd – Majchrzak, 2022). Besides, typical start-up risks summarized by previous research can be used as red flags to warn entrepreneurs proactively before their business strategy is compromised (Venczel et al., 2024).

Practical framework can benefit from methods used in algorithmic management research aimed at determining measurable data-driven business processes that can be delegated to machines (Martorell et al., 2024; Baiocco et al., 2022). Existing case studies of supply chains provide an insight into identification of contingency variables that can influence decision-making in the workplace (Jamalnia et al., 2023). Prior research on innovative business models can sharpen the theoretical framework even further, establishing efficient practices for data collection, as well as addressing data quality and quantity issues to achieve better prediction results (Lee et al., 2019; Valter et al., 2018). Based on previous business process management research, individual business processes can be decomposed into specific process characteristics and contextual variables, determining their cause-effect relationships and enabling the researcher to predict their outcomes with the right process forecasting method (Poll et al., 2018). Scientific research on AI governance in business organizations identifies the criteria for efficient assessment and testing of ML models aligned with stakeholder expectations, highlighting the need to ensure correctness, efficiency, fairness, interpretability, robustness, security and privacy of prediction results (Schneider et al., 2022). Surveys of business leaders who have already adopted AI can provide further insights on key factors that should be measured to enhance the adaptive response to market changes through AI (Sullivan – Wamba, 2024).

Implementation framework should consider modern developments in ML applications by economists, identifying relevant ML models for each prediction

target and discarding overcomplexity where more traditional econometric models provide sufficient results (Athey – Imbens, 2019). Prior research on product performance prediction and identification of process bottlenecks should be taken into account for similar business processes of the practical framework (Behera – Dave, 2024). As business analytics capability itself is increasingly becoming a factor of competitive advantage, prediction accuracy should be carefully measured to secure constant improvement of results by designing customized models where necessary (Kraus et al., 2020). In the meantime, models existing in prior research should be assessed within the implementation framework and leveraged where applicable to capitalize on the recent advancements in ML (Mohammadi – Sheikholeslam, 2023). Intelligent agents can be implemented into the platform to provide strategic advice based on the forecasts made by predictive analytics models (Olan et al., 2022). Retrieval augmented generation (RAG) techniques can be leveraged to fine-tune strategic advice generated by the platform based on the real-time data predictions (Salemi et al., 2024). AI-driven archetypes and delivery models previously introduced for health care start-ups can be reused in the AI-driven real-time intelligence platform to provide additional context for strategic business advice if the identified business processes can be aligned with these archetypes (Garbuio – Lin, 2018). Besides, to improve the performance of the platform and the quality of proactive advice, recent research on inconsistent model training practices should be carefully considered at the platform design stage (Leech et al., 2024).

Ref.	Title	Year	Category	Topic	Application
[1]	Machine Learning Methods That Economists Should Know About	2019	Implementation	ML Methods in Econometrics	Model selection
[2]	The Algorithmic Management Of Work And Its Implications In Different Contexts	2022	Practical	Algorithmic Management Framework	Business process identification
[3]	From Reactive To Proactive: Predicting And Optimizing Performance For Competitive Advantage	2024	Implementation	Product Competitive Advantage Prediction	Model selection
[4]	Entrepreneurial Ecosystem Research: Present Debates And Future Directions	2018	Theoretical	Entrepreneurship Ecosystem Strategy	Taxonomy expansion
[5]	Artificial Intelligence As A Growth Engine For Health Care Startups: Emerging Business Models	2018	Implementation	AI-Driven Business Model Archetypes and Delivery models	Model selection
[6]	Artificial Intelligence As An Enabler For Entrepreneurs: A Systematic Literature Review	2023	Theoretical	AI-Enabled Entrepreneurial Process	Taxonomy expansion

	And An Agenda For Future Research				
[7]	Contemporary Strategy Analysis	2024	Theoretical	Business Strategy Design	Taxonomy expansion
[8]	Sub-Supplier's Sustainability Management In Multi-Tier Supply Chains: A Systematic Literature Review On The Contingency Variables, And A Conceptual Framework	2023	Practical	Conceptual Framework for Sub-Supplier Sustainability Analysis	Business process identification
[9]	Strategy, Strategy Formulation, And Business Models	2019	Theoretical	Entrepreneurial Strategies and Business Models	Taxonomy expansion
[10]	Deep Learning In Business Analytics And Operations Research: Models, Applications And Managerial Implications	2020	Implementation	DL Models for Business Analysis	Model selection
[11]	Emerging Technology And Business Model Innovation: The Case Of Artificial Intelligence	2019	Practical	AI-Based Business Model Development	Business process identification
[12]	Questionable Practices In Machine Learning	2024	Implementation	ML Practices to Avoid in Model Evaluation	Model fine-tuning
[13]	How Does Artificial Intelligence Work In Organisations? Algorithmic Management, Talent And Dividuation Processes	2024	Practical	Real-Time Algorithmic Management in Workforce Profiling	Business process identification
[14]	Intelligent Optimization: Literature Review And State-of-the-art Algorithms (1965–2022)	2023	Implementation	Intelligent Optimization Models	Model selection
[15]	History Of Managerial Thought: A Brief Overview	2010	Theoretical	Schools of Management Classification	Taxonomy expansion
[16]	Artificial Intelligence And Knowledge Sharing: Contributing Factors To Organizational Performance	2022	Implementation	Intelligent Agents and Systems for Knowledge Sharing	Model selection
[17]	Process Forecasting: Towards Proactive Business Process Management	2018	Practical	Proactive Business Process Forecasting Framework	Business process identification

[18]	How Competitive Forces Shape Strategy	1979	Theoretical	Five Forces Model of Competitive Strategy	Taxonomy expansion
[19]	The Competitive Advantage Of Nations	1990	Theoretical	Diamond Model of Competitive Advantage	Taxonomy expansion
[20]	Optimization Methods For Personalizing Large Language Models Through Retrieval Augmentation	2024	Implementation	Retrieval-Augmented Generation Optimization	Model fine-tuning
[21]	Artificial Intelligence Governance For Businesses	2022	Practical	Conceptual Framework of AI Governance in Business	Business process identification
[22]	Machines Augmenting Entrepreneurs: Opportunities (And Threats) At The Nexus Of Artificial Intelligence And Entrepreneurship	2022	Theoretical	AI-driven Opportunities and Threats for Entrepreneurs	Taxonomy expansion
[23]	Artificial Intelligence And Adaptive Response To Market Changes: A Strategy To Enhance Firm Performance And Innovation	2024	Practical	Adaptive Response to Market Changes Framework	Business process identification
[24]	Advanced Business Model Innovation Supported By Artificial Intelligence And Deep Learning	2018	Practical	Business Model Innovation Concept	Business process identification
[25]	The Project And Risk Management Challenges Of Start-ups	2024	Theoretical	Start-up Risk Classification	Taxonomy expansion

Table 1. Literature identified for conceptual framework of AI-driven real-time intelligence for proactive business strategy

3 Methods

This section outlines the research methodology employed in this study, detailing the processes, frameworks, and tools used to establish a conceptual framework for an AI-driven real-time intelligence platform for proactive business strategy. Firstly, we suggest leveraging the theoretical framework specified above to design

a structured taxonomy of internal business processes and external economic indicators that can be efficiently monitored and forecasted by predictive ML models. To achieve this, the established approach to measure competitive advantage introduced by Porter in Five Forces model (Porter, 1979) should be combined with a more comprehensive Diamond model (Porter, 1990), aligning the resulting model with existing scientific literature on entrepreneurial needs regarding the use of AI tools (Giuggioli – Pellegrini, 2023) and providing further grounds for recognition of opportunities and threats that AI tools could bring to entrepreneurship (Shepherd – Majchrzak, 2022). The resulting taxonomy should be further enhanced with Entrepreneurship Ecosystem models (Cavallo et al., 2018). Components of competitive advantage models overlapping with AI-enabled entrepreneurial frameworks should be identified in the process. The resulting taxonomy concept should be expandable to ensure that additional competitive advantage theories and strategic advice methodology can be incorporated into the taxonomy within future research.

Secondly, for each business process in the established taxonomy, individual process characteristics (internal process determinants) and contextual variables (external market determinants) should be identified as input variables for the future model in line with the proactive business process management methodology available from prior research (Poll et al., 2018). Besides, the specified business process indicators should be mapped to the relevant prediction targets that will serve as output indicators for the resulting forecasting model. Other components of the practical framework described above should be carefully considered in the process to facilitate business process identification, classification and decomposition. The resulting business process structure should enrich the theoretical taxonomy with measurable prediction targets for the AI-driven real-time intelligence platform, as well as the underlying algorithms for their assessment.

Thirdly, the comprehensive taxonomy designed at the previous step along with the identified input and output parameters for each business process should be leveraged to identify the adequate data collection policy, as well as select and test the relevant ML models with the most accurate predictive capacity for each individual business process based on the available scientific literature on predictive analytics specified above in the implementation framework (Behera – Dave, 2024; Mohammadi – Sheikholeslam, 2023; Kraus et al., 2020; Athey – Imbens, 2019). The resulting collection of ML-powered forecasting models for the business processes identified above (i.e. the “prediction layer” of the platform) should be combined to create an expandable dataset that can be further used to design LLM agents delivering up-to-date business strategy advice (i.e. the “advisory layer” of the platform). To enhance the advisory capabilities of the platform, auto-generated forecasts should be used as primary context for RAG fine-tuning of the underlying base LLM model (Salemi et al., 2024). Furthermore,

the possibility to leverage intelligent agent archetypes and delivery models from previous research (Olan et al., 2022; Garbuio – Lin, 2018) to provide the platform with additional context for proactive advice based on the role assigned to the LLM agent should be explored. The resulting implementation framework should consider questionable ML practices and avoid using them where alternative options are available (Leech et al., 2024).

4 Results

Conceptual framework for an AI-driven real-time intelligence platform for proactive business strategy presented in this paper aims to combine theoretical competitive advantage models with modern research on the application of ML in entrepreneurship. Figure 1 illustrates the proposed taxonomy concept to integrate the components of Porter's competitive advantage models (Porter, 1979; Porter, 1990) with major fields where entrepreneurs can extract value from AI-powered tools, using the systematic literature review of Giuggioli & Pellegrini (Giuggioli – Pellegrini, 2023) as an umbrella concept for further research and highlighting the necessity to identify where these models overlap. Future research is crucial to leverage this concept to identify specific business processes with measurable process characteristics, contextual variables and prediction targets resulting from different aspects specified by Porter, as well as identify which ML models would fit better to monitor and predict their outcomes on a real-time basis.

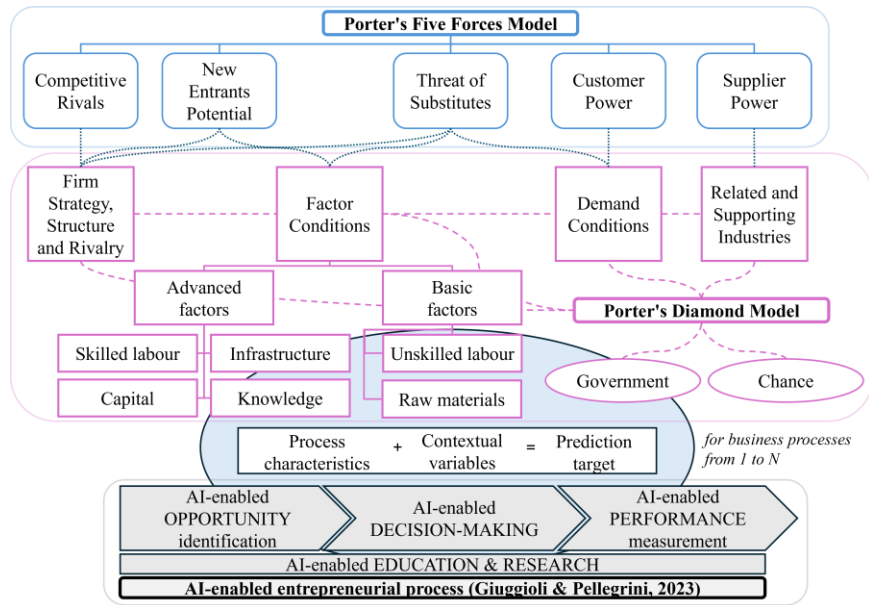


Figure 1. Proposed taxonomy concept

Source: Adapted by the author from Porter's competitive advantage frameworks and AI-enabled entrepreneurial process (Giuggioli – Pellegrini, 2023).

Figure 2 outlines the proposed conceptual architecture for the real-time intelligence platform. Prediction layer aims to forecast process-specific outcomes through various ML models, whereas advisory layer employs LLM agents to deliver real-time business strategy advice to the user based on the dataset of prediction results collected at the previous layer and used to fine-tune the platform in real-time by means of RAG tools.

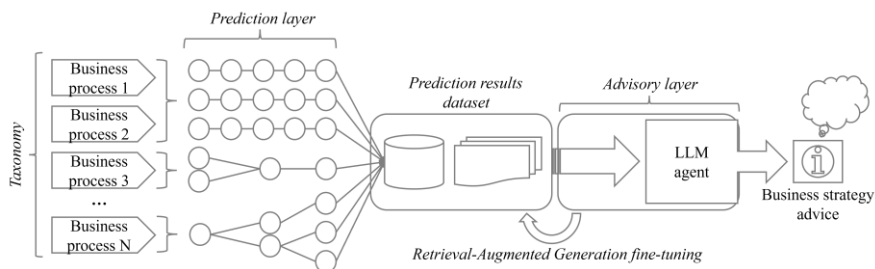


Figure 2. Proposed conceptual architecture

Source: Designed by the author.

Figure 3 explores how the proposed taxonomy concept can be enriched with other strategic analysis methodology and competitive advantage theories specified in the theoretical framework above. As an example proving the extensibility of the proposed taxonomy concept, Entrepreneurship Ecosystem framework was implemented into Figure 1, overlapping with Porter's competitive advantage theories and AI-enabled entrepreneurial process.

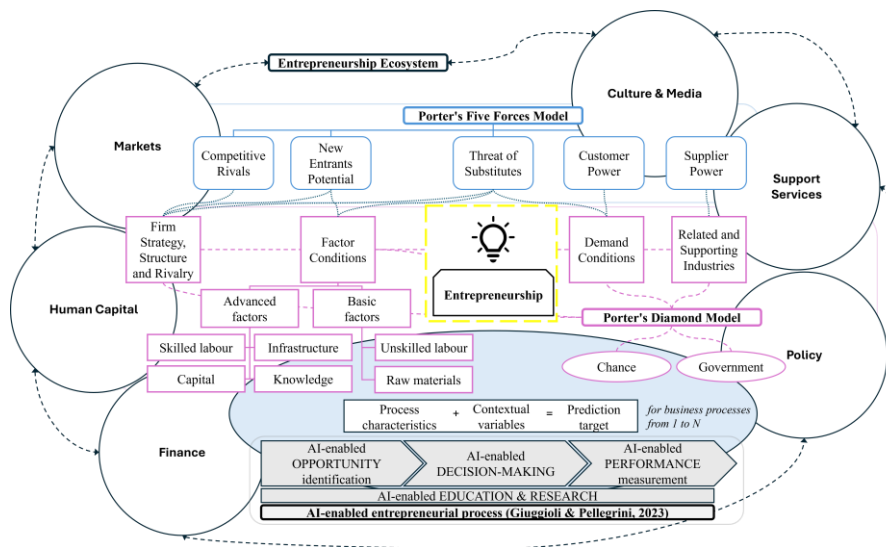


Figure 3. Proposed taxonomy concept enhancement

Source: Adapted by the author from Porter's competitive advantage frameworks, Entrepreneurship Ecosystem models and AI-enabled entrepreneurial process (Giuggioli – Pellegrini, 2023).

5 Discussion

This study highlights the significant potential of AI-driven platforms to enhance strategic agility for entrepreneurs, enabling them with a framework that makes a proactive approach to business strategy feasible. By combining ML-powered predictive analytics for forecasting with generative AI for advice, the proposed conceptual framework integrates real-time intelligence and strategic vision, based on competitive advantage theories such as Porter's Five Forces and Diamond models. This section summarizes the main conclusions, identifies the key limitations and challenges of this research, and provides recommendations for future studies.

Proactive business strategy is critical to survive in a dynamic market environment. Conceptual framework proposed in this paper emphasizes how strategic agility

empowered by AI-driven tools can improve entrepreneurs' ability to identify emerging opportunities and mitigate market threats, ultimately increasing their chances of long-term success. Integration of ML-based predictive analytics and real-time advisory capabilities of LLMs within a single platform allows entrepreneurs to shift their focus from reactive to proactive decision-making, providing them with an opportunity to adopt a data-driven, forward-looking business strategy that can adapt to volatile market conditions as their surrounding environment changes. The timeliness and contextual relevance of generated strategic insights can be provided if the platform will combine two layers – prediction layer and advisory layer. Prediction layer is designed to track and forecast key economic indicators in real-time, while the advisory layer generates actionable recommendations for the entrepreneur based on these forecasts, establishing a seamless decision support system. This paper introduces competitive advantage theories aligned with AI-enabled entrepreneurial frameworks as a foundational component for designing such a platform. These theories provide a comprehensive methodology to understand market forces, factor conditions, and external threats, forming the cornerstone of predictive analytics for strategic advice if they are decomposed into measurable market indicators and the relevant data processing frameworks are identified.

This paper determined several limitations and challenges that should be addressed in future research. The literature review conducted in this study, while foundational, was limited in scope. A systematic literature review on the applicability of competitive advantage theories to AI-driven strategic business planning covering diverse industries, AI applications and management practices could strengthen the conceptual framework. Besides, the proposed framework can be considered general-purpose, which may limit its scalability for industry-specific use cases. Tailoring the platform for different domains will require further research and customization. From the technical perspective, another challenge is identifying the efficient time horizon for the forecast. Introducing the optimal time lag for replacement of predicted values with actual real-time data is crucial to discard outdated figures and avoid data decay in the prediction layer of the platform. Otherwise, the accuracy and reliability of the platform's advisory capabilities can be compromised. Besides, a valid algorithm for continuous training of the platform should be developed in future research, addressing potential biases, model drift and the integration of new data sources over time. Another significant challenge is to incorporate contingency planning techniques into the framework. Competitive advantage theories like Porter's Diamond model highlight the role of "chance" (i.e. force majeure) as one of the factors influencing competitive advantage. Future research should explore methods for modelling and predicting contingency, e.g. developing a modifier or coefficient for adjustment of model results or identifying scenarios where results might require manual intervention. Moreover, even if contingency is properly addressed, whether business leaders will trust the platform's advice remains an open question.

Therefore, developing a user acceptance testing framework for the platform is critical for successful adoption. Engaging strategic advice professionals in the evaluation process could provide an additional layer of credibility and refine the platform's outputs to align with real-world decision-making scenarios.

Building on the proposed conceptual framework, it is recommended to focus future research on identifying specific and measurable business processes aligning with the taxonomy. Furthermore, ML models should be selected and tested for each business process for practical application of the prediction layer. Comparative review of existing models and their adaptation to entrepreneurial business cases is essential for future research. For advisory layer, efficient RAG architecture should be determined to ensure context-aware, real-time strategic advice. Moreover, future research is encouraged to explore additional competitive advantage theories, such as Blue Ocean strategies and knowledge-based entrepreneurial models, for their applicability within the conceptual framework to confirm its extendibility and broaden its scope.

Conclusions

Enhancing strategic agility can improve the likelihood of success for entrepreneurs, whereas AI can be the right asset to achieve this. This study presents a conceptual framework for an AI-driven real-time intelligence platform aimed to provide entrepreneurs with a cost-effective tool for proactive business strategy planning and informed strategic decision-making. The proposed solution combines competitive advantage frameworks with modern ML tools to offer a comprehensive approach to monitoring, predicting, and responding to dynamic market conditions. The taxonomy concept presented in Figure 1 bridges the gap between competitive strategy theory and modern research on AI-driven entrepreneurial tools and business process management, whereas the conceptual architecture outlined in Figure 2 demonstrates how predictive analytics can be integrated with natural language processing capabilities of LLMs to deliver strategic business advice in real-time. Figure 3 suggests extendibility of the proposed taxonomy concept, highlighting the necessity to implement additional competitive advantage theories and strategic business advice methodology into the conceptual framework. Future research should leverage the proposed taxonomy concept to identify specific and measurable business processes to be incorporated in the intelligence platform, as well as test ML models with predictive capabilities on each of the selected business processes to implement the most accurate and efficient combination for the prediction layer of the platform. Besides, additional challenges that should be addressed in future research comprise the industry-specific scalability of the framework, the necessary time lag to ensure suitable replacement of the outdated data, as well as the valid algorithm for continuous training of the platform to guarantee that data updates do not hinder its performance and predictive capabilities. Furthermore, future research is encouraged to implement additional business strategy theories into the proposed

conceptual framework, identify methodology to adjust the model for contingency and consider a reliable user acceptance testing policy for the platform.

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Factors Influencing Consumer Purchase Intention in Fitness Equipment E-Commerce Live Streaming: Evidence from China

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Abstract: Current real-time streaming media services have become a key method for product sales. This paper explores the factors affecting consumers' purchase intentions in fitness equipment live streaming, using reliability analysis, path analysis, and mediation effect testing on 427 valid survey responses. The results confirm the model and hypotheses. Empirical findings indicate that in fitness equipment e-commerce live streaming, the professionalism and similarity of the streamer, interactivity, entertainment, information quality, product quality, and product appearance all significantly enhance consumers' perceived value. However, promotional offers do not significantly affect perceived value. Additionally, the professionalism, similarity, interactivity, entertainment, promotional offers, information quality, and product quality positively influence consumer trust, while product appearance has no significant effect on trust. Both perceived value and trust significantly improve consumers' purchase intentions and act as key mediators between these factors and purchase intention. The study concludes with practical insights for fitness equipment e-commerce live streaming from three perspectives: the live streamer, the streaming scene, and the fitness equipment products. It also discusses the theoretical and managerial implications of this research for live streaming.

Keywords: live streaming; fitness equipment; purchase intention; consumer trust; perceived value

1 Introduction

Nowadays, live commerce has become a familiar concept to everyone. Live commerce is a streaming broadcasting type that introduces and sells products by communicating with consumers (Seo et al., 2020). In recent years, with the growth of online shopping and the rise of live streaming, according to data from Statista, the value of China's live commerce has proliferated and reached nearly five trillion CNY (691 billion USD) by the end of 2023 (Statista, 2024).

Although live commerce has created impressive results in just a few years, prompting many companies to follow suit, the different types of products sold in the live streaming room in the process of carrying out have different effects. Health is always a hot topic of conversation, coupled with the effects of the previous COVID-19 epidemic, live commerce has taken up a part of people's daily shopping, and the demand for home fitness equipment is on the rise. Fitness equipment has been the beginning of the Chinese market in the past two years to carry out live e-commerce sales, so the "e-commerce live streaming plus home fitness equipment" model has not yet had relevant research. Attracting users is also the purpose and goal of all e-commerce platforms, this research limits the research object to the field of live streaming of fitness equipment.

As live commerce's popularity and economic importance grow, more and more scholars are paying attention to it and its impact. Current research involves the influence of online influencer live commerce on purchase intention (Guo et al., 2022), e-commerce consumer purchase intention (Cai et al., 2018), influencing factors include customer value perspectives (e.g. utilitarianism, hedonism, consumer live engagement (Wongkitrungrueng et al., 2020), and consumer sentiment, satisfaction and cognitive status are influencing purchase intentions (Chen et al., 2017).

The application of the S-O-R model to consumer behavior is common (Hsu et al., 2012). "S" stands for stimulus in the external environment (marketing stimulus, other stimuli); "O" refers to the individual's response to the internal state or organism of S; R is a behavioral response (acceptance or avoidance). To fill this gap of factors affecting consumers' purchase intention in the live streaming of fitness equipment, the S-O-R theoretical framework (Xue & Ma, 2024) (Figure 1) was constructed in the early part of this study through the grounded theory, in which the external stimuli include: the streamer factor (professionalism, similarity, interactivity) scene factor (entertainment, preferential) in the live streaming of fitness equipment and the fitness equipment product factor (information quality, production quality, product appearance); the organism assessments include: trust and perceived value; the response is that the consumer generates the purchase intention. Drawing on existing research, the aim of this study is to (1) validate the S-O-R model previously proposed by the authors; (2) determine the significant variables in external stimuli; (3) study the focus of live fitness equipment and

other categories of products in the live streaming.

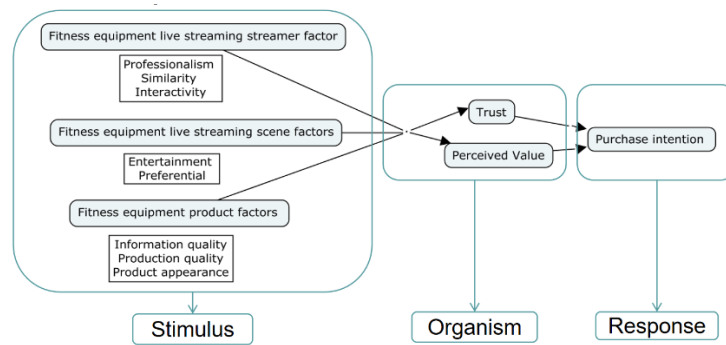


Figure 1. Customer perception and purchase behavior model for home fitness equipment (S-O-R) (N=15)

Source: own research, 2022

1.1 Hypothesis

Based on the authors' previous research using the S-O-R model (as shown in Figure 1), the hypotheses are presented in Table 1.

Number	Hypotheses
H1a	In the livestreaming of fitness equipment, the professionalism of the steamer has a significant positive impact on consumers' perceived value
H1b	In the livestreaming of fitness equipment, the professionalism of the steamer has a significant positive impact on consumer trust
H2a	In the livestreaming of fitness equipment, steamer similarity has a significant positive impact on consumers' perceived value
H2b	In fitness equipment live streaming, steamer similarity has a significant positive impact on consumer trust
H3a	In the livestreaming of fitness equipment, the interactivity of the steamer has a significant positive impact on consumers' perceived value
H3b	In the livestreaming of fitness equipment, the interactivity of the steamer has a significant positive impact on consumer trust
H4a	In the livestreaming of fitness equipment, entertainment has a significant positive impact on consumers' perceived value
H4b	In fitness equipment live streaming, entertainment has a significant positive impact on consumer trust
H5a	In the livestreaming of fitness equipment, discount has a significant positive impact on consumers' perceived value

H5b	In fitness equipment live streaming, discounts have a significant positive impact on consumer trust
H7a	In the livestreaming of fitness equipment, the quality of information has a significant positive impact on consumers' perceived value
H7b	In fitness equipment live streaming, information quality has a significant positive impact on consumer trust
H8a	In the livestreaming of fitness equipment, product quality has a significant positive impact on consumers' perceived value
H8b	In fitness equipment live streaming, product quality has a significant positive impact on consumer trust
H9a	In the livestreaming of fitness equipment, product appearance has a significant positive impact on consumers' perceived value
H9b	In fitness equipment live streaming, product appearance has a significant positive impact on consumer trust
H10	In the livestreaming of fitness equipment, consumers' perceived value has a significant positive impact on consumers' purchase intention
H11	In the livestreaming of fitness equipment, consumer trust has a significant positive impact on consumer purchase intention

Table 1. Hypotheses
Source: own research, 2022

2 Methodology

The study used an online questionnaire shared through Chinese social media platforms such as WeChat, QQ, and Weibo. After removing incomplete or duplicate entries, 427 valid responses from participants with experience in fitness equipment live streaming were analysed. SPSS 26.0 was used for reliability and validity tests, factor analysis, correlation analysis, path analysis, and one-way ANOVA to test the proposed hypotheses.

3 Result

3.1 Reliability analysis

Cronbach's alpha was calculated to assess the reliability of the questionnaire. Values above 0.7 indicated acceptable reliability. All variables in this study

exceeded this threshold, with a total scale alpha of 0.974 (Table 2), confirming high reliability.

Reliability Statistics		
N of Items	Cronbach's Alpha Based on Standardized Items	Cronbach's Alpha
32	0.974	0.974

Table 2. Cronbach reliability analysis
Source: own research, 2022

3.2 Validity analysis

Table 3 shows that the KMO in this study is 0.966, which is greater than 0.8, and the corresponding p-value was less than 0.05, indicating that the data passed the Bartlett sphericity test. Therefore, the data in this study is suitable for factor analysis.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.966
Bartlett's Test of Sphericity	Approx. Chi-Square	7507.900
	df	496.000
	Sig.	0.000

Table 3. KMO and Bartlett's Test
Source: own research, 2022

3.3 Factor analysis

The factor analysis extracted 11 factors from 32 questions, as shown in Table 4. These factors include Professionalism, Similarity, Interactivity, Entertainment, Preferential, Quality of Information, Product Appearance, Quality of Output, Perceived Value, Trust, and Purchase Intention. After rotation, the total variance explained was 75.657%, exceeding the standard threshold of 50%, indicating that the factors captured sufficient information.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	15.337	0.479	47.928%	4.724	0.148	14.761%
2	1.459	0.046	52.488%	3.088	0.097	24.412%
3	1.298	0.041	56.546%	2.696	0.084	32.838%
4	1.032	0.032	59.771%	1.995	0.062	39.071%
5	0.965	0.030	62.786%	1.923	0.060	45.080%
6	0.778	0.024	65.217%	1.912	0.060	51.054%
7	0.762	0.024	67.597%	1.827	0.057	56.764%
8	0.724	0.023	69.861%	1.674	0.052	61.995%
9	0.643	0.020	71.870%	1.480	0.046	66.620%
10	0.622	0.019	73.814%	1.451	0.045	71.155%
11	0.592	0.018	75.663%	1.441	0.045	75.657%

Table 4. Total Variance Explained

Source: own research, 2022

It can be seen from the data results in the Table 5 that the common degree (co-factor variance) values corresponding to all items are higher than 0.4, which indicates that there is a strong correlation between items and factors. Moreover, the absolute value of the load coefficient corresponding to each item and the factor to which it belongs is higher than the corresponding value of other factors, which indicates that each factor can effectively extract the item information, and the scale setting is more reasonable.

Factor	Variable	Non-standard load factor	Normalized load factor	Z	S.E.	P
Factor 1	1A.The steamer is familiar with the relevant knowledge of fitness equipment (materials, functions, applicable groups)	1	0.763	-	-	-
	1B. The steamer is an expert in the field of fitness	0.94	0.733	14.085	0.067	0.000***
Factor 2	2A. The steamer recommends products that I am interested in	1	0.753	-	-	-
	2B. The steamer's view of the movement is	1.015	0.755	15.075	0.067	0.000

	similar to mine					***
	2C. The products recommended by the steamer are very practical for my daily life	0.937	0.727	14.428	0.065	0.000 ***
Factor 3	3A. The steamer can answer my questions quickly	1	0.718	-	-	-
	3B. The steamer can mobilize the atmosphere of the live room	0.973	0.755	13.833	0.07	0.000 ***
Factor 4	4A. Fitness equipment live way is interesting	1	0.803	-	-	-
	4B. The live steaming of fitness equipment can relax people	0.948	0.762	15.961	0.059	0.000 ***
	5A. The price of fitness equipment in the live steaming is lower than other channels	1	0.75	-	-	-
Factor 5	5B. Live room with many discounts	1.056	0.777	15.062	0.07	0.000 ***
	5C. There were raffles and coupons issued during the live steaming	0.857	0.697	13.391	0.064	0.000 ***
	6A. Accurate and objective information in the live steaming	1	0.777	-	-	-
Factor 6	6B. Watching the fitness equipment live gives me a more comprehensive understanding of fitness equipment	0.8	0.722	14.488	0.055	0.000 ***
	6C. Watching the live steaming of fitness equipment allows me to learn fitness knowledge	0.919	0.768	15.571	0.059	0.000 ***
	7A. Fitness products-Fitness equipment with the color match my aesthetic	1	0.764	-	-	-
Factor 7	7B. The style of fitness equipment meets my aesthetic	1.015	0.777	15.154	0.067	0.000 ***
	7C. Fitness equipment has better workmanship	0.87	0.654	12.54	0.069	0.000 ***
	8A. Direct steaming of fitness equipment selection of high-quality materials	1	0.729	-	-	-
Factor 8	8B. live show fitness equipment inspection certificate is important	0.923	0.662	12.334	0.075	0.000 ***
	9A. I think watching live can improve the efficiency of my shopping	1	0.713	-	-	-
Factor 9	9B. I think it saves money to buy fitness equipment by watching live	1.044	0.739	13.629	0.077	0.000 ***
	9C. I think by watching the live steaming of the fitness good feeling increased	0.927	0.689	12.71	0.073	0.000 ***

	9D. The new crown pneumonia outbreak made me realize the importance of improving my immune system	0.705	0.539	9.958	0.071	0.000 ***
	10A. I think the product information provided in the live steaming is true	1.672	0.761	10.972	0.152	0.000 ***
Factor 10	10B. I think the steamer can provide professionalism information	1.658	0.771	11.057	0.15	0.000 ***
	10C. I think the steamer will help the consumer as much as possible	1.679	0.771	11.059	0.152	0.000 ***
	10D. The steamer promises after-sales service to make me feel more comfortable with the product	1.659	0.785	11.177	0.148	0.000 ***
	11A. I am willing to consider the products in the live room when I need them	1	0.715	-	-	-
Factor 11	11B. I would like to continue to watch the fitness equipment live and purchase the products	1.115	0.767	14.345	0.078	0.000 ***
	11C. I would recommend fitness equipment purchase products to friends in my life	1.337	0.837	15.632	0.086	0.000 ***

Table 5. Factor Loading Factors Table

Source: own research, 2022

3.4 Correlation analysis

Correlation analysis is used to study the relationship between quantitative data, including whether there is a relationship or not, and how closely they are. Usually, a correlation coefficient greater than 0.4 indicates a close relationship. For variables, the results of the Pearson Correlation Coefficient Test analysis are shown in Table 6. From the data results, the p-values between the variables are all less than 0.01, indicating that there is a correlation between the variables and can be analysed in the next step.

	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	0.689**	1									
3	0.559**	0.644**	1								
4	0.610**	0.623**	0.619**	1							
5	0.552**	0.659**	0.646**	0.664**	1						
6	0.603**	0.620**	0.580**	0.580**	0.611**	1					
7	0.610**	0.587**	0.543**	0.563**	0.575**	0.629**	1				

8	0.595**	0.634**	0.565**	0.570**	0.665**	0.686**	0.605**	1
9	0.537**	0.547**	0.528**	0.602**	0.590**	0.633**	0.636**	0.623**
10	0.555**	0.593**	0.644**	0.703**	0.653**	0.644**	0.587**	0.627**
11	0.528**	0.557**	0.562**	0.679**	0.602**	0.624**	0.616**	0.595**

Table 6. Correlation analysis results

Source: own research, 2022

Note:(1)Professionalism (2)Similarity (3)Interactivity (4)Entertainment (5)Preferential (6)Quality of information (7)Product appearance (8)Quality of output (9)Perceived value (10)Trust (11)Purchase intention.

According to the above results, it can be shown that the results are significant (there is an * sign in the upper right corner of the results, which indicates that there is a relationship) The correlation coefficients are greater than 0.4.

3.5 One-way ANOVA analysis

		Gender	Age	Education	Occupation	Region	Income
Perceived value	F	1.501	1.166	1.99	1.72	4.377	2.892
	P	0.221	0.325	0.095*	0.129	0.005***	0.035**
Trust	F	4.393	3.076	1.978	3.458	3.504	4.139
	P	0.037**	0.016**	0.097*	0.004***	0.015**	0.007***
Purchase intention	F	1.394	2.938	1.84	3.793	2.666	3.155
	P	0.238	0.020**	0.12	0.002***	0.047**	0.025**

Table 7. Analysis of variance of demographic characteristic variables on purchase intention

Source: own research, 2022

From Table 7, the analysis shows the following results:

Gender: There are no significant differences between genders in perceived value and purchase intention ($p > 0.05$), indicating similarity. However, gender shows a significant difference in trust ($F = 4.393$, $p = 0.037^{**}$).

Age: Different age groups do not show significant differences in perceived value ($p > 0.05$), meaning their views are similar. However, age significantly affects trust ($F = 3.076$, $p = 0.016^{**}$) and purchase intention ($F = 2.938$, $p = 0.020^{**}$).

Academic Qualifications: There are no significant differences in purchase intention across different academic backgrounds ($p > 0.05$). However, academic qualifications show some differences in perceived value ($F = 1.99$, $p = 0.095^{*}$) and trust ($F = 1.978$, $p = 0.097^{*}$).

Occupation: Different occupations do not show significant differences in perceived value ($p > 0.05$). However, occupation significantly affects trust ($F = 3.458, p = 0.004^{***}$) and purchase intention ($F = 3.793, p = 0.002^{***}$).

Geography: Geography shows significant differences in perceived value ($F = 4.377, p = 0.005^{***}$), trust ($F = 3.504, p = 0.015^{**}$), and purchase intention ($F = 2.666, p = 0.047^{**}$).

Income: Income shows significant differences in perceived value ($F = 2.892, p = 0.035^{**}$), trust ($F = 4.139, p = 0.007^{***}$), and purchase intention ($F = 3.155, p = 0.025^{**}$).

3.6 Path analysis

Since there are multiple independent variables and multiple dependent variables in this study, I chose path analysis over linear regression, which can only have one dependent variable at a time. In the existing research, there is a positive correlation between professionalism, similarity, interactivity, entertainment, preferential, information quality, production quality, product appearance, perceived value and trust, and there is a positive correlation between perceived value, trust and purchase intention, so the model hypothesis will be verified with path analysis. The results of the analysis are shown in Table 8.

X	→	Y	Non-standardized coefficient	Standardization factor	S.E.	C.R.	P
Professionalism	→	Perceived Value	0.107	0.120	0.045	2.379	0.017**
Similarity	→	Perceived Value	0.346	0.401	0.041	8.465	0.000***
Interactivity	→	Perceived Value	0.110	0.124	0.046	2.410	0.016**
Entertainment	→	Perceived Value	0.498	0.537	0.040	12.317	0.000***
Preferential	→	Perceived Value	0.023	0.025	0.048	0.478	0.632
Quality of information	→	Perceived Value	0.292	0.065	0.054	5.429	0.000***
Product appearance	→	Perceived Value	0.347	0.341	0.053	6.599	0.000***
Professionalism	→	Trust	0.477	0.495	0.043	11.032	0.000***
Similarity	→	Trust	0.222	0.227	0.051	4.365	0.000***
Interactivity	→	Trust	0.403	0.393	0.053	7.555	0.000***
Entertainment	→	Trust	0.527	0.449	0.041	12.728	0.000***
Offer ability	→	Trust	0.306	0.280	0.054	5.619	0.000***

Quality of information	→	Trust	0.186	0.186	0.051	3.626	0.000***
Product appearance	→	Trust	0.060	0.265	0.054	1.200	0.23
Perceived value	→	Purchase intention	0.551	0.582	0.040	13.848	0.000***
Trust	→	Purchase intention	0.539	0.581	0.039	13.810	0.000***

Table 8. Path analysis results
Source: own research, 2022

From the results of the above table, the influence relationship between the paths is clear, and the effect of preferential on perceived value does not show significant ($z=0.478$, $p=0.632>0.05$), so it shows that preferential does not have an impact on perceived value. The appearance of the product also did not produce significant ($z=1.200$, $p=0.23>0.05$), thus indicating that the appearance of the product had no effect on trust. The remaining paths show the significance of $p < 0.01$ or 0.05 levels, and the standardized path coefficient values are greater than 0, indicating that the influence relationship assumptions of these paths are all true.

3.7 Mediation test

Therefore, this study uses the Bootstrap sampling method to test the mediation effect, and the sampling number is 5000 times. The specific results are shown in Table 9.

	Purchase intention		Perceived value		Trust		Purchase intention	
	B	t	B	t	B	t	B	t
constant	0.726**	3.11	1.440**	6.696	0.696**	3.325	0.185	0.824
professionalism	0.039	0.84	0.102**	0.046	0.107**	0.414	0.033	0.788
similarity	0.008	0.157	0.15**	0.318	0.15**	0.309	0.087	0.002
interactivity	0.052	1.159	0.15**	0.362	0.155**	3.823	0.007	0.156
entertainment	0.312**	6.923	0.151**	3.639	0.274**	6.773	0.183**	4.209
preferential	0.061	1.174	0.07	1.47	0.098*	2.117	0.011	0.238
Product quality	0.109*	1.923	0.163**	3.114	0.124*	2.435	0.032	0.605
Appearance	0.196**	4.194	0.216**	5.032	0.077	1.836	0.124**	2.843
Information quality	0.174**	3.344	0.169**	3.522	0.157**	3.372	0.083	1.724
perceived value							0.201**	3.657
trust							0.361**	6.37
R ²	0.583		0.557		0.631		0.658	
Adjust R ²	0.573		0.547		0.623		0.649	

F value	F (8,366) =63.861, p=0.000	F (8,366) =57.421, p=0.000	F (8,366) =78.134, p=0.000	F (10,364) =70.177, p=0.000
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Table 9. Mediating effect analysis results

Source: own research, 2022

It can be seen from the Table 9 that the mediation effect analysis involves a total of 4 models, which are as follows:

Purchase intention=0.726+0.039*professionalism-0.008*similarity+0.052*interactivity+0.312*entertainment+0.061*preferentiality+0.174*information quality+0.196*product appearance+0.109*product quality

Perceived value=1.440+0.102*professionalism+0.15*similarity+0.15*interactive+0.151*entertainment+0.070*preferential+0.169*information quality+0.216*product appearance+0.163*product quality

Trust=0.696+0.107*professionalism+0.15*similarity+0.155*interactivity+0.274*entertainment+0.098*preferential+0.157*information quality+0.077*product appearance+0.124*product quality

Purchase intention=0.185+0.033*professionalism+0.087*similarity-0.007*interactivity+0.183*entertainment+0.011*preferential+0.083*information quality+0.124*product appearance+0.032*product quality+0.201*perceived value+0.361*Trust

item	c	a	b	a*b	a*b	c'	test results
	total effect			Mediating effect size	(95% BootCI)	direct effect	
Professionalism=> Perceived Value=> Purchase Intention	0.039	0.102**	0.201**	0.020**	0.004 ~ 0.022	0.033**	Partial mediation
Professionalism=> Trust=>Purchase Intention	0.039	0.107**	0.361**	0.03	0.005 ~ 0.028	0.033**	Partial mediation
Similarity=> Perceived Value=>Purchase Intention	0.008	0.15**	0.201**	0.003	0.002 ~ 0.069	0.087	Full mediation
Similarity => Trust => Purchase Intention	0.008	0.15**	0.361**	0.005	0.009 ~ 0.081	0.087	Full mediation
Interactivity=> Perceived Value=> Purchase Intention	0.052	0.15**	0.201**	0.003	0.008 ~ 0.027	-0.007	Full mediation

Interactivity=>Trust => Purchase Intention	0.052	0.155**	0.361**	0.056	0.023 ~ 0.106	-0.007	Full mediation
Entertainment=> PerceivedValue=> Purchase Intention	0.312**	0.151**	0.201**	0.03	0.006 ~ 0.075	0.183**	Partial mediation
Entertainment => Trust => Purchase Intention	0.312**	0.274**	0.361**	0.099	0.048 ~ 0.184	0.183**	Partial mediation
Preferential=> PerceivedValue=> Purchase Intention	0.061	0.07	0.201**	0.014	-0.005 ~ 0.044	0.011	Insignificant mediation
Preferential=>Trust => Purchase Intention	0.061	0.098*	0.361**	0.035	0.002 ~ 0.082	0.011	Full mediation
Information Quality => Perceived Value => Purchase Intention	0.174**	0.169**	0.201**	0.034	0.010 ~ 0.065	0.083	Full mediation
Information quality => trust=>purchase intention	0.174**	0.157**	0.361**	0.057	0.017 ~ 0.106	0.083	Full mediation
Product appearance => perceived value => purchase intention	0.196**	0.216**	0.201**	0.044	0.016 ~ 0.080	0.124**	Partial mediation
Product appearance => Trust=>Purchase Intention	0.196**	0.077	0.361**	0.028	-0.010 ~ 0.082	0.124**	Insignificant mediation
Product Quality => Perceived Value => Purchase Intention	0.109	0.163**	0.201**	0.033	0.008 ~ 0.063	0.032	Full mediation
Product Quality => Trust=>Purchase Intention	0.109	0.124*	0.361**	0.045	0.007 ~ 0.080	0.032	Full mediation

* p<0.05 ** p<0.01

Table 10. Summary of mediation test results

Source: own research, 2022

The 95% BootCI represents the 95% confidence interval calculated by Bootstrap sampling, and the significance of the mediating effect can be judged according to whether the confidence interval contains 0. If the interval does not contain 0, the mediating effect is significant, otherwise it is not significant. Therefore, from Table 10, it can be concluded that perceived value has a mediating role in the influence of professionalism, interactivity, entertainment, information quality, product quality, and product appearance on consumers' purchase intention, and trust plays an important role in professionalism, similarity, interactivity, and information quality. , product quality, and the influence of consumers' purchase intention have a mediating role.

3.8 Research Hypothesis Results and Model Revisions

According to correlation analysis, path analysis and mediation effect, data test is carried out, and the establishment of the hypotheses proposed above is summarized. The results are shown in Table 11.

Number	Hypotheses	Test results
H1a	In the livestreaming of fitness equipment, the professionalism of the steamer has a significant positive impact on consumers' perceived value	√
H1b	In the livestreaming of fitness equipment, the professionalism of the steamer has a significant positive impact on consumer trust	√
H12a	In the livestreaming of fitness equipment, steamer similarity has a significant positive impact on consumers' perceived value	√
H2b	In fitness equipment live streaming, steamer similarity has a significant positive impact on consumer trust	√
H3a	In the livestreaming of fitness equipment, the interactivity of the steamer has a significant positive impact on consumers' perceived value	√
H3b	In the livestreaming of fitness equipment, the interactivity of the steamer has a significant positive impact on consumer trust	√
H4a	In the livestreaming of fitness equipment, entertainment has a significant positive impact on consumers' perceived value	√
H4b	In fitness equipment live streaming, entertainment has a significant positive impact on consumer trust	√
H5a	In the livestreaming of fitness equipment, discount has a significant positive impact on consumers' perceived value	×
H5b	In fitness equipment live streaming, discounts have a significant positive impact on consumer trust	√
H7a	In the livestreaming of fitness equipment, the quality of information has a significant positive impact on consumers' perceived value	√
H7b	In fitness equipment live streaming, information quality has a significant positive impact on consumer trust	√
H8a	In the livestreaming of fitness equipment, product quality has a significant positive impact on consumers' perceived value	√
H8b	In fitness equipment live streaming, product quality has a significant positive impact on consumer trust	√
H9a	In the livestreaming of fitness equipment, product appearance has a significant positive impact on consumers' perceived value	√
H9b	In fitness equipment live streaming, product appearance has a significant positive impact on consumer trust	×
H10	In the livestreaming of fitness equipment, consumers' perceived value has a significant positive impact on consumers' purchase intention	√

H11	In the livestreaming of fitness equipment, consumer trust has a significant positive impact on consumer purchase intention	√
H12a	In the livestreaming of fitness equipment, the professionalism of the steamer positively affects consumers' purchase intention through the mediating role of consumers' perceived value	√
H12b	In the livestreaming of fitness equipment, the similarity of steamers positively affects consumers' purchase intention through the mediating effect of consumers' perceived value	√
H12c	In the livestreaming of fitness equipment, the interactivity of steamers positively affects consumers' purchase intention through the intermediary role of consumers' perceived value	√
H12d	In the livestreaming of fitness equipment, entertainment positively affects consumers' purchase intention through the intermediary role of consumer perception value	√
H12e	In the livestreaming of fitness equipment, preferential positively affects consumers' purchase intention through the intermediary role of consumer perception value	√
H12g	In the livestreaming of fitness equipment, information quality positively affects consumers' purchase intention through the intermediary role of consumer perception value	√
H12h	In the livestreaming of fitness equipment, the quality of products positively affects consumers' purchase intention through the intermediary role of consumers' perceived value	√
H12i	In the livestreaming of fitness equipment, the appearance of products positively affects consumers' purchase intention through the intermediary role of consumers' perceived value	√
H13a	In the livestreaming of fitness equipment, the professionalism of the steamer positively affects the consumer's purchase intention through the intermediary role of consumer trust	√
H13b	In the livestreaming of fitness equipment, the consistency of the steamer positively affects the consumer's purchase intention through the intermediary role of consumer trust	√
H13c	In the livestreaming of fitness equipment, the interactivity of the steamer positively affects the consumer's purchase intention through the intermediary role of consumer trust	√
H13d	In the livestreaming of fitness equipment, entertainment positively affects consumers' purchase intention through the intermediary role of consumer trust	√
H13e	In the livestreaming of fitness equipment, preferential treatment positively affects consumers' purchase intention through the intermediary role of consumer trust	√
H13g	In the livestreaming of fitness equipment, the quality of information positively affects consumers' purchase intention through the intermediary role of consumer trust	√
H13h	In the livestreaming of fitness equipment, product quality positively affects	√

	consumers' purchase intention through the intermediary role of consumer trust	
H13i	In the livestreaming of fitness equipment, the appearance of the product positively affects the consumer's purchase intention through the intermediary role of consumer trust	√

Table 11. Modify the hypotheses.

Source: own research, 2022

4 Discussion and implications

In this study, according to the extracted variables, the coding classification and relationship hypothesis are carried out, and the problems suitable for this study are selected in the previous research and the scene of the live streaming of fitness equipment is selected to form a new scale belonging to this study. Data analysis is then performed with the help of the SPSS 26.0 statistical analysis tool to descriptive statistical and reliability tests of the collected and deleted nonconforming samples to determine whether the data are true and valid. This is followed by path analysis validation and mediation effects testing of the model. The empirical method provides strong support for this study and proves most of the hypotheses, demonstrating the applicability of the S-O-R model in the context of this study. The external stimuli assumed in the paper (streamer characteristics, live streaming scenarios, product characteristics) have a positive impact on consumers' purchase intention through mediation (perceived value, trust). The final data results show that the professionalism of the streamer, the similarity of the streamer, the interactivity, entertainment, information quality, product quality, and product appearance of the streamer are all the purchase intentions of consumers. The model built is shown in the figure 2.

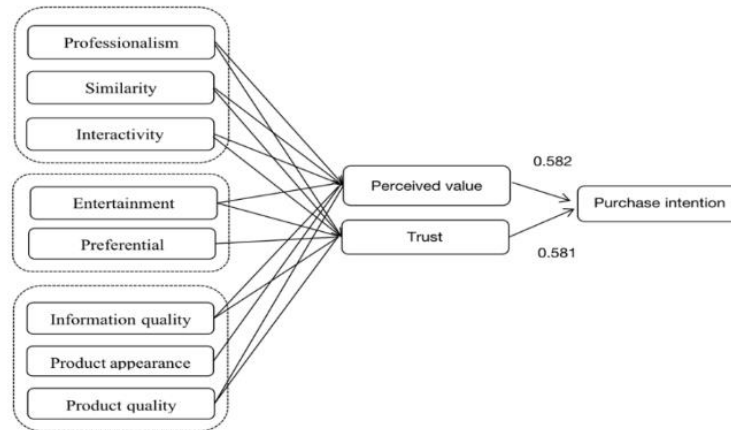


Figure 2. S-O-R model
Source: own research, 2022

When buying fitness equipment in the live streaming room, entertainment and streamer similarity are important factors affecting the perceived value. (Gan & Wang, 2017) believed that perceived value has a positive impact on purchase intentions in studies that use live streaming as a research background. Homogeneity theory has been maturely applied to the study of individual influence, and some scholars have found that the higher the homogeneity of the communicator and the receiver in communication, the more persuasive the communicator's message becomes. The similarity of streamers is the concrete manifestation of this theory. Gilly et al. (2017) argued that perceived homogeneity can increase the word-of-mouth effect of a product. Thus, building a favourable impression of the product.

Professionalism is the primary factor affecting consumer trust, in China's manufacturing power, fitness equipment in the e-commerce platform brands, diverse styles, consumers have a variety of choices, through the power of personal to choose the right products for themselves and often consume time and money, which requires professionalisms to help us choose more suitable products with less investment. Consumers in the selection of products through expert advice tend to get a more pleasant shopping experience (Wu et al., 2018).Gilly et al. (2017)found that professionalism can significantly reduce the uncertainty of potential consumers about the product, (Chen et al., 2021) believed that in the buying and selling scenario, professionalism performance closes the distance between the two parties, thereby affecting the willingness of potential consumers to buy.

Most of the previous research has analysed the live streaming environment, but the type of live streaming products, the choice of steamers, and the choice of platforms can reflect the relatively broad scope of research. And the choice of

scale is often based on the choice of predecessors in the subject category, lacking accuracy and pertinence. For example, due to the interactive characteristics of streamers in the early days, it was widely used in game live streaming, and later it was gradually extended to e-commerce live streaming. The application of the grounded theory more accurately refines the analysis of the factors affecting consumers' purchase intentions in the context of live streaming of fitness equipment, and the 11 initial concepts extracted according to the code are applied to the S-O-R model for specific division. More emphasis is placed on accuracy. Secondly, COVID-19 makes improving immunity has become one of the daily concerns of people, and fitness exercise is one of the ways. However, according to the scale, this is not the main factor for consumers to watch the live steaming of fitness equipment, which needs to be further studied.

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Machine Learning-Driven Anomaly Detection in Serverless Computing to Enhance Cloud Security

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Abstract: As cloud computing evolved further, serverless architecture started to be widely noticed, especially due to Function-as-a-Service models, since it provides ease in the deployment and management of applications. The main benefits of serverless computing, such as a reduction in operational overhead and the ability for an application to scale with costs proportionally to use, are all greatly dependent on being event-driven and stateless. Yet, the unique benefits come with their own security challenges, whereby traditional security no longer fits the special needs brought by serverless environments. For the security responsibilities arising from shared models between cloud providers and users in serverless architectures, because of limited infrastructure control and a dynamic nature of functions, an attack surface introduces many complexities.

This paper proposes an adaptive anomaly detection framework that aims to enhance serverless systems security by taking advantage of cloud-native operational metrics such as invocation frequency, execution time, and error rates. By monitoring these metrics, the proposed approach can establish adaptive baselines for the detection of anomalous behaviour indicative of a potential security threat. This framework will, therefore, discuss different machine learning techniques that will be able to provide scalable, flexible, real-time threat detection without requiring any changes in the underlying infrastructure, unlike traditional rule-based methods. The current study will bridge the gaps in serverless security research and lay the foundation for a comprehensive machine learning-driven approach toward the security posture of serverless applications running in cloud-native environments.

Keywords: Serverless Computing, Function-as-a-Service (FaaS), Cloud Security, Anomaly Detection, Machine Learning, Adaptive Security

1 Introduction

Serverless computing has become one of the major paradigms of modern cloud architectures, enabling organisations to design and deploy applications without concern for managing traditional infrastructure (Lynn et al., 2017). The power of FaaS and BaaS models drives serverless platforms (Nupponen & Taibi, 2020). Predominant serverless models such as AWS Lambda (*AWS Lambda Documentation*, n.d.), Microsoft Azure Functions (*Azure Functions – Serverless Functions in Computing | Microsoft Azure*, n.d.), and Google Cloud Functions (*Cloud Run Functions Documentation | Cloud Run Functions Documentation*, n.d.), enable developers to instantly deploy code in reaction to certain events, relieving them from the complexities of provisioning, scaling, and maintaining servers (Hassan et al., 2021). This event-driven, streamlined approach helps drive efficient and scalable applications, therefore making serverless ever so attractive to businesses. However, while serverless architectures bring these operational benefits with them, unique security challenges are also introduced (*OWASP Serverless Top 10 | OWASP Foundation*, n.d.). Traditional security models don't have all the right tools and capabilities for dealing with the unique needs created by highly distributed, ephemeral, and stateless serverless functions.

In serverless, the responsibility for security is shared: the cloud providers secure the infrastructure, while the users are responsible for securing the application configuration and permissions, including the data therein. This setup, combined with the rapid and frequent changes that are common in serverless applications, cripples conventional rule-based security approaches that may not keep up with the constantly evolving threats. Moreover, serverless architectures provide a broader attack surface due to event-driven architecture that interconnects many separately executing functions. This can be challenging when monitoring and detecting anomalies in real time (Ibrahim et al., 2016).

This research provides a framework for anomaly detection studies as a solution that will help in enhancing security in the serverless architecture. The proposed work will investigate different operational metrics, such as invocation frequency and execution time and error rates, as methods of detecting anomalies that present a potential security threat. By setting adaptive baselines on these metrics, the project will aim at identifying unusual patterns of behaviour which may indicate an attack or misconfiguration on the serverless platform. It aims to develop a model that utilises native infrastructure provided by cloud providers, working seamlessly in the serverless ecosystem to provide real-time, adaptable security insights without any modifications on the user side. In this paper, development

and validation are focused on the proposed approach and aimed at solving the securing of serverless applications efficiently and in a scalable manner against emerging threats.

2 Research Problem

Serverless computing is one of those paradigms that has revolutionized cloud architecture by enabling developers to deploy their applications without managing the headaches of underlying infrastructures. The key benefits it provides are automatic scaling and cost efficiency based on actual usage, which makes its adoption so widespread. However, such benefits are usually accompanied by a number of security challenges not well addressed as yet.

The ephemeral, and event-driven nature of the serverless environment complicates detection of abnormal or malicious behavior. Traditional security approaches rely on static thresholds or rule-based systems, not suited to dynamic and distributed characteristics of serverless architectures. Furthermore, this shared responsibility model between cloud providers and users further complicates the process, leaving wide critical gaps in security that can be used by adversaries.

3 Analysis of previous work

3.1 Definition and Architecture

Serverless computing is a cloud model whereby developers can deploy and execute applications without managing the underlying infrastructure. In serverless environments, cloud providers perform all the server provisioning, scaling, and maintenance while the developers focus solely on application logic. The serverless model is mainly divided into two primary services: Function-as-a-Service, FaaS, and Backend-as-a-Service, BaaS (Nupponen & Taibi, 2020).

Function-as-a-Service (FaaS) enables the execution of single, stateless functions on a particular trigger or event, like a file request in an HTTP server or a change in a database. FaaS services, including AWS Lambda, Google Cloud Functions, and Microsoft Azure Functions, all run functions in isolation while automatically scaling to match demand (Lynn et al., 2017).

Backend-as-a-Service (BaaS), on the other hand, is short for the backend solutions of managed databases, authentication, and storage that the developers could integrate into applications without taking any care of server management. Examples include services such as Google Firebase and AWS Amplify. These

BaaS solutions take away the infrastructure for the backend components even further from the operational burdens on the developers (Nupponen & Taibi, 2020).

This serverless architecture abstracts infrastructure complexities and provides a "pay-per-use" model, where users are charged based on execution time and resource consumption rather than maintaining dedicated servers (Nupponen & Taibi, 2020).

3.2 Comparison with Other Cloud Architectures

Compared to traditional cloud models, such as monolithic architectures, microservices serverless computing offers several unique characteristics:

Monolithic Architectures: In monolithic systems, applications are built as a single entity running on either a dedicated server or virtual machine. This can be fairly rigid; manual scaling requires much effort in server management and hence is less agile compared to serverless models (Dragoni et al., 2017).

Microservices: While microservices architecture decomposes applications into independently deployable services, each with its own functionality in many cases managed in containers, most of the advantages provided by microservices come at the cost of still needing orchestration, monitoring, and manual scaling even in container environments. In turn, Serverless further raises the bar by covering automatic scaling and abstracting server maintenance. This makes it even lighter and cheaper for event-driven tasks (Dragoni et al., 2017).

By being stateless and event-driven, functions in Serverless execute only when triggered, further optimising resource use and, by extension, cost. Another thing is that the functions of serverless are ephemeral; they run briefly to get some particular tasks done after which they terminate, further reducing resource consumption.

3.3 Benefits and Limitations

Along with serverless computing come several advantages and limitations that influence its suitability for specific applications.

Benefits:

Scalability: Serverless platforms automatically scale functions. For example, this is particularly useful for applications with variable workloads, such as web applications or real-time data processing (Nupponen & Taibi, 2020).

Cost Efficiency: With Serverless, the pay-per-use model only bills for actual execution time and resource utilisation. This model could reduce the bill, especially in applications that receive irregular traffic since the developer isn't paying for a resource that sits idle (Nupponen & Taibi, 2020).

Limitations:

Limited Control Over Infrastructure: In a serverless environment, control over the underlying infrastructure is really minimal because provisions and maintenance fall under the care of cloud providers. This layer of abstraction limits customization options and might inhibit advanced security or monitoring configurations (Lynn et al., 2017).

Incompatibility with Long-Running Tasks: Serverless is not very suitable for tasks that require a long time to execute. Functions on FaaS environments normally have some kind of limit on execution time, such as 15 minutes for AWS Lambda, which can make serverless unsuitable for workloads that include training machine learning models or complex data processing (Nupponen & Taibi, 2020).

Cold Start Latency: Since serverless functions are created on demand, these might suffer from some latency to be fired up; these are called "cold starts." That could potentially affect applications needing low latency responses, although providers have introduced features aiming to reduce this (Lynn et al., 2017).

In other words, serverless computing offers a flexible and inexpensive model suitable for event-driven, short-duration tasks with variable workloads but with limited infrastructure control; it is not suitable for long-running processes either.

4 Potential solution for solving the research problem

The proposed framework shall offer real-time, flexible threat detection capability that can quickly and properly respond to security incidents in dynamically changing and event-driven serverless architectures, free from any manual configurations or infrastructure changes. It aimed to fill in the gaps that existed within serverless security and hence sought to establish a much firmer and automated approach toward the security of serverless applications.

Based on this, the overall objective is addressed by the specific research objectives below:

Critically review the security challenges in serverless architecture: loss of control over infrastructure, wide attack surface, and vulnerabilities that may emerge due to shared responsibility.

Discuss traditional and cloud-native security practices with their shortcomings with respect to serverless environments.

Investigate cloud-native metrics—such as invocation frequency, execution time, and error rates—that could be indicative of abnormal behaviour in serverless functions.

Indicate which of these metrics may best serve to accurately classify different types of security threats, such as brute-force attacks, unauthorised access, and data exfiltration.

Design and develop a machine learning-based anomaly detection model capable of adapting to dynamic traffic patterns; it should also be able to establish baselines for normal behaviour in serverless applications.

Validate the feasibility of both approaches of supervised and unsupervised learning to enable the model to detect both known and unknown security threats.

Deploy the model in a controlled serverless environment to see its efficiency in finding anomalies without many false positives.

The simulation of popular attack scenarios, such as injection attacks and API abuse, should be done to confirm the ability of the model to identify such threats in real time.

Based on the model performance and insights from present work, outline best practices and concrete recommendations for the organisations willing to secure their serverless applications.

Set the background for further research, underlining the potential limitations of the approach to serverless anomaly detection and possible directions of the extension of the proposed framework into wider cloud-native environments.

This research is intended to take the security of serverless computing a step forward by delivering a real-time, adaptive anomaly detection solution that capitalises on the properties unique to serverless architectures. This contribution in research will help bridge gaps in traditional security approaches and provide a framework that will not only work cohesively with cloud providers' infrastructures but also offer a practical, scalable means of extending security for modern cloud ecosystem serverless applications.

5 Methodology to achieve potential solution

The prevailing security frameworks and techniques will be reviewed for parameters such as adaptability, precision, and suitability in serverless environments as a critical analysis of the prevailing security methodologies is undertaken within the paradigm of serverless computing. It involves the systematic review of rule-based approaches and machine learning-driven approaches to identify the main limitations and gaps that exist in prevailing serverless security practices.

The specific properties of a serverless environment, like restricted infrastructure control, stateless function invocations, and the shared responsibility model, will be

examined in great depth regarding their implications on security. This phase will comprise in-depth analysis of how these factors define a special attack surface and thus affect the ability to conduct security monitoring and anomaly detection in serverless environments.

A critical aspect of this research involves the identification of key cloud-native operational metrics that would form the basis for anomalous behaviour. The following set of metrics will be investigated further, given their relevance to security threat detection: invocation frequency, execution duration, error rates, and volume of data transfer. Statistical methods combined with the initial data analysis will provide knowledge about normal metric baselines and determine which ones indicate potential anomalies most in serverless environments.

This will involve the design and deployment of an anomaly detection model using machine learning that is custom-fit for serverless environments. From the results developed in the previous phase, the model will adopt both supervised and unsupervised learning methods to detect deviations from established metric baselines. Further, the model will be trained and tuned within a simulated serverless environment through dynamic adjustment to different patterns of traffic while ensuring the accurate identification of anomalies with very few false positives.

The model will be deployed in a controlled test environment on platforms such as AWS Lambda or Google Cloud Functions to make sure it is adequately assessed for effectiveness. It will simulate both benign user behaviour and possible attack scenarios, such as brute-force attempts, injection attacks, and API abuses-which have become prime vectors in testing the accuracy of detection by the model. Results in terms of performance metrics, including precision and recall and response time, will be analysed in refining this model to ensure it is reliable in real-world settings.

The proposed machine learning model will be systematically compared to traditional rule-based and static threshold-based security mechanisms to evaluate the gains in adaptability and accuracy. To this end, this comparative study will be carried out on a side-by-side manner using the same testbed for the model's response to a wide range of attack vectors, and its ability to keep detection accuracy consistently over time.

Recommendations for best practices and security guidelines are made, based on knowledge and experience of model deployment and performance, to further improve serverless application security. This will include recommendations for key operation metrics, configurations of models, and practical considerations while deploying anomaly detection in serverless environments.

This will ensure that the research methodically investigates the role of adaptive anomaly detection in serverless architectures, addressing the current limitations

and opening up opportunities toward more resilient security frameworks within cloud-native applications.

Conclusion

While serverless computing is now in full flight, changing the face of cloud architecture, its scaling potential, cost efficiency, and agility make it increasingly popular for modern applications. However, the specific features of serverless environments introduce significant security challenges, especially regarding the ephemeral and event-driven nature of functions, which traditional security models cannot efficiently address. This research has proposed an adaptive anomaly detection framework that leverages cloud-native operational metrics, such as invocation frequency, execution time, and error rates, to detect potential security threats in real time. Establishing dynamic baselines, the proposed model provides a scalable and flexible solution without changing the underlying infrastructure, which is suitable for the rapidly evolving nature of serverless applications.

Looking ahead, this could definitely be integrated into wider cloud-native security systems, enabling better security postures for cloud environments. For instance, the anomaly detection model linked to other security tools, such as cloud-native firewalls or threat intelligence platforms, could build up a more comprehensive adaptive ecosystem of security. Such integration would allow for automatic detection and response to security incidents in real time, hence keeping serverless applications resilient against emerging threats without requiring human intervention.

Furthermore, the potential of generative AI in enhancing anomaly detection could be explored in further research. Synthetic data for better training could be generated, using GANs or other generative models for improving the ability of detecting novel threats that a model has when it lacks large labeled security datasets. Much more important in cloud environments is another aspect: ethics related to the deployment of AI-driven security. Key in the responsible adoption of AI models for security will be considerations around transparency, accountability, and data privacy, especially in environments that handle sensitive user data.

This work merely provides the initial base toward a machine learning-based anomaly detection framework for serverless computing; the true power of it will be derived as part of an integrated cloud-native security system. Moving forward in cloud infrastructures, there is an additional need for considering advanced AI techniques in relation to ethical concerns and to keep the security robust and future-proof in terms of serverless applications.

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Enhancing Food Safety in China's Food Supply Chain: Risk Identification and Mechanism Optimization

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Abstract: Food safety continues to be a paramount societal issue and a considerable difficulty in China's food sector. Food traverses several phases in the supply chain, and safety concerns may emerge at any juncture, from manufacture to consumption. This study aims to identify the principal risk factors in China's food supply chain and emphasize the contrasts between China's supply chain, which lacks a complete structure, and the more developed supply networks in advanced nations. The study used netnography to gather data on food safety incidents in China, then doing empirical analysis which indicates that a significant proportion of food safety issues arise during the production and processing links. The research designates these phases as key control points for food safety. Furthermore, it suggests methods to augment food safety via enhanced practices in manufacturing, processing, logistics, traceability systems, and safety credit assurance. The results provide crucial insights for enhancing supply chain management in China, increasing food safety efficiency, and diminishing the occurrence of safety events in the food sector.

Keywords: food safety; food supply chain; nemography

1 Introduction

Food is essential to life. The food industry, as a fundamental pillar affecting the livelihood of the nation, is currently booming worldwide. At the present time, with continuous social and economic development, the living standards of people have been significantly improved, accordingly, the requirements of people for food from the beginning of just to solve the food gradually changed to pay more attention to the quality and safety of food.

According to statistics, consumer awareness of food safety is high in both China and other countries, and in May 2014, a survey of the most important issues of concern to the general public released by the Public Opinion Research Laboratory of the Chinese Academy of Social Sciences, food safety ranked first with a high level of concern of 70.4% (Zhong, 2013). October 2020, the first-ever Lloyd's Register Foundation World Risk Poll data reveals that over half of the world's population, 60 per cent of people worldwide, are worried about the food they eat (Gallup., 2020).

Therefore, based on the above, this paper believes that food safety will always be a very important issue in the society, whether in China or in other countries, a matter of the utmost concern to the public and always worthy of high priority. However, at the same time, food safety is a complex issue, because food safety problems can occur not only in food production, but also in food processing, transportation and distribution, storage and sales (Zhao & Chai, 2003). In addition, low safety awareness and Low moral standard of some food producers and loose supervision of regulatory authorities will also induce food safety problems to some extent.

Therefore, when considering food safety issues, it is important to look at the entire food supply chain. The only way to systematically and comprehensively control food safety problems in China is to start with each link in the food supply chain and break them down one by one. This approach is more important because the main objective is not to address security problems, but to prevent them.

Scholars at China and foreign scholars (Kinsey, 2005; Wang, 2010) have conducted in-depth discussions on food safety, supply chain management and food safety from the perspective of the whole food supply chain and each link of the supply chain, although it has played a certain role in ensuring the food quality and safety, this current research mainly focuses on the establishment of food safety early warning system, control system, traceability system. These studies rarely propose specific measures and mechanisms to ensure the quality and safety of Chinese food from the production, processing, logistics and end-consumption

links of the food supply chain in turn, and therefore lack a certain degree of comprehensiveness and systematicity, and in actual operation, this is unavoidably incompatible with the current technical level of China.

Therefore, this paper plans to analyse the main links in the supply chain, including food production, processing, logistics and end-consumption, in order to identify the root causes of food safety problems and to propose measures and mechanisms to ensure food safety in the main stages of China's food supply chain in line with the current state-of-the-art in China.

2 Literature review

2.1 Food quality safety management theory

Food quality and safety management is the general term for all activities undertaken to improve food quality and safety and protect the vital interests of consumers, including the use of legal, administrative, and technical means by the government and other public management entities to implement food quality and safety management, including rationalising the management system, improving laws and regulations, strengthening technical support and enhancing market supervision (Zhou, 2008).

In the current economic environment of the food market in China, it can be seen that the market, due to many factors, does not guarantee food safety by retaining the good and discarding the inferior or even poor quality goods, and that it increases food safety problems due to public nature, externalities, information asymmetry and many other reasons. In the face of market failures, the food quality and safety management were born, which can to a large extent correct and monitor the market.

Food safety management theory includes food risk assessment, standardization systems, and information management (Zhou, 2008). The HACCP (Hazard Analysis and Critical Control Point) theory reduces potential risks through the analysis and monitoring of critical nodes (Chen, 2015; Manning, 2013). Additionally, social monitoring theory and process monitoring theory emphasize the shared responsibility of the public, enterprises, and government in ensuring food safety (Cao et al., 2017; Diabat et al., 2012).

2.2 Food variety

At the end of 2007, China classified food products into 28 categories according to the QS (Quality Safety) market access system . Firstly, the classification of food

products The Food Quality and Safety Market Access System classifies food products into 28 categories, which shown in Table 1.

Processed grain products (FV1)	Edible oil, fat and fat products (FV2)	Seasonings (FV3)	Meat products (FV4)
Dairy products (FV5)	Soft drinks (FV6)	Convenient food (FV7)	Biscuits (FV8)
Canned food (FV9)	Iced drinks (FV10)	Fast-frozen food (FV11)	Potato and dilated food (FV12)
Candies (including chocolate and chocolate products) (FV13)	Tea (FV14)	Alcoholic beverages (FV15)	Vegetable products (FV16)
Fruit products (FV17)	Roasted seeds and nuts (FV18)	Egg products (FV19)	Cocoa and bakery coffee products (FV20)
Sugar (FV21)	Processed aquatic products (FV22)	Starch and starch products (FV23)	Pastries (FV24)
Bean products (FV25)	Bee products (FV26)	Special diet food (FV27)	Fruits (FV28)
Vegetables (FV29)	Eggs (FV30)	Fresh aquatic products (FV31)	Others (F32)

Table 1. Food variety.

Source: The QS (Quality Safety) market access system

As some food categories do not appear in the QS food classification, they are added, namely: Fruits (FV28), Vegetables (FV29), Eggs (FV30) and Fresh aquatic products (FV31). Therefore, the classification of food categories in this research is 32 above ('Others' is considered to be coded as FV32 in this research as they appear in the previous QS classification but as additional items to the food categories).

2.3 Food supply chain

The European food supply chain differs slightly from the Chinese food supply chain, which is a short food supply chain (SFSC). According to the EU definition of a supply chain, a supply chain consists of a limited number of economic operators who work together to develop the local economy and maintain close geographical and social relationships between food producers, processors, and consumers (Official Journal of the European Union, 2013). China's food supply chain consists of economic players ranging from primary producers to consumers (including input suppliers at the front and government regulators at the rear)(Zhao & Chai, 2003), including food producers, processors, logistics and distributors, and retailers.

2.4 International food safety management practices

United States: Utilizes cold chain technology and comprehensive risk assessment systems to improve freshness and safety during food transportation and sales.

Netherlands: Adopts a multi-stage delivery model and enhances efficiency and food quality through standardized supply chain processes.

Japan: Establishes a comprehensive traceability system, integrating batch management and inter-company data exchange to enhance transparency.

These practices provide valuable references for Chinese enterprises.

3 Methodology

This study employed the method of netnography to collect 380 food safety cases from Chinese social media platforms (e.g., WeChat) between 2017 and 2021. The data were coded and quantitatively analyzed using Excel, and a Food Variety-Root Cause Matrix (FV-RC Matrix) was constructed. The analysis focused on four aspects: The region where the cases occurred; The types of food involved; The problematic links in the food supply chain; The root causes of the safety issues.

3.1 Hypothesis

H1. In practice, food safety incidents are more likely to occur in the production and processing parts of the food supply chain.

H2. The key control points in the food supply chain are the food production chain and the processing chain.

H3. Maximising food safety from a supply chain perspective is the control of raw materials.

H4. There is a relationship between the different variety of food that cause food safety cases and the root causes.

4 Results

4.1 The region of occurrence

The regional distribution of food safety cases in China is concentrated in economically developed coastal provinces, such as Guangdong, Tianjin, Beijing, and areas within the Yangtze and Pearl River Deltas. This prevalence is attributed to higher market activity, increased economic incentives for substandard practices, and a more robust media environment in these regions. The disparity between eastern, central, and western regions highlights the need for provinces with greater marketization to prioritize food safety, strengthen press involvement in regulatory oversight, and enhance collaboration between media and government authorities

4.2 Food variety

In terms of the food variety involved in food safety cases, we found that four food categories, namely Meat products, processed food products, beverages, dairy products, occupied the top four food safety incidents. One of the commonalities among these four food groups is that they are consumed very frequently, especially meat products and processed food products, which are present in almost every meal and therefore they are also more vulnerable to food safety problems. The number of safety problems with meat products (92 cases) in the sample is much higher than the second highest number of processed food products (54 cases), indicating that the safety of meat products is currently the most important of China's food safety issues to be strictly addressed.

4.3 Links in the food supply chain where food safety cases occur

Food safety issues predominantly arise during agricultural production (41.3% of cases), followed by primary and further processing stages (over 25%). Most incidents occur before the sales phase, aligning with nationwide trends of high food safety incident rates.

4.4 The root causes of the food safety cases

Table 2 identifies the primary root causes of food safety cases as the addition of harmful inputs, use of substandard raw materials, and improper use of natural ingredients, with these factors significantly outweighing others, such as improper storage environments. These issues predominantly stem from raw material inputs, underscoring their critical role in food safety risks. Additionally, all 12 identified root causes are present in the sample, revealing the pervasive nature of food safety challenges across the entire supply chain. This highlights the necessity for comprehensive reform of food safety regulatory strategies and systems in China.

The root causes of food safety accidents	No. of events
Addition of harmful inputs (RC4)	127
Use of substandard raw materials (RC3)	86
Improper use of natural ingredients (RC1)	56
Improper storage environment for finished products (RC11)	19
Recycling of waste materials (RC2)	18
Improper storage of raw materials (RC7)	16
Unhygienic personnel environment (RC9)	16
Improper processing procedures (RC5)	15
Improper application of elements (RC6)	13
Improper packaging (RC8)	13
Pollution of the natural environment (RC12)	9
Improper disposal of waste (RC10)	7

Table 2. Classification of the root causes of food safety in the sample
Source: Own research, 2022

4.5 Analysis of the FV-RC Matrix Model in the food supply chain

The collation of cases using the FV-RC matrix model yields the results of the empirical analysis as shown in Table 3.

The table needs to be interpreted both horizontally and vertically, with the horizontal axis representing the essential causes of food safety and the vertical axis representing the specific food categories in which food safety occurs, using "food variety - root cause - frequency of incidents" to indicate the food quality and safety incident problems arising from The " food variety - root cause - frequency of incidents" indicates the type of food, the essential cause and its frequency. For example, "FV1-RC1-8" indicates that there were eight food safety cases due to improper use of natural ingredients (RC1) in the category of processed food products (FV1). A closer look at the data in the table leads to the following conclusions.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	SUM
FV1	8	5	8	14	2	1	5	1	6		4		54
FV2	5	2	4	6	4		6						27
FV3			2	7							1		10
FV4	28	7	13	15	4	3	3	10	2	4	4	1	92
FV5	2		13	12		2	1		1				31
FV6	7		10	6		4			2		1	6	36
FV7			2	1				1	1				5
FV8			4						1				5
FV10		4	3	2							2		11
FV12			4	3									7
FV13			1	2									3
FV14				2		1				1			4
FV15	3		2	5		1		1					12
FV16				1									1
FV17			1										1
FV18				3			1						4
FV19				5									5
FV20				1									1
FV22	2		4	5	1					2	1	2	17
FV24	1		3	4	1				3				12
FV25				4									4
FV26					3								3
FV28			1	5							2		8
FV29				19		1							20
FV32			6	10							4		20
SUM	56	18	81	132	15	13	16	13	16	7	19	9	

Table 3. FV-RC matrix results for food safety incident food types and essential causes, 2017-2021

Source: Own research, 2022

4.5.1 Analysis of the high incidence of food safety cases and root cause relationship

Pick three root causes which occurs over 50 times: The addition of harmful inputs (RC4), The use of substandard raw materials (RC3), and The improper use of natural ingredients (RC1) and four varieties of food safety cases occurred more than 30 times: Meat products (FV4), Processed grain products (FV1), Soft drinks (FV6), Dairy products (FV5) to create a 3×4 column table (Table 4) .

The numbers in the table are the actual and expected observations (in parentheses), respectively. Although there are cases where the actual observed value is less than five, the Chi-square test is used for correlation analysis because the sample content is greater than 40 and the expected observed value is greater than five (Chen, 2002).

Test hypothesis:

H0: The root causes of food safety cases are not identical for different varieties of food.

H1: The root causes of food safety cases are identical for different varieties of food. Calculate the test statistic.

Root Cause					χ^2	<i>p</i>
	FV1	FV4	FV6	FV7		
RC1	8(9.926)	28(18.529)	7(7.610)	2(8.934)	45	19.377 0.004**
RC3	8(9.706)	13(18.118)	10(7.441)	13(8.735)	44	
RC4	14(10.368)	15(19.353)	6(7.949)	12(9.331)	47	
	30	56	23	27	136	

* $p < 0.05$ ** $p < 0.01$

Table 4. List of varieties of food with a high incidence of food safety cases and root causes
Source: Own research, 2022

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^c \frac{(f_{ij} - e_{ij})^2}{e_{ij}}$$

Based on this formula,

it is concluded that $X^2 = 19.377$

$$df = (r-1) \times (c-1) = (3-1) \times (4-1) = 6$$

The significance level of 0.01 was selected and the table was checked to obtain:

$$\chi^2 (0.01, 6) = 16.812.$$

Since $\chi^2 = 19.377 > \chi^2 (0.01, 6) = 16.812$, H1 is rejected and H0 is accepted, and the root causes of food safety cases occurring in different varieties of food are not all the same; in other words, the types of products in which safety cases occur are statistically significantly associated with the root causes ($p < 0.01$). Thus, it can be confirmed that although there are many varieties of food products and the root causes of food safety cases occurring are not the same, there is a close relationship between the varieties of food products and the root causes.

4.5.2 Based on the descriptive analysis on FV-RC matrix results

The study identifies key food safety issues in China, focusing on raw material inputs, improper use of natural ingredients, substandard materials, and environmental pollution. Meat products were particularly prone to the improper use of natural ingredients, while substandard ingredients and hazardous inputs were common across most food categories. Water pollution, especially in beverages and processed aquatic products, also posed a significant risk. The majority of food safety problems were linked to raw material inputs, with fewer cases related to processing procedures, storage, and packaging. The findings suggest that the primary control point in China's food supply chain lies in production and processing, particularly concerning raw material quality. While there are fewer issues related to other factors, these should not be overlooked, as secondary issues can escalate into major problems. There is still room for improvement in food safety, particularly in comparison to industrialized countries, requiring enhanced oversight and coordinated growth across all supply chain stages.

4.6 Results of the proof of hypothesis

Research hypothesis	The research result justified the hypothesis
H1. In practice, food safety incidents are more likely to occur in the production and processing parts of the food supply chain.	√
H2. The key control points in the food supply chain are the food production chain and the processing chain.	√
H3. Maximising food safety from a supply chain perspective is the control of raw materials.	√
H4. There is a relationship between the different variety of food that cause food safety cases and the root causes.	√

Table 5. The research result justified the hypothesis

Source: Own research, 2022

5 Discussion

5.1 Comparison of Chinese and international practices

Standardization Management: Similar to the Netherlands, China needs to enhance the standardization of processes across its supply chain to reduce operational errors.

Technological Innovation: Learn from Japan's traceability systems to establish complete batch records throughout the production and distribution processes.

Cold Chain Logistics: Borrow from the United States' cold chain technology to reduce food transportation losses.

5.2 Recommendations for Improvement

To improve food safety, it is essential to strengthen regulation and enforcement by enhancing food safety laws and imposing stricter penalties on non-compliant companies. Additionally, promoting technological solutions is crucial, particularly through the introduction of smart detection equipment, which would enhance

transparency across food production, processing, and transportation stages. Furthermore, public participation plays a vital role in ensuring food safety, necessitating efforts to raise consumer awareness and advocate for rational consumption practices. These combined approaches are necessary for creating a more robust and reliable food safety system.

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Digital threat assessment: the impact of phishing and security risks on young people

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Abstract: The explosive development of digital technology and online space in recent years has fundamentally transformed our everyday lives, especially those of young generations. However, this has been accompanied by an increase in the threats posed by the digital environment, such as the risks of misuse of personal data and other malicious attacks. As key arenas for the socialisation and knowledge formation of young people, educational institutions play a central role in addressing these threats. My research focuses in particular on identifying digital threats to young people. It approaches the issue of digital threats from several angles, presenting the security challenges and the most common forms of malicious attacks in the online space. The research will include a large sample of 5067 respondents to a questionnaire survey analysing the most common threats affecting young people, with a particular focus on phishing. The results show that a significant proportion of respondents have already encountered some form of online threat, especially among Generation Z, who are more exposed to the digital space. The analysis examined the correlations between the level of threat perception, educational attainment and generational differences.

Keywords: security, digital challenges and threats, phishing

1 Introduction

In a digitalised world, phishing as a form of cyber-attack is a major threat, especially among young people. Young people, who often lack experience and awareness, can easily become victims. Phishing attacks are one of the most common forms of cyber fraud, where attackers use deception to gain access to sensitive information. The aim of this research is to describe the different types of phishing attacks and their mechanisms of operation. The analysis aims to highlight the need for prevention against the ever evolving cyber-attacks and to contribute to raising awareness among young people.

Digitalisation, and therefore digital threats, are present in every aspect of our lives. It affects education, the way we manage our finances and our social relationships. In recent years, a number of researchers have looked at the issue. They point to generational differences between digitalisation and financial literacy, which have a significant impact on the modern economy and society (Garai-Fodor, 2022). The authors highlight the fact that different generations value digital solutions differently in promoting financial literacy, which is key to determining the direction of technological development. Labour market aspects cannot be neglected in the context of digitalisation. Mészáros and Csiszárík-Kocsir's research (Mészáros - Csiszárík-Kocsir, 2024a; 2024b) shows that educational background and fields of study play a significant role in developing teamwork skills or even agility, which are essential for succeeding in a digital world. For all these factors, the role of education is paramount, so it is primarily the education system that needs to equip students for the threats and challenges.

2 Literature review

The digital developments of recent years have radically transformed social and individual lives, as the rapid advance of information and communication technologies has led to a new cultural revolution (Schild, 2012). Digitalisation, the most important social and technological transformation of the 21st century, brings both benefits and security challenges, among which cyber-attacks and data security issues are particularly prominent (Ürmösi, 2013). One of the major global challenges is the issue of cybersecurity. In a digitalised world, critical infrastructures are increasingly reliant on digital technologies. This, however, makes them vulnerable to malicious cyber-attacks that can cause serious economic, social and political damage (Europol, 2020; Nagasako, 2020). The processes of data collection, processing and storage pose significant security risks. Protecting the personal data of individual users and the sensitive data of larger organisations is essential to maintain trust. Data leaks, hacker attacks, and the illegal use of personal data pose a serious threat to the functioning of society, including the privacy of individuals and the security of business operations (Nagasako, 2020; Pimenta et al., 2024).

Another serious threat in the digital space is disinformation and online manipulation. With the proliferation of social media platforms and the globalisation of digital communication, the spread of misinformation has become an unprecedented threat to society (Mezei & Szentgáli-Tóth, 2022; Moral, 2022; Dobák, 2022).

In the digital age, security is not only a technical issue, but also concerns the protection of society and young people. The concepts of risk and security are often seen as opposites, but are increasingly recognised as complementary, with risk

management playing an important role in maintaining security (Aven, 2009, 2010, 2014; Blokland & Reniers, 2020). Security can be broken down into two main approaches: one is an engineering approach that focuses on addressing accidental, unintentional threats, while the other focuses on intentional threats such as cyber-attacks and terrorist attacks (Ale, 2009; Aven, 2010; Baldwin, 2018; Smith & Brooks, 2012). Piètre-Cambacédès and Bouissou emphasise that engineering security and protecting against deliberate threats cannot be separated, but that an integrated approach is needed to effectively address rapidly evolving threats (Piètre-Cambacédès & Bouissou, 2013).

Security is a dynamic state that is constantly changing due to environmental, social and technological factors. Buzan et al. argue that security is not simply a lack of protection, but requires a proactive approach that constantly adapts to changing threats. This requires cooperation between society, governments and organisations to identify threats and develop the necessary protective measures (Buzan et al., 1998).

A threat is the first indication that a harmful or undesirable event may occur that could have a negative impact on security. This concept refers to the presence or the possibility of the emergence of potential threats that could compromise security in various ways (Kaplan & Garrick, 1981; Perrow, 1999; Aven et al., 2011). The concept of hazard refers to the existence of potential adverse events that could negatively affect security and can be interpreted as a sign of threat. The identification and analysis of threats is essential to prevent the occurrence of undesirable events that directly threaten the integrity and stability of the systems involved (Johnston, 2004; Broder, 1999).

Threat is a more specific category, as it includes not only the possibility of a threat, but also the direct pressure or constraint on resources. Security can be ensured when the level of threat is minimised and the system concerned is able to effectively resist potential threats (Ale, 2009; Renn, 2017; Baldwin, 2018).

Information protection is critical. Attackers have recognized the value of data and their attacks are aimed at damaging operational processes and making profit (Erdősi & Solymos, 2018). Cybersecurity aims to protect information systems and the data stored in them, including protecting systems from damage and unauthorized access (Beláz & Berzsényi, 2017; Melody et al, The human factor is the most vulnerable in cybersecurity, as most attacks rely on the active participation of the target. Perpetrators often try to obtain confidential information through social manipulation (Algarni et al., 2017; Beláz & Berzsényi, 2017). The risks in cyberspace have been on a steadily increasing trend in recent years. The number of various attacks, data thefts and other threats is increasing at an alarming rate.

One of the most challenging cybersecurity threats today is phishing, a technique that relies on misleading victims to obtain sensitive information such as login

credentials, financial data or other confidential information. The most sophisticated cyber attacks, which can bring down organisational systems or networks, often start with a simple email (Hong, 2012, Kumar 2005). Such attacks are most often aimed at obtaining sensitive information, such as users' credit card details or login details for various online platforms (Ramzan & Wüest 2007). Attackers usually use this information for financial gain or to prepare further, more damaging attacks. All phishing attacks are based on deceiving victims in order to extract valuable information from them for future use. Attackers seek to trick the victim into clicking on a link or responding to a request, providing the necessary personal information (Jakobsson & Myers 2006).

Different types of phishing pose a significant threat to cyber security as they target sensitive user data using different approaches. Mass email phishing is one of the most common methods, where attackers send generic messages to a large number of recipients. Although the effectiveness can be low, they can still achieve significant success due to the large volume of messages sent (Jakobsson & Myers 2006; Adu-Manu et al., 2022). Spear phishing targets individuals or organisations with personalised messages, often after a thorough study of the domain names or internal communication style of companies, increasing the chances of deceiving victims (Aleroud & Zhou, 2017; Nadeem et al., 2023).

Whaling against high-level executives takes a particularly sophisticated approach, using emails that refer to influential individuals to manipulate hierarchy-based decision-making. This method is combined with psychological manipulation to convince victims to take immediate action (Nadeem et al, 2023; Hong, 2012; Kalaharsha & Mehtre, 2021). SMS-based phishing (smishing) and voice-based attacks (vishing) attempt to obtain data through the use of modern communication technologies such as shortened URLs or VoIP, while attackers often use spoofing to establish credibility (Apandi et al., 2020; Jakobsson & Myers 2006; Adu-Manu et al., 2022).

Link manipulation uses links clicked by users to direct victims to fake websites that resemble real sites. These sites often request sensitive information, such as login credentials or financial information (Bhavsar et al., 2018). Social engineering relies on the exploitation of human behavioural patterns, whereby attackers exploit the trust and credulity of victims to breach security protocols (Algarni et al., 2017; Asiri et al., 2024; Koyun & Al Janabi 2017).

Technological advances have made new forms of phishing, such as QR code phishing and fake browser windows, particularly dangerous. In QR code phishing, attackers use fake QR codes that can lead to malicious websites, collect personal data or download malicious applications to victims' devices. Such codes can be used by attackers to obtain, for example, bank account details or social profile information (Amoah & Hayfron-Acquah, 2022; Galadima et al., 2024). In addition, fake browser-in-the-browser windows create authentic-looking but fake

login interfaces where users enter their details unsuspectingly. In some cases, automated chatbots are also deployed to try to obtain users' credentials under the illusion of trustworthiness, especially on malicious websites (Asiri et al., 2024). These innovative methods are difficult to detect and specialise in circumventing traditional defence technologies.

3 Material and method

Cybercrime and data theft in online spaces are increasingly common phenomena that have a serious impact on young people's sense of security and mental health. Schools have a responsibility not only to focus on teaching traditional subjects but also to prepare students for the dangers of the digital space. The aim of my research is to assess how young people are affected by the dangers of the digital space, especially malicious attacks. In my research, I present the partial results of a complex, cross-cutting, pre-tested, standardised questionnaire survey on malicious attacks in the online space. The research was conducted at the end of the year 2023, and I drew my conclusions based on a total of 5067 evaluable questionnaires. The survey was conducted in an online format with closed questions, where respondents could choose the most relevant to them and to themselves from the options given in the questions. The questions were evaluated using SPSS software. In this paper, I present distributions and the results of the cross tabulation analysis for the questions examined, based on the respondents' generational affiliation and educational attainment. The gender distribution of the respondents shows that 51% of the respondents were male and 49% were female. This distribution shows an almost even picture, which contributes to ensuring a gender-balanced representation in the research.

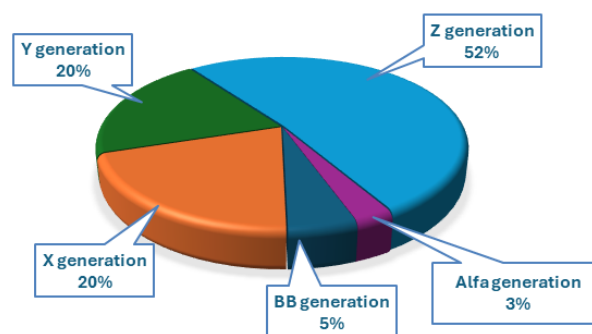


Figure 1. Generational distribution of respondents

Source: own source, 2023, N = 5067

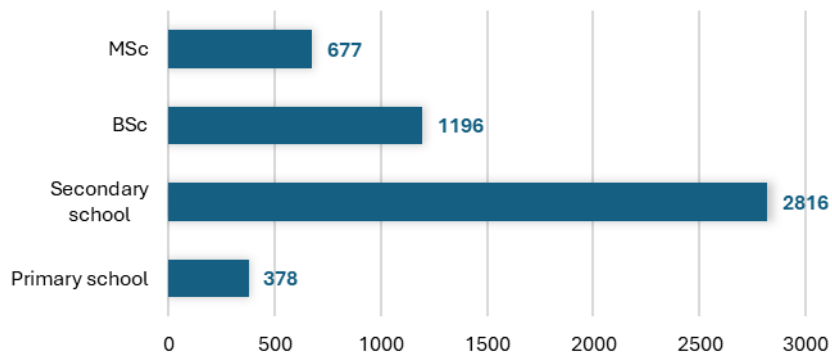


Figure 2 - Distribution of respondents by education
 Source: own source, 2023, N = 5067

4 Results

In terms of malicious attacks, more than 40 percent of the total sample of respondents (Figure 3) have been involved in an attack in the online space. However, a positive message from the responses is that the number of respondents who have encountered this problem on a regular basis is just over 3%.

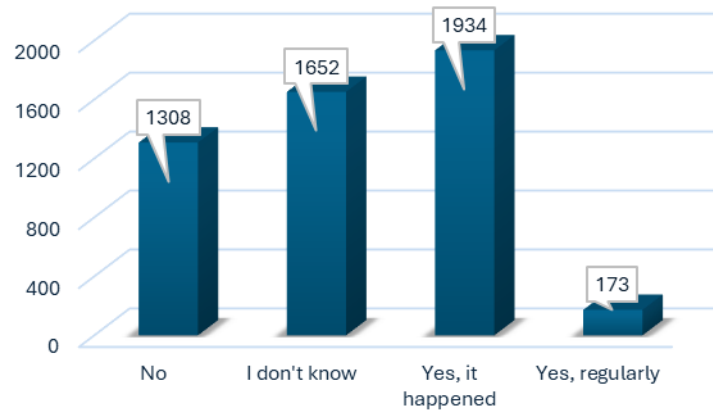


Figure 3 - Incidence of malicious attacks on user devices
 Source: own source, 2023, N = 5067

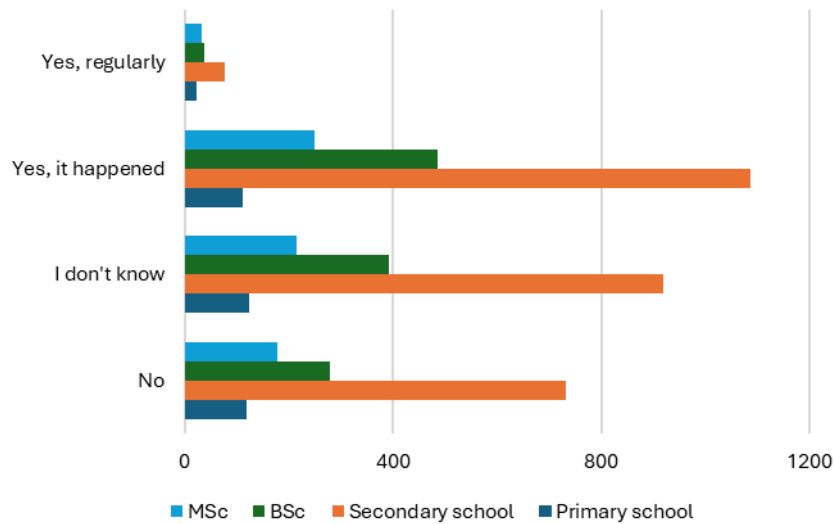


Figure 4 - Prevalence of malicious attacks on user devices by educational level (cross tab)

Source: own source, 2023, N = 5067

The cross-tabulation analysis (Figure 4) shows that the prevalence of malicious attacks varies significantly by educational attainment. Of the respondents, 1600 said they had experienced such attacks, while just over 200 reported regular occurrence. Among those with primary education, 'no' answers predominate, with more than 600 reporting that they had not experienced such attacks. However, the number of "yes, it has happened" responses is significantly higher among those with secondary education, with almost 900 people in this group. Among those with higher education (BSc), the proportion increases further, with more than 1,000 people admitting to having had such an experience. Among the highest educated, MSc graduates, the proportion of those who have experienced a malicious attack is also significant, with more than 500 people saying they have. However, the regular occurrence is relatively low at all levels of education, indicating that although many people encounter such attacks, they are not necessarily frequent. An interesting finding is that the highest incidence rates are found among those with secondary and BSc education, which may suggest that these groups may be more likely to use online platforms where malicious attacks are more common.

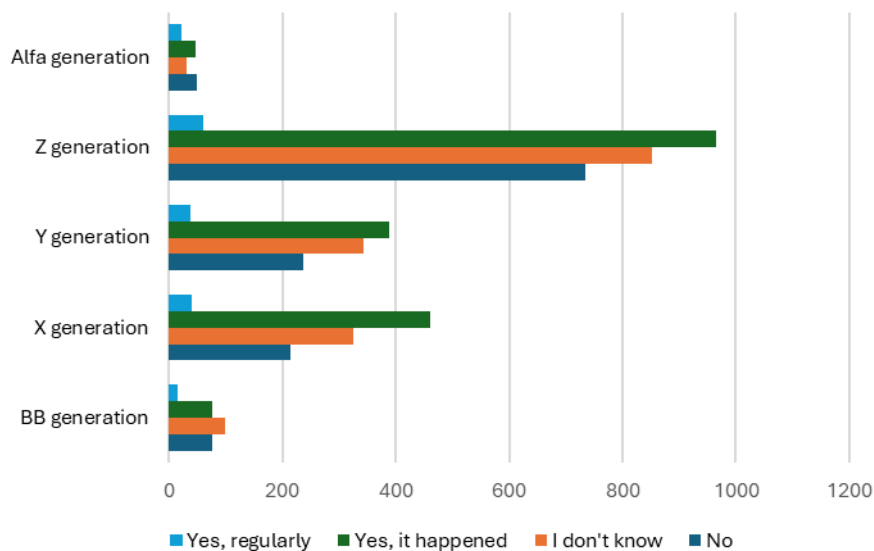


Figure 5 - Prevalence of malicious attacks on user devices by generation (cross-tab)

Source: own source, 2023, N = 5067

The cross-tabulation analysis of the prevalence of malicious attacks by generation (Figure 5) clearly shows that Generation Z members are the most likely to encounter these types of attacks. Nearly 37% of respondents have experienced such attacks, while more than 12% of respondents report regular occurrences, giving an overall exposure of 49.1% for this generation. This is an exceptionally high proportion compared to other generations. The proportion of Generation Y respondents who have experienced attacks is close to 30%, while the proportion who report regular occurrence is over 10%, for a total exposure of 40%. For Generation X, the exposure is more moderate, with 20% of respondents reporting having experienced malicious attacks and a further 7.3% reporting regular occurrences. Overall, this represents an exposure of 27.9% of the generation, which is lower than for younger generations. The BB generation is the least affected: only 28.6% (75 people) reported having experienced attacks and 5.3% reported regular occurrences, the lowest at 33.9%. An interesting picture emerges for the Alpha generation, where although the number of respondents is low, it is noteworthy that more than 21% have experienced malicious attacks, while nearly 10% have experienced them regularly, for a total exposure of 31%. These results suggest that younger generations, in particular Generation Z, are particularly at risk of malicious behaviour in the online space. Older generations, such as generations BB and X, show lower exposure, which may be partly due to differences in their technological habits. These findings highlight the need for generation-specific cybersecurity measures, especially for younger generations.

Summary, conclusions

The findings of the study clearly indicate that malicious attacks in the online space disproportionately affect younger generations, particularly Generation Z, with nearly half (49.1%) of respondents from this generation reporting exposure to such incidents. Generation Y also shows notable vulnerability, with 40% reporting similar experiences. Older generations, including Generation X and the BB generation, demonstrate significantly lower levels of exposure, likely due to differences in online behavior, technology usage patterns, and digital literacy. Interestingly, the Alpha generation, though underrepresented in the sample, exhibits a notable level of exposure (31%), suggesting early vulnerability to digital threats among younger children.

The analysis by educational attainment reveals a similar trend: individuals with secondary and bachelor's level education are most affected, potentially reflecting increased usage of online platforms in these groups, while those with primary education reported the lowest exposure. The results emphasize that while exposure to malicious online behavior is prevalent, regular encounters remain relatively rare across all demographics.

These findings carry several important implications for educational institutions, policymakers, and cybersecurity experts. The high exposure rates among younger generations, particularly Generation Z, highlight the urgent need for targeted, generation-specific cybersecurity education and awareness programs. Schools should integrate digital literacy and online safety into their curricula to prepare students for the risks associated with the digital space.

Further research is necessary to explore the underlying reasons for the observed generational and educational disparities, such as differences in online activity, risk perception, and digital resilience. Understanding these factors can guide the development of more nuanced and effective cybersecurity interventions.

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The Pan African E-network as a Collaboration for India-Africa Digital Transformation

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Abstract: The Pan African E-Network Project (PAENP) is an initiative supported by India to connect the African continent through multiple mediums such as satellite, fiber optics, and various other technologies in an attempt to bridge the digital divide and bring online the population of Africa. This project exemplifies how technological-driven innovation can transform a society and create opportunities for a sustainable future.

The paper will analyze how PAENP has assisted in creating a sustainable future in Africa through e-governance, e-commerce, tele-education, and tele-medicine initiatives and address the deficiencies in development through modern technological solutions.

The paper will also address the question of technology as an aid in improving society and its role in poverty reduction, improving opportunities for education, and increasing efficiency for governments and businesses.

By analyzing case studies from various parts of Africa, the paper will attempt to analyze the on-the-ground results and impact of this initiative, understand the role of technology as an enabler, and attempt to understand the opportunities created by the PAENP and the future possibilities of circular economy and global sustainability goals.

Keywords: Digital divide, Africa, India, Innovation, Sustainability

1 Introduction

From the beginning of the early 1950s, the digital revolution became a major catalyst in reshaping economies, industries and societies worldwide. It not only transformed how economies, industries and societies operate, but also improved productivity, created new avenues of growth and innovation and laid the foundations for the information age (“The Fourth Industrial Revolution,” 2022).

While western nations, enjoyed the fruits of the revolution, early in the second half of the 20th century, China (“China’s Digital Revolution,” 2018) and India

(Sharma, 2015) also joined in, a few decades later with their own digital revolution in the 1980s and 1990s respectively.

But despite various developing countries joining in the digital revolution, the digital divide widened. The digital divide became a major challenge for developing economies and even among the developing countries, this divide was stronger in Africa. While the western and the eastern world adapted their economies and societies to technological innovation, Africa remained behind in digital adoption and digital economic transformation (*Bridging the Digital Divides*, 2023).

To overcome this challenge, India leveraged its technological capabilities in ICT and IT and assisted the African nations with the Pan African e-Network Project (PAENP).

2 The Pan African e-Network Project (PAENP)

The Indian Information Technology (IT) and Information and Communications Technology (ICT) sectors have played a key role in transforming Indian society and economy and become a catalyst in Indian growth and development. This success also resulted in various international partnerships to share Indian expertise in the IT and ICT sectors and the Pan African e-Network Project (PAENP) became a major collaboration between India and the African Union (AU).

The Pan African e-Network Project (PAENP) is an initiative first proposed by the former Indian President Dr. A.P.J. Abdul Kalam in 2004 and launched in 2009 to connect all major African countries with physical and digital communications mediums such as fiberoptics and satellite connections to bridge the digital divide in Africa and overcome educational and healthcare challenges through initiatives such as tele-education, tele-medicine and e-governance (Pan African e-Network Project (PAENP) & M/s. TCIL, 2013).

Today the PAENP connects 54 African countries, exemplifying the role of south-south cooperation. Furthermore, through tele-education and tele-medicine, the gaps in critical infrastructures have been mitigated and improved human skill development and enhanced healthcare delivery (Confederation of Indian Industry (CII), 2024).

3 Case Study: Tele-Education

Tele-Education uses various forms of digital education strategies such as live video classes, recorded lectures and two-way video classes to foster interactive

sessions. Students also get access to digital libraries and content, which helps them access learning materials, digital resources and academic papers (“Pan-African e-Network Project,” n.d.).

Through the tele-education initiative as part of the PAENP, across Africa, over 21,000 students have taken the opportunity to attend digital classes and earn a degree (“PAENP: e-VBAB Network Project,” 2019). The most preferred courses remain in management and technical skills, which potentially improve employability and career advancement opportunities for the students (“Pan-African e-Network Project,” n.d.).

Among the many Indian universities, which provide classes through this network, the Indira Gandhi National Open University (IGNOU) plays a key role by offering access to skill development courses and university degrees to African students. In Ethiopia, for example, IGNOU’s MBA program, is very popular, which has improved employability and graduates have credited the program for their career advancements (“Pan-African e-Network Project,” n.d.).

4 Geo-Politics and Economics

The Pan African e-Network Project (PAENP) can also be viewed as an institutional framework to promote Indian foreign policy objectives and interests in Africa and improve African Indian relations.

From the geopolitical perspectives, India’s interests in improving its relations with Africa can be seen as an attempt to challenge growing Chinese influence in the region. China through its Belt and Road Initiative (BRI) has invested billions of dollars into the economies of various African states and has become the major trading partner for most African countries (Wachira, 2024). Projects such as Pan African e-Network Project (PAENP) and various other provide India political capital to counter Chinese influence in Africa and maintain its geopolitical interests.

From an economics perspective, as the Indian economy boomed following 1991 liberalization, the need for raw materials and natural resources such as oil, coal, critical minerals etc. also increased. This demand of natural goods and commodities augmented Indian public and private interests in Africa (*India Eyes Africa in Its Quest for Superpower Status | ISS Africa*, n.d.), which led to massive investments from India in Africa, making India the second largest investor in Africa (Nantulya, 2024).

Furthermore, African is among the fastest growing populations in the world and is expected to increase from 1.3 billion as of 2024 to over 2.5 billion by 2050 (*Berlin-Institut Für Bevölkerung Und Entwicklung | Population and Development*

in Africa, n.d.). This increase in population will also increase demand for goods and services, which could potentially benefit Indian companies and make Africa a major trading partner for Indian goods and services.

Conclusion

The south-south cooperation is an essential tool for overcoming developmental challenges, decreasing poverty and improving the standards of living in the developing world and initiatives such as the Pan African e-Network Project (PAENP) is an example of this cooperation.

With tele-medicine and tele-education, bridging the digital divide in infrastructure and technological gaps, African citizens can use these services for better health and educational opportunities, which could potentially improve their standards of living and open new avenues for business opportunities through e-commerce and digital business transformations.

From a geo-political and geo-economic framework, Indian initiatives such as Pan African e-Network Project (PAENP) seek to balance the growing foothold of China in Africa and assist Indian public and private sector companies in exploring opportunities in the growing African market.

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Fostering a New Era of Trade between India and Africa

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Abstract: The 21st century has presented an interesting opportunity for growing the India-Africa trade and economic relationship. With its economic liberation in 1991, India has grown at an average of 6-7% annually over the past 30 years and transformed its economic and industrial base.

With this growing industrial base and the rise of Indian IT, pharmaceutical, and telecommunications corporations, India is actively investing in Africa to capitalize on its faster-growing population and vast natural resource reserves. India has invested over 70 billion USD in the African continent through various public and private sector investments and aims to increase the investment to over 150 billion USD by 2030.

As the African population is expected to increase from 1.5 billion citizens in 2024 to over 2.5 billion by 2050, coupled with the declining Western influence over the continent, Africa and its middle class will present an immense market for Indian goods and services, which could usher in a new era for Indian African collaboration at the macro-economic level.

The paper aims to identify the current state of Indian investments and opportunities in Africa at the macroeconomic level and understand the avenues for growth and further economic collaborations in the continent.

Keywords: Africa, India, Trade, Investments, South-South Cooperation

1 Introduction

India and Africa share a long historical, cultural and trade relationship which renewed itself post-independence of India and various African states. While economically weakened, India and Africa came together in the Non-Aligned Movement (NAM) and tried to stay independent from the Western and the Eastern bloc influences (India-Africa Relations: 1947 to the Present, 2020).

In the early decades, post-independence, due to lack of economic development in both India and Africa, the trade relationship didn't reach its potential. But post India economic liberalization in 1991, which augmented India from a 274 billion USD economy in 1991 to over 3,8 trillion USD in 2024 (Statista, 2024).

Owing to this rise in the Indian economy, from 2003, India's trade with Africa has grown at 18% annually and reached USD 103 billion as of 2024 (Nantulya, 2024). Furthermore, India has invested over USD 70 billion in the African continent through various public and private sector investments and aims to increase the investment to over 150 billion USD by 2030 (Nantulya, 2024).

Indian major exports to Africa include mineral fuels and oils, automobiles pharmaceuticals, machinery and textiles while major imports from Africa to India include crude oil, coal, minerals such as gold, copper and iron ore etc. and diamonds. Moreover, India also supports African Least Developed Countries (LDCs) with preferential market access for wide varies of goods exported to India (India's Investment Potential in Africa, 2023).

Although various Indian companies, such as Vedanta Resources and its various investment such as the in Zambian mining sector and major investments by ONGC Videsh in oil and gas fields in Sudan and Mozambique and various others have taken forward the Indian African trade relationship, it the Bharti Airtel, which stands out the major Indian investor in Africa (Paul & CUTS CCIER, 2012).

Bharti Airtel is an Indian telecommunications company which in 2010, became the single largest Indian investor in Africa, by acquiring Zain telecommunications for USD 10.7 billion. Through various investments, acquisitions and long-term strategic policies, Airtel has become the second largest telecommunications operator in Africa, and operates in over 14 countries (Airtel Africa: The Turnaround Story - the Case Centre, n.d.).

2 Potential of Growth

The two main avenues of potential growth in trade relations between India and Africa are, the growing population in Africa and the abundance of natural resources in the African continent.

Africa is home to one of the fastest growing populations in the world, expected to increase from 1.5 billion in 2024 to over 2.5 billion by 2050 (Berlin-Institut Für Bevölkerung Und Entwicklung | Population and Development in Africa, n.d.). This population growth, coupled with a rapidly growing middle class would increase market demand for goods and services in Africa (Middle of the Pyramid:

Dynamics of the Middle Class in Africa, 2011). This makes Africa an important strategic investment for long term Indian investment interests.

Furthermore, the abundance of natural resources in the African has augmented Indian interests in the African continent. These resources are critical for sustaining long term Indian economic growth and Indian companies have undertaken major investments in the oil and gas, mineral resources and other energy resource sector in Africa (India Eyes Africa in Its Quest for Superpower Status | ISS Africa, n.d.).

The Indian union Minister of Commerce and Industry, Piyush Goyal expressed confidence that India and Africa have the potential to double their 2022 trade of almost USD 100 billion and reach USD 200 billion by 2030 (India and Africa: Shri Piyush Goyal, n.d.).

3 Challenges

While the opportunities due to the rise of African middle class and increase in its population coupled with abundant natural resources, critical for India's development does present an opportunity to further increase Indian African trade relations, strong structural challenges remain, which could derail the growth momentum of the relationship.

The four major issues being infrastructural constrains, lack of common African market, security challenges in various African regions and the growing concern of neo-colonialism and unfair trade practices such as land grab acquisitions against various Indian companies.

Africa suffers from major infrastructure challenges with lack and poor state of physical infrastructure, such as roads, highways, seaports, railways lines etc. (Z_Omawumi_Kola_Lawal, 2024). For potential investors, poor logistics due to infrastructure issues can create challenges in business expansion and productivity.

Another major issue in Africa is the lack of a common African market. Africa consists of over 50 nations, with their own national regulations of trade. While African Continental Free Trade Area (AfCFTA) does open up the possibilities of a potential internal agreement between African states, it struggles with implementation challenges and non-trade barriers impact the potential trade opportunities created by the AfCFTA (AfCFTA: A Beacon of Hope or a Failed Project?, 2024).

Beyond infrastructural and common market challenges, major security challenges such as the ongoing security challenge various parts of Africa, such as the ongoing internal conflict in Sudan, socio-political issues in Ethiopia (Davis (n.d.)), issues with terrorism in Nigeria (Nigeria: EUAA, n.d.) and various other African countries, issues with ocean piracy off the coast of Somalia (Chibelushi, 2024),

organized crime and threat of civil wars in various parts of Africa create issues for potential investors and safety issues with their physical and capital investments and local working staff members.

Furthermore, another challenge in trade relations between India and Africa could be the accusations of unfair trade practices such as landgrabs by Indian firms in countries such as Ethiopia (Hules & Singh, 2016). These accusations create public disapproval for Indian firms, which could affect the Indian African relationship.

Conclusion

As rightly said by minister Piyush Goyal of India, “Blessed with demographic dividend, India-Africa partnership can drive the global progress in this century” (India and Africa: Shri Piyush Goyal, n.d.). The India Africa relationship present an opportunity to uplift the most vulnerable people in the global south and present a successful implementation of the south-south cooperation.

Africa presents a continental size opportunity for Indian businesses looking for strategic investments in a rapidly growing region of the world with a rising population and a growing middle class.

As Indian companies are gaining financial strength, and technological capabilities, Africa could be a potential destination for strategic investments for long term growth potential, which could increase the overall Africa-India trade partnership and create new opportunities for growth.

While challenges remain with infrastructural gaps, market access, security and public image challenges faced by Indian companies, with effective policy and strategies, these challenges could be mitigated and redefine the African Indian relationship in the 21st century.

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The relationship between accounting research and accounting in practice – a Literature review

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Abstract: Scientific research has taken on a special importance in Albania. Today, much is discussed about the challenges of this sector, one that is its connection to reality and aiming at a "problem solving" approach. We have chosen to make an analysis of the connection between scientific research in the field of accounting and accounting practice, as in this field the connection of practice with academia and research seems to be more visible.

The purpose of this paper is to conduct a literature review regarding studies that investigate the relationship between scientific research related to accounting and accounting in practice. This paper examines the extent to which theoretical frameworks and findings derived from scientific papers influence accounting practice and real-world decision-making. Through the examination of a series of studies, the paper identifies the key issues and trends that exist between scientific research and accounting practice, highlighting the gaps in the current literature. The results of this paper show that regardless of the fact that scientific research in accounting provides valuable knowledge, they are often seen as unrelated to each other, due to the different priorities of researchers and accountants. Likewise, communication barriers between researchers and accountants are another factor that affects the connection between scientific research and practice in

accounting. Based on the findings from the analyses performed some recommendations are given to overcome the gap, emphasizing the need for collaborative efforts among practitioners and academia hat increase the importance of scientific research for accountants and that improve the general quality of accounting practice.

Keywords: scientific research for accountants, accounting practice, Albania

Jel Code: M40, M41, M49

1 Introduction

The relationship between accounting research and practice has been a subject of an ongoing debate in recent years. The roots of accounting research are shown in Mesopotamia and Egypt where simple techniques were developed to manage resources and trade in that epoque. In 1494 Luca Pacioli, an Italian mathematician published for the first time the concept of double entry accounting. The industrial Revolution in 18th and 19th centuries brought out the need of a regulated financial reporting, that was accompanied by the establishment of the Accounting Bodies and the accounting profession (Tredwell, 2022). AICPA (American Institute of Certified Public Accountants) the first accounting body was created in 1887. In the late 19th century accounting was formalized as an academic discipline. This can be proven by the development of Generally Accepted Accounting Principles (GAAP) and a growth of IFRS all over the world. The first accounting degree program was created in Michigan, U.S in 1850. From the late 20th century up to date, technological advancements, such as artificial intelligence and automation, cloud computing, and block-chain technology—have transformed and further develop accounting practices. Meanwhile, globalization has fostered efforts to unify international reporting standards and streamline reporting methods across different countries in the world.

Both academics and practitioners are becoming increasingly interested in the relationship between accounting research and accounting in practice. Different studies show different findings regarding to the relationship between accounting research and accounting in practice. Some researchers Guerreiro (2022), Fraser, K., & Sheehy, B. (2020), Burton et al, (2020), Tucker and Parker (2012), Quagli et al. (2015), state that practitioners of accounting do not employ the research findings of accounting research in their work. They argue that scientific research is frequently excessively theoretical and disconnected from the practical challenges encountered by accountants. Their assertion is that research may provide valuable insights; however, it occasionally fails to address the practical challenges and immediate and contemporary requirements of the profession. On the other hand, Barth, M. E (2015, Gow, I. 2021, Sinclair and Cordery (2016), Rajgopal (2019 found that accounting practice is driven by accounting research.

The advocates of scientific research emphasize that accounting research is essential for understanding the changing patterns in accounting, regulatory changes, and technological developments, thus improving that knowledge in the decision-making processes within the field.

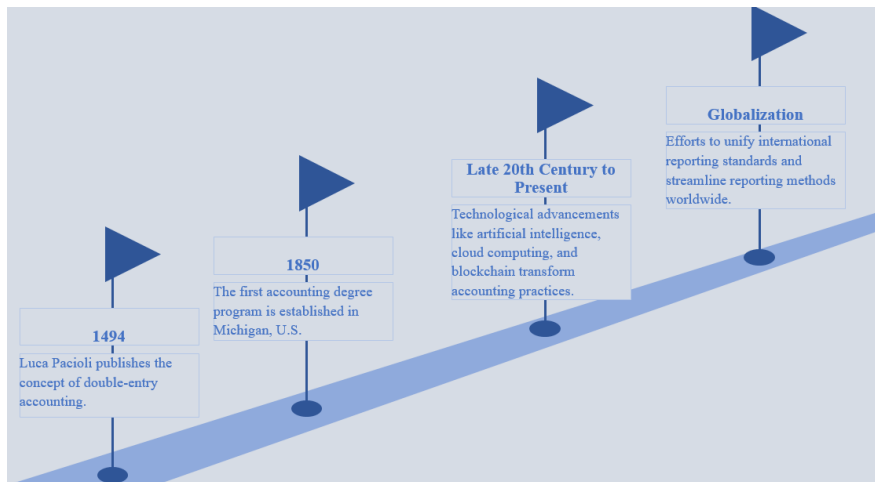


Figure 1: Evolution of accounting (analyses made by the authors)

Accounting academics plays a crucial role in the relationship between accounting research and accounting in practice. They are in a distinctive position to witness and influence this relationship, as they serve as both researchers and educators. We can acquire valuable insights into the ways in which research informs professional activities by analysing their perceptions of how academic research interacts with accounting practice. This review will improve our comprehension of the importance of scientific research in the accounting profession and emphasise its potential to enhance accounting practices

Ultimately, the advancement of accounting necessitates to overcome the gap between research and practice. The field can benefit from both empirical insights and real-world applications by fostering collaboration between researchers and practitioners, resulting in more informed and effective accounting practices.

2 Problem Statement

The connection between accounting research and accounting in practice is an issue that is being debated a lot in recent years. While scientific research in accounting aims to produce theoretical frameworks, methodologies, and provide knowledge for practice in the real world, there is a "perceived disconnection" between academic studies and the actual practices applied by accountants. Regardless of

the fact that scientific research in accounting provides valuable knowledge, they are often seen as unrelated to practice, due to the different priorities of researchers and accountants. Likewise, communication barriers between researchers and accountants are another factor that affects the (dis)connection between scientific research and practice in accounting.

The research questions of the study is:

- *What factors contribute to the perceived disconnection between accounting research and its implementation into practice?*
- *What are the barriers for a “problem solving “approach of the research in the field of accounting?*

Objectives of the Research

1. To provide an overview of existing research regarding the relationship between accounting research and accounting in practice.
2. To describe the challenges and barriers that exists between accounting research and accounting in practice.
3. To propose some interventions in order to improve the relationship between research in accounting and accounting in practice

3 Methodology

The main objective of this paper is to give an overview of the literature regarding the relationship that exists between accounting research and accounting in practice in recent years. To achieve the objective of this paper, a systematic literature review as a research method has been used. A Systematic Literature Review is a research methodology to collect, identify, and critically analyze the available research studies through a systematic procedure (Pati & Lorusso, 2017). In this paper, we present a literature review analyses of the research on accounting practice and research in accounting, focusing on the citation patterns and the most cited papers in the field. The data collected were published from 2012 to 2024, considering journal articles and conference proceedings papers in English. The first search was done on Google Scholar, as a tool available for free and broadly used for literature searching. Science direct was also used in reviewing different articles. In addition to the database searching, a number of articles were located using the Snowball method. Snowball method is a method used in qualitative research, that uses references of the articles to identify other relevant articles (*Cranfield Libraries: Conducting Your Literature Review: Snowballing and Grey Literature*). The search terms used to gather data were “accounting research”, “relationship” and “accounting in practice”. After all articles were appeared, we have filtered all the articles that were published during 2012-2024. The time

selection criteria is applied in aim to examine the trend of using accounting research in accounting practice in recent years. All the articles included in this paper were in English language.

4 Research findings based on literature review

Parker et al. (2011), revealed that academic accounting research is important to the higher education system, careers and publishers. However, its impact on teaching, professional practice, professions and society is a much debated issue.

Tucker and Parker (2012), in their paper “In Our Ivory Towers? The Research-Practice Gap in Management Accounting: An Academic Perspective” concluded that the major part of senior academics surveyed believe there is a significant and widening gap between academic management accounting research and practice, and this gap is concerning. The minor part of senior academics believes the division between academic research and practice is appropriate, and efforts to bridge this division are unnecessary or irrelevant.

According to Barth, M. E (2015), scientific research in accounting, which mainly focuses on financial accounting issues, is an essential activity for the drafting of corporate reports that guide the decision-making process by users of accounting information, and that play a key role in creating a healthy society.

Quagli et al. (2015), revealed that the primary motivation for scholars is to publish in highly ranked journals, which can sometimes conflict with their positive attitude towards practice. The gap between research and practice is driven by the current evaluation logic that prioritizes publishing in highly ranked journals over practical relevance. This is also due to the incentive structure that rewards publication in high-ranking journals over practical relevance.

Sinclair and Cordery (2016) reveals that the traditional gap between academics and standard setters is diminishing, as standard setters are increasingly seeking input and utilizing research from academics. Standard setters can help bridge the gap by identifying important research topics and facilitating connections between academics and practitioners. Academics can help bridge the gap by focusing on research topics that are relevant to standard setters and effectively communicating their findings.

Rajgopal (2019) revealed that Accounting academic research is important within the higher education system, careers, and publishing. The paper calls for accounting academics to engage more with the accounting profession and society to better understand and demonstrate the impact of their research, which is an important issue globally.

The same conclusion is reached by Burton et al, 2020. In their study “Do We Matter? Attention the General Public, Policymakers, and Academics Give to Accounting Research” they investigate the importance of scientific research in different fields (economics, psychology and other sciences) in the practice of the respective fields. Their study highlights that less attention is paid by accountants regarding scientific research in this field. Scientific research in relation to taxes is the sub-field that is more significant and is utilised more frequently in practice.

Fraser, K., & Sheehy, B. (2020), empirically examine the relationship that scientific research has with practical use and impact on society. The results of their study show that scientific research in accounting is not as important as research done in other areas of the economy, for practice and impact in society.

Gow, I. 2021, states that scientific research is very important for both academics and accounting practitioners. According to his study, scientific research can affect teaching, through the transmission of the results achieved in the scientific research of the students, or simply from the fact that the students have professors who have done more research and that disseminate their knowledge to students. Also, scientific research influences accounting organizations as well as accounting practitioners. The lack of appropriate use of scientific research is mainly the result of not disseminating the results of this research to stakeholders (Osma et al., 2023). They recommend that universities should support, reward and enable the distribution of scientific research results so that they are more useful to stakeholders.

IFAC asserts in its discussion "Accounting research for shaping a Better world" that scientific research in accounting improves comprehension of historical and contemporary studies, thereby facilitating the application of accounting knowledge to foster a sustainable future. This discussion also asserts that the academic world, practice and scientific research are interdependent, so in higher education, they should be considered interconnected. Professors should be encouraged to undertake scientific research in accounting that is consistent with the proposed redevelopment of the discipline, which has to do with focusing on how accounting practices can promote increased performance not only of organizations, but also of individuals and the environment.

Practitioners are less likely to read or reference academic accounting journals, while researchers are more likely to read or reference practitioner publications (Justice et al. 2022). Practitioners are more likely to read or reference practitioner publications for practice guidance, while researchers are more likely to read or reference practitioner publications that are peer reviewed. The research expectations gap is rooted in academic incentive structures, lack of practitioner

experience among newly-graduated PhDs, and decreased opportunities for academic-practitioner collaboration in publishing.

According to Guerreiro (2022), there has been increasing criticism over the years regarding the relevance of scientific research in accounting conducted by universities. In his paper, he underscores that scientific research should serve not only to the accounting profession and its practitioners but also to the society as a whole.

Clor-Proell et al. (2024) in their study proposes practical strategies for authors, reviewers, editors, and business school deans to promote a more integrated approach between accounting research and practice. The aim of these strategies is to enhance the relevance and impact of accounting scholarship on real-world financial practices, thereby enriching both the academic and professional realms of accounting.

Based on the literature review it results that the main challenges related to the relationship between accounting research and accounting in practice are the followings:



Figure 2: Main findings (elaborated by the authors)

Conclusions

From an in depth analysis of the literature reviewed it results that there is a complex relationship between accounting research and accounting in practice. While accounting research supplies with valuable perceptions and the changes in the regulatory framework, there is still a disconnection due to different priorities, communication barriers and incentive structures within academia realm.

Important conclusions of the review show that:

Many practitioners believe accounting articles are too theoretical and not related to their daily concerns. Researchers are focused primarily in publishing in prestigious publications instead of trying to find solutions to the accounting

problems faced in practice. Thus, the majority part of the practitioners see the research as not related to the practice and as not result of a “problem solving” approach.

There is no any structured cooperation among the stakeholders in the field of accounting. The practitioners are not very much interested in research. One major conclusion is that academic accounting research is often perceived as overly theoretical and disconnected from the practical realities of the profession. This disconnection gets deeper by academic priorities that emphasize publication in high-ranking journals over the practical applicability of findings. Practitioners, in turn, tend to rely on practitioner-oriented resources for immediate guidance, further reinforcing the gap.

The primary concern is the absence of multiple methods that foster the collaboration and the communication between researchers and practitioners. The existence of these barriers, do not allow the dissemination of the research results and their use in a proper way, resulting in exclusion of valuable academic insights in professional practice of accounting. This issue gets worse by the lack of a structured collaboration framework, thus limiting the opportunities to conduct research. Frequently, professionals rely heavily on books to resolve their everyday issues, which leads to a reduced application of academic research findings.

Furthermore, the paper suggests certain areas, which, if integrated with practice and research, can provide revolutionary changes for example, focusing on the “problem-solving” approaches in research and linking the academic rewards with the practical needs can help in closing the gap. Also, engaging the professional bodies and setting some research priorities can help make the findings relevant and applicable. From the figure below we have outlined the main activities that should be undertaken in order to reduce the research-to-practice gap.

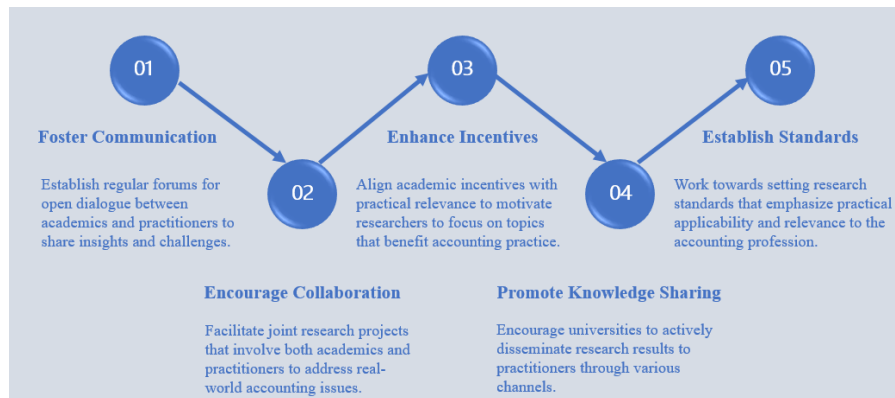


Figure 3: Bridging the gap (elaborated by the authors)

The gap should therefore be addressed by encouraging cooperative research projects, improving communication measures, and aligning academic rewards with practical values. Some of the ways to enhance this integration include involving professional organizations and setting guidelines in research discussions. Universities and accounting programs should encourage their faculty members to engage in active sharing of results to practitioners and also choose research topics that address practical issues. This will not only raise the relevance of accounting research but also improve its influence on the profession and society at general level. In essence, even if accounting research has great power to affect practice, realising this potential calls for coordinated efforts to close the current discrepancies. Encouragement of deeper relationships between academics and the accounting profession will help to improve the quality and relevance of both practice and research, therefore advancing the accounting discipline.

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Exploring Theories Behind Energy Startups: A Pathway to Innovation and Sustainability

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Abstract: This paper explores the theoretical foundations driving the growth and impact of energy startups in the global transition to renewable energy. The aim is to examine how frameworks such as disruptive innovation theory, entrepreneurial ecosystems theory, and sustainable entrepreneurship contribute to understanding the success and challenges these startups face. Through a conceptual analysis, the paper highlights how innovative approaches have disrupted traditional energy systems, democratized access to clean energy, and addressed pressing environmental and social challenges.

The method involves synthesizing existing literature and analyzing market trends. The study also examines the interplay between supportive policies, financial mechanisms, and technological advancements in fostering energy innovation.

The primary outcome reveals that energy startups, by leveraging disruptive technologies, integrated ecosystems, and sustainable business models, play a pivotal role in accelerating the adoption of renewable energy and mitigating climate change. The findings emphasize the need for collaborative efforts among policymakers, investors, and entrepreneurs to create favorable conditions for energy innovation. This research provides actionable insights for stakeholders aiming to advance sustainable energy solutions and transition toward a low-carbon economy.

1 Introduction

The global energy sector is at a critical juncture, facing immense pressure to transition from traditional fossil fuels to cleaner, renewable energy sources (Feng & Wang, 2020). This shift is driven by the need to combat climate change, reduce greenhouse gas emissions, and adapt to policy shifts that increasingly favor sustainable practices. The urgency of this transition has created opportunities for new players in the energy space, notably startups, which bring innovative solutions and business models to address these pressing challenges. Energy startups are often characterized by their agility, forward-thinking approaches, and

focus on technology-driven disruption, all of which position them as significant contributors to the evolving energy ecosystem (Grüner & Ruppert, 2017).

Dobrowolski et al. (2024) mention that energy startups span various activities, from renewable energy generation (e.g., solar, wind, geothermal) and energy storage to grid management, energy efficiency technologies, and advanced data-driven solutions like energy analytics and smart metering. They are not only addressing energy demand but also creating solutions that are environmentally responsible and economically viable. This aligns them closely with global initiatives, such as the Paris Agreement (Delbeke & Vis, 2019), which aims to limit global warming to well below two °C, and the Sustainable Development Goals (SDGs) (Khan & Zhao, 2021), particularly Goal 7, which calls for affordable, reliable, and sustainable energy for all.

The success and impact of energy startups can be better understood through several theoretical frameworks. This paper focuses on three key theories: **disruptive innovation theory** (Christensen et al., 2013), **entrepreneurial ecosystems theory** (Malecki, 2018), and **sustainable entrepreneurship theory** (Cohen and Winn, 2007; Gibbs, 2006). Each of these frameworks provides a unique perspective on the factors that drive the growth and influence of energy startups, offering insights into how they can effectively navigate the complex and highly competitive energy market.

While these theories offer valuable insights, energy startups still face significant challenges. The high capital requirements, technical risks, regulatory hurdles, and the dominance of established players can all impede market entry and growth (Dobrovolska et al., 2024; Myroshnychenko et al., 2024). However, the rapidly changing energy landscape, coupled with an increasing flow of venture capital into clean technology and impact investment, creates a favorable environment for innovation and growth in this sector.

This paper aims to deepen the understanding of the theoretical foundations that influence energy startups and assess how these frameworks can guide future developments in the field. Ultimately, this paper argues that energy startups, driven by robust theoretical underpinnings and supported by evolving ecosystems, are poised to play an essential role in the global transition toward a sustainable, low-carbon energy future. The insights gained from these theories can help entrepreneurs, investors, and policymakers develop effective strategies for fostering innovation and accelerating the adoption of clean energy technologies globally.

2 Disruptive Innovation Theory and Energy Startups

Clayton Christensen introduced the disruptive innovation theory to describe how smaller companies with limited resources successfully challenge established businesses (Christensen et al., 2013). In this theory, innovations begin by addressing niche markets or underserved customer segments with more straightforward, more affordable, or more accessible solutions. Over time, these innovations improve and expand, eventually appealing to the broader market and displacing incumbent players. This model is especially relevant in the energy sector as small, agile startups leverage technology to challenge and transform traditional, centralized energy systems. Hettich and Kachi (2022) sustain that with a focus on renewable energy sources, energy storage, and decentralized power systems, energy startups are gradually reshaping the global energy landscape.

2.1 Evolution of Disruptive Innovation in Energy

Historically, large utility companies with centralized infrastructures have dominated the energy sector for generating and distributing electricity from fossil fuel sources, such as coal, oil, and natural gas (Goyal, Esposito, & Kapoor, 2018). These systems required significant capital investment, leading to high barriers to entry for new market participants. As a result, energy systems have been slow to adapt to shifts in consumer demands or environmental policies. However, technological advances and the growing demand for sustainable energy sources have created fertile ground for disruptive innovation within the industry (Chu & Majumdar, 2012).

Renewable energy sources such as solar and wind represent classic examples of disruptive technologies within the energy sector. Initially, solar photovoltaics (PV) and wind power were considered too costly and inefficient to compete with traditional fossil fuels (Hirth, 2015). However, due to continuous technological improvements and decreasing costs, these technologies are now more competitive and widely adopted, moving from niche applications to mainstream energy sources. For instance, the price of solar panels has decreased by more than 80% over the past decade, enabling widespread adoption in developed and emerging markets (Reslan et al., 2022).

2.2 How Energy Startups Drive Disruption

Energy startups embody the principles of disruptive innovation by focusing on underserved needs and creating products that address specific gaps in the market

(Musta, 2022). Many startups target segments where large incumbents are too slow or entrenched to provide effective solutions. For instance, startups working on **off-grid solar systems** address the energy needs of remote communities that lack access to traditional power grids. By offering affordable and scalable solar systems, these companies bypass the limitations of centralized power infrastructure.

Another example is **battery storage technology** (Divya & Østergaard, 2009), which addresses the intermittent nature of renewable energy sources like solar and wind. Large utility companies historically relied on the assumption of continuous, centralized power generation from fossil fuels. However, as renewables have become more prevalent, startups have stepped in to address the need for reliable energy storage solutions. Companies like **Tesla with its Powerwall** (He et al., 2022), **Fluence** (Ritchie & Roser, 2018), and **Sonnen** (McGee, 2016) are examples of energy startups that have developed battery storage systems capable of storing surplus renewable energy for use during peak demand. This technology has not only provided a solution to the intermittency problem but also empowered consumers and businesses to achieve greater energy independence, posing a challenge to traditional utility companies.

2.3 Technology as a Catalyst for Disruptive Innovation

Technological advances have been crucial in enabling energy startups to introduce disruptive innovations. Advances in solar cell efficiency, manufacturing processes, and economies of scale have significantly reduced the cost of solar PV technology, making it accessible to a broader audience (Pillai, 2015). Startups developing residential and commercial solar solutions have effectively disrupted traditional energy supply models by allowing users to generate electricity.

Battery technology improvements (Zhu et al., 2021), including lithium-ion and emerging solid-state batteries, have enabled reliable energy storage solutions. Startups in this space provide alternatives to the centralized grid, facilitating microgrids, community solar projects, and off-grid applications that reduce reliance on traditional utilities.

Digitalization has enabled startups to create solutions that offer real-time energy monitoring, predictive analytics, and demand-response capabilities (Zhang et al., 2021). For instance, smart grid technologies (Costa, Diniz, & Kazmerski, 2016) optimize energy use by allowing consumers to adjust their consumption patterns based on pricing signals or grid demand. Startups like Opower are pioneers in using and transforming data to induce behavioral change, resulting in a considerable reduction in energy and waste (Jetzek, Avital, & Bjorn-Andersen, 2014).

2.4 The Role of Policy and Market Conditions in Supporting Disruption

Supportive policies and market conditions often influence the success of disruptive energy startups. Government incentives, subsidies, and tax breaks for renewable energy technologies create a conducive environment for these companies to grow (Bolinger, 2014). Policies like **feed-in tariffs** (Mendonça, 2012) and **net metering** (Cozma et al., 2016) have made it financially viable for consumers to invest in distributed renewable energy systems, fostering the growth of solar startups and battery storage companies.

In addition, the decline in the costs of renewable technologies has shifted consumer preferences, creating a market demand that aligns with the capabilities of disruptive startups. For instance, as awareness of climate change grows (Almoneef & Aljohani, 2021), consumers are increasingly motivated to adopt clean energy solutions, thus accelerating the market for renewable energy technologies. This creates a virtuous cycle in which increased demand drives further innovation, improving technology and lowering costs, allowing energy startups to capture larger market shares.

2.5 Barriers to Disruption and Strategic Approaches for Energy Startups

While energy startups present compelling solutions, they face significant barriers to scaling and achieving widespread disruption. The capital-intensive nature of energy technology development, regulatory constraints, and competition from established utilities can pose challenges. Many startups adopt strategic approaches to overcome these barriers, such as forming **partnerships with incumbent energy companies** (Altunay & Bergek, 2023) or **engaging with government programs** (Kuckertz & Wagner, 2018) that provide grants and subsidies.

Startups often use strategic pricing and financing models, like power purchase agreements (PPAs) and leasing arrangements, to make their solutions more accessible and to build consumer trust (Parks et al., 2014). By reducing or eliminating upfront costs, these models allow customers to experience the benefits of renewable energy or energy storage without financial risk, facilitating greater adoption and supporting long-term growth.

2.6 Future Directions of Disruptive Innovation in Energy

Looking ahead, the energy sector will likely see further disruption as new technologies and business models emerge. Innovations in **blockchain for energy trading** (Wang et al., 2019), **artificial intelligence for energy efficiency** (Farzaneh et al., 2021), and **hydrogen fuel cells** (Singla, Nijhawan, & Oberoi,

2021) are on the horizon, with startups leading the charge in their development. These technologies hold the potential to decentralize energy systems further, enhance grid resilience, and reduce reliance on traditional fossil fuels, ultimately contributing to a more sustainable and resilient global energy system.

As the world moves towards cleaner energy, disruptive startups are expected to play an increasingly important role in the transition. By continuing to target niche markets, improve their technologies, and challenge the status quo, these companies create economic value and accelerate the global shift toward a sustainable, low-carbon future.

In conclusion, disruptive innovation theory provides a robust framework for understanding the impact of energy startups on the traditional energy sector. By leveraging technology and targeting unmet needs, energy startups have introduced products and services that challenge established energy models, democratizing access to clean energy and fostering a decentralized, resilient energy landscape. This ongoing disruption offers a promising pathway for addressing climate challenges and reshaping the future of energy.

3 Entrepreneurial Ecosystems Theory

Entrepreneurial ecosystems theory explores how clusters of interconnected actors, resources, and institutions support entrepreneurial ventures within a specific industry or region (Alvedalen & Boschma, 2017). In the context of energy startups, these ecosystems comprise a complex network that includes government bodies, research institutions, investors, incubators, corporate partners, and other supportive organizations. These entities provide critical financial, regulatory, technological, and social resources that help startups overcome the challenges of entering and scaling within the capital-intensive and highly regulated energy industry.

Entrepreneurial ecosystems theory emphasizes that thriving ecosystems provide startups access to funding, mentorship, talent, and partnerships, enabling them to develop, test, and commercialize innovative energy solutions (Battistella, De Toni, & Pessot, 2017). In this section, we examine the core components of energy entrepreneurial ecosystems, highlight the role of policy and regulation, explore the importance of strategic partnerships, and consider examples of leading entrepreneurial ecosystems in the energy sector.

3.1 Components of Energy Entrepreneurial Ecosystems

Energy entrepreneurial ecosystems comprise a range of stakeholders and resources that support startups throughout their lifecycle. Access to capital is essential for

energy startups (Garg & Shivam, 2017), which often require significant funding to develop and commercialize technologies. Venture capital firms, impact investors, and government grants are primary funding sources in these ecosystems. Specialized funds, such as **Breakthrough Energy Ventures** and **Energy Impact Partners** (Zhang, Li, & Wang, 2023), specifically target energy and climate tech startups, providing capital as well as strategic guidance.

Incubators and Accelerators (Hausberg & Korreck, 2021) offer energy startups access to mentorship, resources, and networking opportunities, helping them refine their business models, access industry experts, and scale their technologies. Notable energy-focused incubators and accelerators include **Greentown Labs** in Massachusetts, **Elemental Excelsior** in Hawaii, and **EnergyLab** in Australia. These organizations often provide specialized support, such as access to testing facilities for hardware or access to corporate partners for pilot projects. Partnerships with universities and research organizations enable startups to access cutting-edge technology, research, and expertise (Frølund, Murray, & Riedel, 2018). Institutions like the **National Renewable Energy Laboratory (NREL)** in the United States and the **Fraunhofer Institute** in Germany collaborate with startups to help advance energy technologies, often providing testing facilities, technical expertise, and collaborative research opportunities. Government policies, tax incentives, and subsidies are crucial in encouraging energy innovation (Bartik, 2003). Startups benefit from supportive regulatory environments, including subsidies for renewable energy, carbon taxes, or feed-in tariffs that incentivize clean energy. Governments can also support energy startups by streamlining the permitting process, providing grants, and establishing favorable procurement policies (Nakamura, 2018).

Large energy companies like Siemens, Schneider Electric, and Shell often partner with startups (Krasnokutskaya, Danko, & Shyriaieva, 2023) to pilot new technologies and integrate innovations into their operations. These partnerships provide startups with access to industry expertise, market validation, and potential distribution channels, reducing the barriers to scaling. Public support for sustainable energy and increasing demand for clean technology drive market growth and create favorable conditions for startups. Consumers, businesses, and governments are seeking ways to reduce emissions, presenting opportunities for startups that address these needs with innovative solutions.

3.2 The Role of Policy and Regulatory Support in Energy Ecosystems

Supportive policy and regulation are essential for fostering a robust energy entrepreneurial ecosystem (Ajayi-Nifise et al., 2024). Regulatory frameworks set rules of engagement, influencing market conditions and creating incentives for startup innovation. Government policies encouraging renewable energy

development (Sadorsky, 2012), such as **tax credits, subsidies, carbon pricing,** and **net metering**, provide favorable conditions for startups by reducing costs and lowering market entry barriers. Policies like the **Investment Tax Credit (ITC)** in the United States (Mikkola & Salpakari, 2016), which provides tax relief for solar energy installations, have significantly impacted the growth of solar startups by improving the economic viability of their offerings.

Additionally, governments can create supportive procurement policies, requiring public agencies to prioritize clean energy solutions. For example, several U.S. states have mandated that state-run buildings use renewable energy sources, creating demand for clean technology solutions and opening doors for energy startups. Programs like **California's Title 24** energy efficiency standards encourage startups to develop innovative solutions in energy-efficient buildings and appliances (Persily & de Jonge, 2014).

Regulation can also support the emergence of decentralized energy solutions (Leal-Arcas, Alemany Rios, & Akondo, 2019), such as microgrids and community solar projects, which allow energy startups to develop locally focused solutions. These regulatory frameworks provide the basis for new business models that empower communities and enable consumers to participate actively in the energy system. By establishing grid interconnection standards, net metering policies, and other supportive frameworks, regulators help create the conditions for startups to experiment with and scale innovative energy solutions.

3.3 The Importance of Strategic Partnerships

Strategic partnerships are critical for energy startups (Nesner, Eismann, & Voigt, 2020), offering access to resources, expertise, and market channels that can help them overcome the challenges of scaling in a competitive and regulated market. These partnerships often occur between startups, established energy companies, research institutions, and technology providers. Through partnerships, startups gain access to pilot programs, large customer bases, distribution networks, and even manufacturing support, all crucial for scaling.

Partnerships with research institutions provide energy startups with access to technical expertise, testing facilities, and cutting-edge research (Rosienkiewicz et al., 2024). Collaboration with institutions like **Stanford University's Precourt Institute for Energy** or **MIT's Energy Initiative** allows startups to conduct R&D with advanced resources, increasing the feasibility of technology development and deployment.

3.4 Challenges and Opportunities within Energy Ecosystems

While entrepreneurial ecosystems offer substantial support, energy startups face unique challenges that ecosystems must address to foster their success. Unlike software startups, energy companies often require substantial capital to develop hardware and infrastructure (Liu et al., 2022). Long development cycles can be prohibitive for early-stage companies. To address this, ecosystems must facilitate access to patient capital, including government grants, impact investing, and corporate venture funds willing to support longer timelines. The energy sector is heavily regulated (Eberlein, 2008), which can create challenges for new entrants unfamiliar with industry standards and policies. Entrepreneurial ecosystems that provide legal guidance, connections to regulatory agencies, and mentorship from experienced industry players can help startups navigate these complexities.

Energy startups need to establish trust with customers who may be wary of new technologies. Ecosystems can support startups by promoting consumer education initiatives, public awareness campaigns, and partnerships with reputable companies, helping to build credibility. As the global focus on climate change intensifies (Ferreira, Fernandes, & Ramírez-Pasillas, 2024), energy entrepreneurial ecosystems are likely to grow in importance. With rising interest in sustainable finance, ecosystems are expected to attract more impact investors who prioritize financial returns and positive environmental outcomes (Paetzold, Busch, Utz, & Kellers, 2022). This shift will provide additional capital for startups focused on climate tech and renewable energy.

In conclusion, entrepreneurial ecosystems are a cornerstone of the energy startup landscape, providing the resources, support, and collaboration needed to drive innovation. By fostering partnerships, streamlining access to funding, and promoting favorable regulatory environments, these ecosystems empower energy startups to navigate industry complexities, scale effectively, and contribute to the global shift toward sustainable energy solutions. As these ecosystems continue to evolve, they will play a critical role in accelerating the development and deployment of clean energy technologies, ultimately shaping the future of the energy sector.

4 Sustainable Entrepreneurship

Sustainable entrepreneurship is a business approach that combines economic goals with environmental and social objectives, aiming to positively impact society and the planet (Schaltegger & Wagner, 2011). This concept is particularly relevant in the energy sector as startups seek to develop clean, renewable, and socially

responsible energy solutions. Sustainable entrepreneurship stands in contrast to traditional business models, which often prioritize profit over social or environmental outcomes. Energy startups practicing sustainable entrepreneurship (Bergset & Fichter, 2015) focus on addressing global challenges, such as climate change, energy access, and resource efficiency, through innovations that are financially viable and aligned with long-term ecological and social sustainability goals.

In this section, we explore the core principles of sustainable entrepreneurship, examine how energy startups integrate these principles into their business models, highlight innovative financing and business strategies, and provide examples of companies making a measurable impact in the clean energy transition.

4.1 Core Principles of Sustainable Entrepreneurship

Sustainable entrepreneurship in the energy sector is driven by several foundational principles (Hockerts & Wüstenhagen, 2010), which guide startups toward creating holistic value for society, the environment, and their stakeholders.

Sustainable energy startups often adhere to the triple bottom line framework (Loviscek, 2020), focusing on "people, planet, and profit." By balancing financial performance with social and environmental objectives, TBL-driven companies strive to create products and services that deliver economic value while addressing societal needs and reducing ecological impact.

Many sustainable entrepreneurs in the energy space adopt circular economy principles (Velenturf & Purnell, 2021), focusing on designing products and processes that minimize waste and maximize resource efficiency. In energy startups, this might include developing technologies for recycling or reusing materials in battery production or designing systems that operate efficiently to minimize energy loss.

Unlike traditional startups focused primarily on short-term profits, sustainable energy startups adopt a long-term perspective, assessing their operations' environmental and social impact. These companies often track their impact through standardized frameworks, such as **Environmental, Social, and Governance (ESG)** metrics (Huang, 2021) or **Global Reporting Initiative (GRI)** standards (Brown, de Jong, & Lessidrenska, 2009), to evaluate and communicate their contributions to sustainability.

Many sustainable entrepreneurs prioritize access to clean energy for underserved communities, focusing on affordability and inclusivity. By ensuring that vulnerable populations benefit from their innovations, these startups promote social equity and address the energy divide, particularly in regions with limited access to reliable electricity.

4.2 Challenges and Opportunities for Sustainable Entrepreneurship in Energy

Sustainable energy startups face unique challenges as they balance financial returns with environmental and social goals. However, these challenges also present opportunities for innovation and differentiation.

Many sustainable energy solutions, such as solar and battery systems, require substantial upfront investments (Kabir, Sandeep Kumar, Adelodun, & Kim, 2018). To address this, startups often need to secure patient capital from impact investors and build business models that generate long-term revenue streams.

Navigating the regulatory environment in the energy sector (Oduro, Uzougbo, & Ugwu, 2024) can be challenging, especially for startups that prioritize environmental impact over immediate profitability. Sustainable entrepreneurs often work closely with policymakers to advocate supportive regulations, such as carbon pricing, renewable energy incentives, and streamlined permitting processes.

Educating consumers about the environmental benefits of renewable energy and encouraging sustainable choices is essential for the growth of sustainable energy startups. Many companies invest in awareness campaigns and community engagement initiatives (Gutterman, 2020) to foster consumer trust and highlight the broader impact of their solutions.

For sustainable energy startups focused on expanding access to clean energy in developing regions, reaching remote or low-income communities can be difficult. However, these markets represent significant opportunities for growth, especially as sustainable startups develop innovative models that prioritize affordability and accessibility.

As global climate goals and sustainable development objectives gain momentum, sustainable entrepreneurship in the energy sector will continue to evolve. Digital technologies like blockchain, AI, and IoT enable more efficient and sustainable energy systems (Kumar et al., 2020). For instance, blockchain-based energy trading platforms and AI-driven demand response systems can optimize energy use, improve grid stability, and reduce carbon footprints. Demand for carbon removal solutions will grow as more companies and governments commit to carbon neutrality.

Conclusion

The emergence of energy startups is reshaping the global energy landscape, offering innovative solutions to some of the most pressing challenges of our time—climate change, resource scarcity, and the need for a sustainable energy future. These startups, driven by a combination of entrepreneurial vision, technological advancement, and commitment to environmental and social goals,

disrupt traditional energy markets and lead the way toward a cleaner, more resilient energy ecosystem. Through disruptive innovation, entrepreneurial ecosystems, and sustainable entrepreneurship, we gain insights into the key factors enabling energy startups to thrive and make a meaningful impact.

Disruptive innovation theory has shown how startups can enter the market by addressing unmet needs and gradually gaining ground against entrenched incumbents. Energy startups have harnessed this approach by introducing affordable, scalable, and decentralized solutions, allowing consumers and businesses to transition to renewable energy sources. This innovation pathway has enabled energy startups to tackle challenges ranging from energy storage and grid management to microgrid deployment and off-grid electrification, ultimately empowering individuals and communities to produce and manage their energy.

Entrepreneurial ecosystems theory highlights the importance of networks, resources, and regulatory environments in supporting energy startups. A robust ecosystem provides startups access to financial capital, mentorship, industry expertise, and partnerships, all essential for scaling innovative solutions. This paper underscores the role of energy incubators, government incentives, and impact-driven venture capital funds in creating conditions that allow startups to grow.

Sustainable entrepreneurship theory reflects the broader trend of aligning business goals with social and environmental objectives. Energy startups that adopt a triple-bottom-line approach—people, planet, and profit—are poised to deliver financial returns and significant societal benefits. These startups are integral to global efforts to combat climate change and promote sustainable development by prioritizing renewable energy access, resource efficiency, and carbon reduction. Startups focused on pay-as-you-go solar systems, community-owned renewable projects, and energy-as-a-service models enable communities, particularly in underserved regions, to access affordable and reliable clean energy.

Challenges and Opportunities in the energy startup landscape are both substantial and transformative. Energy startups face numerous barriers, including regulatory complexities, high capital requirements, and competition from established incumbents. Nevertheless, these challenges also create opportunities for innovation, particularly as governments, investors, and consumers increasingly prioritize sustainability. The global transition toward clean energy presents startups with expanding markets driven by favorable policies, rising consumer demand, and advancements in renewable technologies. Integrating digital tools, decentralized energy systems, and flexible financing models allows startups to address these challenges creatively, reaching wider audiences and accelerating the adoption of sustainable solutions.

Future Directions for energy startups are promising as the demand for innovative clean energy solutions grows. Moving forward, it will be crucial for energy

startups to adapt to emerging trends in sustainable finance, carbon offset technologies, and cross-sector partnerships. As global climate policies, such as the Paris Agreement, continue to drive emissions reduction targets, the need for carbon-neutral solutions will likely spur new growth areas for startups specializing in energy efficiency, carbon capture, and green hydrogen. Furthermore, digitalization and data analytics advances will enable startups to optimize energy production and consumption, creating intelligent, resilient energy systems that support a low-carbon economy. By embracing interdisciplinary approaches and collaborating with stakeholders across the public and private sectors, energy startups have the potential to lead the charge toward a decarbonized, equitable, and economically viable energy future.

In conclusion, energy startups are at the forefront of a historic transformation in how the world produces, distributes, and consumes energy. Through the lens of theoretical frameworks and real-world examples, this paper has illustrated the vital role these companies play in reshaping the energy sector. For entrepreneurs, investors, and policymakers, understanding and supporting the unique dynamics of energy startups will be essential to accelerating the global transition to renewable energy. As the world moves toward achieving its sustainability and climate goals, energy startups will continue to act as critical drivers of innovation and resilience, catalyzing progress and paving the way for a future where clean, accessible, and reliable energy is a reality for all.

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Examining the marketing capabilities of family businesses

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Abstract: Small and medium-sized enterprises, including family businesses, are key players in national economies. Their role in employment and GDP generation is critical to the economy. The skills and knowledge they possess are important for their ability to operate. In my research, I will examine how family business managers assess the marketing capabilities of their businesses in relation to their competitors. In doing so, I evaluate the innovative content of the product structure, the quality of the products, customer confidence or the quality of the relationship with partners. But I also look at the efficiency of asset management, cost management, liquidity or the financing of businesses. I focus on the characteristics of marketing information systems and their interrelationships with other variables.

Keywords: small and medium enterprises, family business, marketing capabilities, marketing-controlling

1 The family businesses

De Massis and colleagues (2012) set the following criteria for the definition of a family business: family ownership, family participation in management, family participation in the board of directors, family generational turnover, the business identifies itself as a family business, and the participation of several generations in the business. Ownership appears to be the most important criterion, while the second most important was participation in management.

Despite the widespread use of these defining criteria, from a theoretical point of view, their inclusion in the definitions raises several problems. One of them is that the concepts of ownership, control, management and generational change are difficult to define precisely. Nor is there an answer to why family involvement in the business generates behaviours and outcomes that distinguish family firms from non-family firms. These observations have led some researchers to focus on the

essential elements of family firms from a theoretical perspective rather than on the operational elements. On this basis, the following criteria have been put forward: 1) family influence over the strategic orientation of the firm; 2) the intention for the family to hold the reins of control; 3) family entrepreneurial behaviour; 4) unique, inseparable, synergistic resources and capabilities that arise from family involvement and interactions (Chrisman et al, 2005).

Baros-Toth (2023) defines a family firm as a firm that, regardless of its size, can be considered a family firm if it considers itself a family firm, at least 50 percent of the firm is owned by a family, the family has influence on the firm's strategy, the family is involved in the management of the firm, and there is a willingness to change ownership and/or management within the family.

Based on considerable literature research, Kása et al. (2019) have created their own definition of a family business, according to which a family business is a business: 1. that considers itself a family business, or 2. where at least 51 percent of the firm is owned by a family, and 3. the family is involved in the management of the business, or 4. family members participate as employees in the operation of the business, or 5. the transfer of management and ownership is partly or fully within the family

As regards the factors that define family businesses, there are authors who are more lenient on the factors that define family businesses. If one of the following three criteria is met, the enterprise is considered a family business (Tóth-Bordásné Marosi (2014) and Chua et al (2009)):

- Family ownership and control,
- Family ownership, but control is not in the hands of the family,
- Family control, but ownership is not in family hands.

Family and non-family businesses differ in a number of characteristics. These are summarised in Table 1.

Viewpoints	Family businesses	Non family businesses
Intent	The continuity	Short-term maximisation of share prices
Purpose	Preserving assets and reputation	Meet the expectations of institutional investors
Founding belief	Protecting against the downside of risks as a priority	More risk can bring more return
Strategic orientation	Adaptation	Continuous growth
Key risk carriers	Customers and employees	Shareholders and management
Management focus	Ongoing, incremental improvements	Innovation
Perception of the business	Social institution	A disposable asset
Personal leadership	Caregiver	Charismatic

Table 1. Comparison of family and non-family businesses
Source: Thomassen (2007, cited in Szabó (2013)

2 Method and sample

The results of the research are presented on the basis of an online questionnaire survey conducted since 2017. The questionnaire surveyed micro, small and medium-sized enterprises, including family businesses. The share of SMEs in the survey was 99% and the share of family businesses 89%. The number of valid questionnaires was 2,628. The sampling followed the principles of the snowball method. The sample is not representative and the results obtained are interpretable for the sample under study.

A large proportion of the respondents were managers, a smaller proportion were business owners without managerial positions, and 12.5% were employees among the managers. The managers of the enterprises surveyed were 75% men and 25%

women. In terms of education, the majority of them had a higher education (college or university) (51%) and 5% were in progress. 20% had a vocational secondary school degree and 13% had a high school degree.

Of the enterprises surveyed, 73.8% were micro, 19.6% small, 5.5% medium and 1% large in terms of size. 34.8% of the surveyed firms were active in the consumer services market, 18.7% in industrial services, 12.2% in consumer durables and 12% in raw materials and components. Consumer bulk goods accounted for 9.3%, market producer equipment for 3.4%, other and who did not know for 5-5%.

27.2% of SMEs in the survey were active in trade and repair, 15.2% to 15.2% in construction and other community services, 7.5% in agriculture, 7.2% in manufacturing, 6% in accommodation and food service activities, 5.9% in financial and business services and real estate, and 4.6% in transport, storage and communication.

51.3% of the enterprises surveyed were located in Budapest or Pest county, 13.1% in Northern Hungary, 8.5% in Southern Transdanubia, 8.3% in Northern Transdanubia, 7.7% in Central Transdanubia, 7% in Western Transdanubia and 4% in Southern Transdanubia.

3 The results of the survey

The marketing capability of enterprises was assessed using 23 variables. The SMEs surveyed were able to rate their marketing capabilities in relation to their competitors on a 5-point Likert scale. A score of 1 meant that the competitors had a significant advantage in the given capability, and a score of 5 meant that the respondent company had a significant advantage. The companies surveyed typically assess their position in relation to competitors favourably in terms of customer indicators. For example, 85% of them considered that they were in a better position than their competitors in terms of good relations with customers, and only 2.7% thought that their competitors had a more favourable position (Figure 1.). Similarly, their perceptions are favourable for customer confidence (83 and 3%), high customer service (80 and 3.4%) and long-term partnerships (76 and 5.4%). The latter indicator obviously includes suppliers. This positive assessment of the situation is probably due to the positive feedback received by the enterprises surveyed in their relations with customers or suppliers. This is obviously a general picture, not a real advantage, as it is perceived by the majority of enterprises, but rather a positive picture of the situation in the relationship between SMEs' customer and supplier partners.

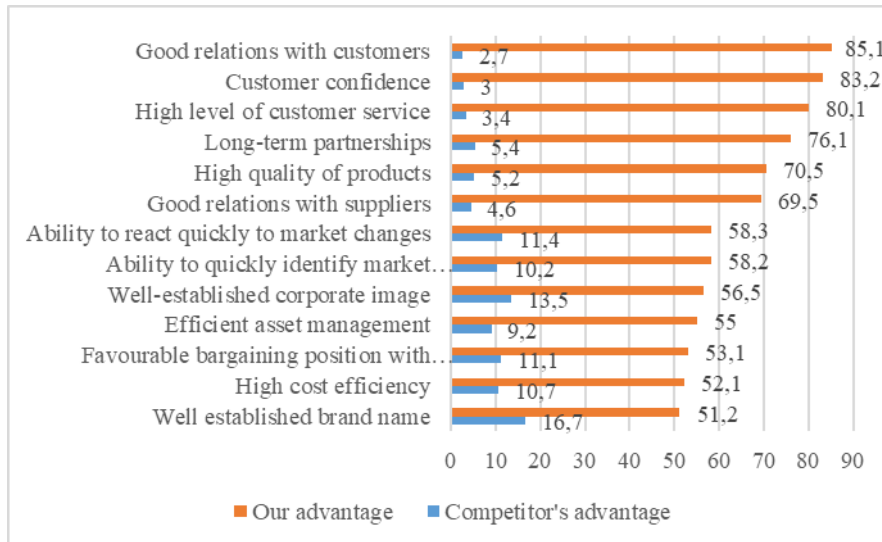


Figure 1. How well has your company performed compared to your competitors? 1. (%)

Source: own research

In terms of product quality, 70% of respondents preferred to perceive their own business as having an advantage over competitors. For corporate image and brand name, they also perceived their own advantage (56% and 51% respectively) as compared to that of their competitor (13% and 17% respectively). Some aspects of management efficiency were also perceived positively. 55% of family businesses that completed the questionnaire said that their asset management was more efficient than their competitors', while 52% said that their cost management was more efficient than their competitors'. In contrast, 9% said they preferred to be in a better position than their competitors. In terms of their ability to respond quickly to market changes (58.3) and to identify market opportunities quickly (58.2%), they also perceived themselves as having more of an advantage over competitors, with only 11.4 and 10.2% respectively perceiving themselves as having more of an advantage over competitors.

While 53% of the family businesses surveyed said they had a more favourable bargaining position compared to their competitors, only 47% said they were in a better position to bargain with suppliers (Figure 2.). In terms of a favourable financing structure, 44% perceive a more favourable situation, while 15% perceive a rather unfavourable situation. The SMEs surveyed also perceive a less positive situation in terms of innovative product structure, with 42% perceiving their own advantage and 13% perceiving a more favourable situation vis-à-vis competitors. This is more a reflection of the innovation potential and product innovation capacity of small businesses, where they perceive their situation as less "prosperous". In the case of unique know-how, respondents also perceive a much

smaller overall advantage, with 36.5% perceiving an advantage for their own business and 22.7% perceiving a stronger advantage for competitors. In terms of partnerships, I also asked about banking relationships. In contrast to customer or supplier relationships, only 39.8% of entrepreneurs perceived a favourable situation, while 21% perceived a competitive advantage. This may be linked to the fact that SMEs are much less able to negotiate favourable terms with banks due to their unfavourable bargaining position. The distribution system is also perceived to be noticeably less efficient than, for example, asset management (40% and 12% respectively).

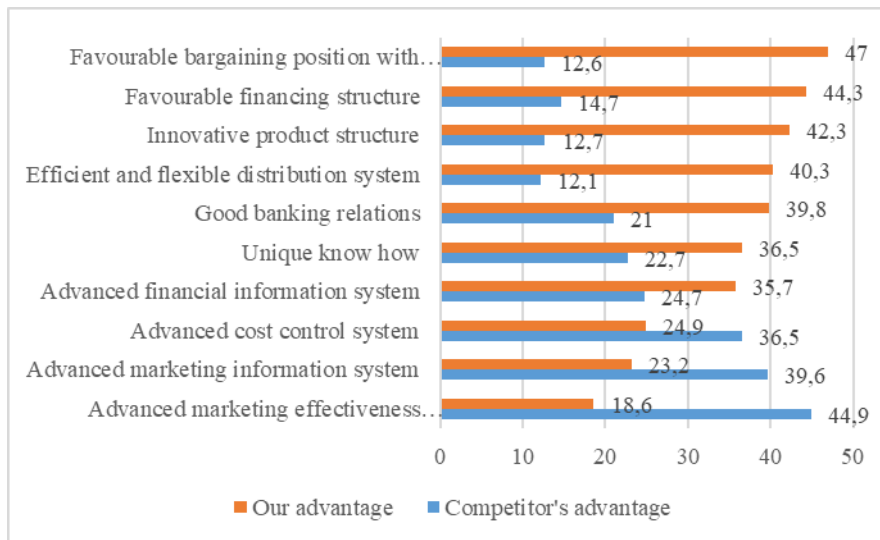


Figure 2. How well has your company performed compared to your competitors? 2. (%)
Source: own research

And if we move further towards enterprise information systems, the indicators of competitiveness perception will deteriorate further. In the case of the Financial Information System, a higher proportion of micro and small enterprises surveyed perceived their own advantage (35.7%) and only 25% perceived that they had an advantage over their competitors, while for the Cost Control System the ratio is already reversed, with more perceiving an advantage over competitors (36.5%) than their own advantage (24.9%). I still do not believe that the businesses surveyed are aware of their competitors' capabilities at a general level, but rather that they are judging their own business' capabilities when responding. Looking further, the assessment is even worse in the area of marketing information systems, with 40% perceiving a competitive advantage compared to 23% perceiving their own advantage. This is clearly an indication of the lack of development of the marketing information system in the SME sector. And the general lack of a marketing controlling system to assess the effectiveness of

marketing activities is well reflected by the "rather our competitor's advantage" rate of 45% and the "rather our advantage" rate of 18.6%. This is the worst of the 23 variables measuring marketing capabilities.

Conclusions

In terms of customer-related indicators, the businesses surveyed perceive a significant advantage over their competitors. In my view, this is more to do with the fact that a large proportion of the family businesses surveyed perceive a favourable situation in terms of customer and partner relations. They do not really have a real basis for comparison with their competitors in general.

In the case of the various efficiency indicators (asset management, cost management, financing structure, etc.), the SMEs surveyed also perceive a significant advantage compared with their competitors. In my opinion, this reflects the satisfaction of the SMEs surveyed with the efficiency of their business, since businesses in general rarely measure their efficiency using specific indicators.

There are some marketing capabilities (e.g. banking relationships, know how, distribution system) where family businesses see themselves and their competitors as being disadvantaged.

In the field of controlling and marketing information systems, family businesses "perceive" a significant advantage over their competitors, which tends to mean that they are underdeveloped or, more importantly, that they do not have such systems.

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Empowering Generation Z: The Importance of Conscious Lifestyle and Self-Development through Coaching in Higher Education

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Abstract: The 21st century, defined by the rise of Generation Z and the emergence of Industry 5.0, has raised the issue of consciousness and social responsibility. Today's young people, often referred to as the new generation, represent the demographic that will play a pivotal role in shaping the future and society, with tomorrow's leaders and decision-makers growing up from this cohort. However, modern society and the dynamically changing environment bring constant change and technological development, making it almost impossible to adapt and find stability. In a world, full of challenges, today's Generation Z needs to find their place, to build a secure set of values, and self-awareness and fostering social relationships that can provide as a compass and a signpost towards a more conscious, balanced, and sustainable life. This paper emphasizes the characteristics of Generation Z and the critical role of self-awareness and self-development within higher education, specifically among this generation.

Keywords: Gen Z, social impact, self-awareness, conscious lifestyle, sustainable development, coaching, higher education

1 Introduction

The sustainability of the global economy and social development has been a major focus of attention in recent decades, as the long-term adverse impacts of current economic models have become increasingly evident. Challenges such as climate change, resource decrease, and growing social inequalities point to the need for new strategies. The two defining resources of the 21st century are people and information. The main focus of my research is on people, and within them, Generation Z, which has a huge impact on both society, economy and the environment. By new generations, I therefore focus on Generation Z.

The new generations, especially GEN Z and future generations, are shaping our society and the future, their values, their way of thinking and their vision of the

future are shaping what the world will become. However, as they are not yet fully developed in their lifetime, they need support and orientation to gain a deeper understanding of themselves and their life path. The aim of my research is to find an innovative solution to support orientation and life path planning that helps Generation Z young people to develop a deeper self-awareness, to define their goals, to develop a vision of their future, to develop soft skills that are of particular importance for the labour market and to integrate more easily into the corporate environment. The most effective way to support this generation is to have an insight and understanding of their mindset, values and skills (*2024 Gen Z and Millennial Survey: Living and Working with Purpose in a Transforming World*, 2024).

Generation Z is not just a new demographic, but a set of values and attitudes that will shape the thinking of future leaders and decision-makers. Its members are confronting the complex challenges of the present while striving to develop responses and solutions that will serve a more sustainable future. According to McCrindle's research, Generation Z is a group of people born between 1995 and 2009 who share common experiences, values and aspirations. Their experiences are shaped by economic, political and environmental factors, as well as cultural and technological developments. Together, these factors are shaping the generation's worldview and future role in society. (*Generational Worker Profiles Infographic - McCrindle*, 2024; Konstantinou & Jones, 2022).

They are so called, digital natives in science. Technology is integrated into their lives. They have been using digital devices from a very young age. It is part of their DNA. It defines every aspect of their relationships. This is a global generation. Everything that's happening in the world is almost instantly accessible through digital channels. They know about fashion, food, global trends and online entertainment. They are unquestionably the most connected and socially engaged online generation to date. This can be seen as a positive response to the complex challenges of the world. However, it also presents difficulties when it comes to communicating face-to-face and offline. What is clear is that this generation has shown unparalleled mobility, whether in terms of moving or changing jobs (*2024 Gen Z and Millennial Survey: Living and Working with Purpose in a Transforming World*, 2024). More conscious life planning is not just for individuals, but also for the transformation of society, allowing for a more balanced and sustainable community. This process is increasingly reflected in the ESG (Environmental, Social, Governance) aspects, which cover the different dimensions of sustainability dimensions. („Integrating the Sustainable Development Goals into the Strategy of Higher Education Institutions | Request PDF”, 2024). In addition to ESG, the IDG (Inner Development Goals) initiative also plays an important role, which identifies sustainability with the human factors, i.e. the inner development and identity of individuals. IDGs (Inner Development Goals) define personal development goals that focus on the

emotional and mental well-being of individuals. These goals include self-awareness, self-acceptance, empathy and the development of personal values. IDG's principle is that sustainability starts with the individual: values, mindset and responses to environmental impacts (Lynden és mtsai., 2024; *(PDF) Coaching College Students to Thrive: Exploring Coaching Practices in Higher Education*, é. n.-a) .

2 Methods

In a primary research study, quantitative data collection was carried out using non-random sampling procedures and the arbitrary sampling technique. No filter condition was applied in the selection of subjects.

The arbitrary sampling method is not a probability sampling method, nor did we aim to achieve a sample representative of any population. Our aim was to select the elements of the population that were considered typical, average and the most accessible. The reason for this was that there were no financial resources available to conduct the research, so this procedure was chosen in order to meet the research objectives. The stratified technique was used within the arbitrary sampling, where the stratifying criterion was generational affiliation. The aim of stratified random sampling was to successfully recruit from each generation in a simple and cost-effective manner. Nevertheless, the sampling technique is not representative of any population. Due to the nature of the technique, the results obtained from the sample are not representative. Thus, the findings and results presented in this study are valid for the sample.

The quantitative research (partly) resulted in 1118 evaluable questionnaires through an online survey process. The main aim of our research was to find out how open the respondents were to coaching, either in individual or group sessions. The contribution to a more conscious future (participation in the coaching process) has generation-specific elements (H2). The quantitative data were processed using descriptive statistics, bivariate and multivariate analyses using SPSS 26.0 software to test the hypotheses. Analysis of variance (ANOVA), including the one-way ANOVA method for comparing multiple sample means, was used to examine the correlation of the results measured on the metric scale.

3 Results

In terms of socio-demographic characteristics of the sample, 55.5% of the respondents were male and 44.5% female. Respondents with secondary education

were over-represented in the sample (66%), followed by respondents with tertiary (28%) and primary (6%) education.

Generationally, Generation Z was the majority (66%) of the sample, Generation Y and Generation X were represented at 11% and 19% respectively, while Baby Boomers were represented at 2% of the sample, similar to the youngest generation Alpha at present. In terms of type of residence, the majority of respondents live in the capital (36%) or in cities (46%). Residents of villages and hamlets accounted for 18%.

For the first time, we wanted to know how active the respondents were in terms of individual and group coaching. The results show that 53% of respondents are open to individual coaching, of which more than half, 52%, are men. 44.5% of the respondents were women, of whom 37.9% said yes to the possibility of individual coaching. It can be said that the data shows that 50-50% of women are open to individual and group coaching, while the majority of men are open to individual coaching as a method for more conscious life planning.

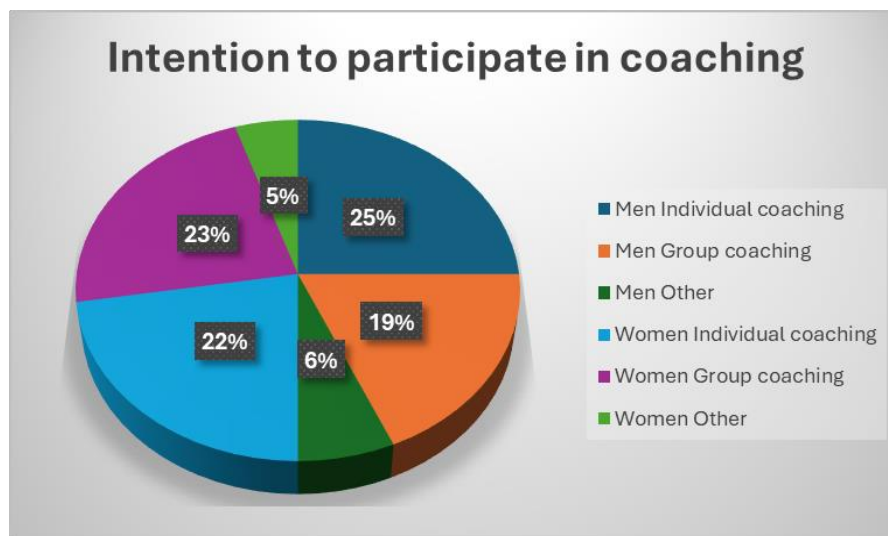


Figure 1. Intention to participate in coaching

Source: own source

The sample members were then asked to rate themselves according to their self-reported level of self-awareness of their lives. The data showed that respondents were living a conscious lifestyle, as evidenced by a sample mean of 2.99.

To test our hypothesis, we then looked at whether there is a correlation between the degree of conscious living and one's generational affiliation. The significance result of the analysis of variance showed that the two variables are not independent (sig=0.000), which confirmed H1.

The results show that members of Generation X are most likely to live consciously, at least according to their own claims and value judgements. Although many studies mention that Generation Z is the generation that is more sensitive and open to social and environmental problems. In our view, the results of this research can best be explained by the fact that Generation X already has a mature set of values and life experience.

Conclusions

93.5% of the respondents confirmed that they would participate in either individual or group coaching to help them develop their personal development and deepen their self-awareness in relation to conscious life planning. Individual perceptions of conscious life management and individual activities for a more conscious future showed no statistically verifiable correlation with either gender or educational attainment. Generational affiliation was the only socio-demographic factor we examined that could statistically confirm or partially confirm the associations. We believe that conscious living can be developed through coaching especially in higher education where students would have a deeper understanding about themselves. Developing self-awareness is a key element of becoming a better person and making right decisions ((PDF) *Coaching in Higher Education*, é. n.). One of the best platform to support the students in their journey would be to implement coaching methods into the curriculum (Hunaiti, Z. (2021). *Introducing coaching to higher education*. In Z. Hunaiti (Ed.), *Coaching applications and effectiveness in higher education* (pp. 1–20). *Information Science Reference/IGI Global*. <https://doi.org/10.4018/978-1-7998-4246-0.ch001> - Google-keresés, é. n.; London és mtsai., 2023; (PDF) *Coaching College Students to Thrive: Exploring Coaching Practices in Higher Education*, é. n.-b).

Thus, we believe this is the criterion that is most determinant of conscious living and its practice Therefore, as a continuation of our research, we would like to analyse in more depth the dimensions of conscious living in a generation-specific way. Extending this research is also a future goal. We would like to make international comparisons in order to find out which are the culture-specific elements in terms of differences between generations and the relationship between consciousness, thus helping to apply the results in practice later on.

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"Balancing Local and Non-Local Cuisine" A Study of Restaurant Menus Around Shkodra Lake, Albania

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Abstract: This analysis the content of local restaurants' menus around Shkodra lake area, in Shkoder, Albania. It aims to examine the balance between local and non-local food while focusing on the juxtaposition of traditional and modern cuisine. For the ratio assessment of between local and non-local food will be used observation methodology. Menu items will be analyzed to quantify and compare the presence of local and non-local food, which will help to reveal patterns in menu design that focus broader customer base and how it affects the visibility of local food. Our hypothesis suggests that local restaurants might highlight non-local food to appeal to a diverse clientele and that possibly reduce the focus on local food. Expected results are related to the understanding on how much restaurants integrate international influence compared to the local one. The findings will provide insights for restaurant decision makers, who are looking to preserve and promote local food and meet the needs of the customers effectively. Studying how restaurants promote their menus contributes to an exploration of culinary that also intersects h tourism.

Keywords: local restaurants, menus, local – non local food, traditional cuisine, modern cuisine, customer base, Shkodra lake, tourism

1 Introduction

Albania is characterized by a potential of natural and cultural resources, favorable climate and strategic geographical position. It has a significant number of unique territory products, which can become competitive in the domestic market as well

as the international one. Shkodra region located in northern Albania, has set place to Shkodra lake, the largest lake in the Balkans, which is situated on the border between northern Albania and Montenegro. The lake is known for its stunning natural beauty, territory products, inherited culinary and rich tradition, culture and history. Shkodra Lake area “owns” lots of local food products with unique quality and cultural features. Local restaurant around Shkodra lake have in their menus food offerings that incorporate important local products, ensuring authenticity and using storytelling to immerse visitors in the local food experience, as they are looking for more authentic experiences that go beyond tourist attractions (Schmitt et al., 2017). The interplay between the local and the non-local food that is offered in restaurants, is one of the key elements of this trend as it demonstrates how the process of globalization impacts the processes of preserving and developing the culinary tradition (Ishak et al., 2023). This paper presents some literature review related to local food and its impact in tourism promotion and development, and the trend state of some restaurants menus located around Shkodra Lake, and their culinary offerings.

1.1 The goal

To explore the balance between local and non-local food offerings in restaurant menus around Shkodra Lake.

1.2 The objectives

- **Analyze Menu Content:** Examine the proportion of local versus non-local food items in the menus of restaurants around Shkodra lake, in order to understand the existing culinary offerings.
- **Explore Motivation for Menu Design:** Explore the reasons of prioritizing local or non-local food by restaurants, including customers target.
- **Evaluate Cultural Impact:** Assess the visibility and promotional strategies of local cuisine as an important cultural and tourist attraction.
- **Propose Recommendations:** Suggest strategies to achieve a good balance between local and non-local food offerings to fulfill diverse customer demand.

2 Literature review

2.1 The role of food in tourism and cultural preservation

Local food in tourism has been the subject of various studies, with researchers highlighting the potential benefits for both the local community and the businesses such as restaurants. Local food is one of the most important symbols of a culture and is closely linked with the concept of identity of a place and its preservation. It is not only a representation of the culture of a specific area but also one of the major factors that define cultural tourism, including culinary tourism as a rising tourism branch. There is an increase of interest by visitors on specific experiences related to food, such as learning vacations, horticulture tours, and gastronomy among others (Brokaj, 2014). As a developing country, Albania has emerged a strong prospect for tourism and economic growth given its rich historical and natural attractions.

2.2 The Definitions and Characteristics of Local and Non-Local Food

2.2.1 Definition and Characteristics of Local Food

Local food refers to food that is produced, processed, and distributed within a relatively small geographic area (Pribadi et al., 2021). The concept of 'local' can be defined in various ways, such as:

- Food produced within a 100-mile radius of the point of consumption ((Lang et al., 2014).
- Food produced within the same state or region as the point of consumption (Cappelli et al., 2022).
- Food produced by small, local producers and sold directly to consumers (Zerbian et al., 2022).
- Food is considered fresher, tastier, and more environmentally friendly than non-local options (Kovács et al., 2022).

The key aspects of local food are the proximity of production to consumption, the involvement of small-scale producers, and the shorter supply chain with fewer intermediaries.

2.2.2 Definition and Characteristics of Non-Local Food

In contrast, non-local food refers to food that is produced and distributed through large-scale, industrialized supply chains that often span multiple regions or even

countries. Non-local food may travel thousands of miles before reaching the consumer, resulting in a significant carbon footprint and disconnect between the source of the food and the end consumer. In contrast to the small-scale, tradition-oriented nature of local food systems, non-local food is typically characterized by standardization, mass production, and a primary focus on cost-efficiency and maximizing profit margins rather than on sustainability or local cultural values (Zahaf, 2015; Materia et al., 2021)). Furthermore, the long distances that non-local food travels can contribute to a larger environmental impact in the form of increased greenhouse gas emissions and resource depletion (Coelho et al., 2017).

2.3 The Impact of Local Food on Restaurant Menus

Food that is produced within a certain distance, usually ranged from 100-400 miles. The exact definition of what local food constitutes, may differ according to the region and context. Some of the restaurants have adapted their menu by incorporating local products. This has been influenced by several factors such as the increasing concern of consumers on the sustainability and environmental impact of food, but also the interest in the varieties of flavors and tastes of the food. (Coelho et al., 2017) (Feenstra & Hardesty, 2016).

Local food is also among the leading foods that are ordered by consumers wanting to know more about the food they consume and where does it come from. A market research conducted by Harris Interactive revealed that 63% of consumers said that they would be willing to spend extra money on organic or locally sourced food, thus showing high level of interest in such products (Jang et al., 2011).

This may be because people think that foods locally produced are fresh, environment-friendly since they minimize transportation, and also help the local economy and farmers (Marco et al., 2014).

The integration of local food into the restaurant menus has also been highlighted as one of the current trends in the foodservice industry. Besides consumer demand, the application of local food in restaurants can also have positive impacts on the businesses themselves. They can gain a competitive edge due to their restaurant's offerings, and may appeal to consumers who seek connection with the community and flavors of the specific area and its traditions.

2.4 Cultural Markers in Menu Promotion of Local Dishes

Using original language names for dishes in menus not only adds authenticity but also serves as a powerful cultural marker, connecting diners to the dish's heritage and origin. This practice enhances the perceived authenticity of the culinary experience and can increase customer interest and willingness to try unfamiliar dishes (Lequeux-Dincă et al., 2024). Additionally, Cohen and Avieli (2004) argue that the use of original names can create a sense of culinary adventure for diners,

encouraging them to explore new flavors and cuisines. The original language names in menu promotion. Their research explores how unfamiliar local foods can serve as both an attraction and a potential barrier for tourists.

2.5 The Impact of Menu Design on Restaurant Customer Satisfaction

The menus are important marketing tools for promoting the products and services, and also for shaping the customers' expectations and guiding them to choose food. (Suarez et al., 2019). For the restaurant industry, the use of proper menu design is very crucial. Several studies have been conducted in order to define the elements that contribute to the success of menu design, and it has resulted that the common elements needed to be considered and analyzed are layout, item placement, descriptive language and pricing. Menu analysis has been identified as a useful management instrument for restaurants which helps owners to determine where they have to make changes to enhance restaurant's performance and profit by reaching customer satisfaction (Annaraud, 2007). Therefore, it is important to explore the role of menu design of restaurants as well as menu's impact on customer satisfaction and profit generation.

2.6 Storytelling in Restaurants for Local Dishes

Storytelling about local dishes enhances customer satisfaction and their willingness to pay (Kim and Jang, 2019). Menus having narratives significantly impact customers' dining experience and their perception of authenticity' (Peng et al., 2021). It strengthens local food identity in a global market (Mkono, 2019). 'Storytelling creates an emotional connection between customers and the restaurant, leading to increased loyalty and positive word-of-mouth' (Moin et al., 2020). The integration of authenticity in food storytelling, is very important for highlighting the cultural and historical significance of local dishes (Youn & Kim, 2018). Furthermore, digital storytelling in restaurants. such as augmented reality menus, can significantly enhance the perceived value of local dishes' (Pera et al., 2022, p. 205).

Also the use of social media in food storytelling, sharing compelling stories about local dishes can increase engagement and customer visits' (Lu et al., 2020).

3 Methods

To address the research objectives, were conducted:

- a comprehensive literature review, focusing on the most relevant and latest articles related to the key themes of the study. The review included sources from various academic journals, conference proceedings, and industry reports, with a particular emphasis on publications that explored the intersection of food, tourism, and cultural preservation. The search for relevant literature was conducted using reputable academic databases, such as Scopus, Web of Science, and Google Scholar. The search terms included a combination of keywords such as "food tourism," "culinary tourism," "local food promotion," "menu design," "globalization," and "cultural preservation," among others. To ensure the relevance and quality of the sources, the selection process involved a thorough examination of the abstracts, keywords, and content of the identified articles.
- observation for menu analysis to examine restaurant menus in the Shkodra Lake area. This approach facilitated a detailed categorization and assessment of menu items, focusing on the presence and prominence of local and non-local food offerings. Observational methods were deemed suitable as they provided unobtrusive and objective insights into menu structures without relying on self-reported data from restaurant proprietors.

3.1 Data Collection

Restaurants included in the study were selected based on their geographic proximity to Shkodra Lake and their accessibility to both domestic and international visitors. Selection criteria emphasized diversity by including some of the restaurants well known for their local cuisine serving to a diverse clientele, including tourists. To ensure a representative sample, a mix of traditional and modern dining restaurants were included.

3.1.1 Sampling

For this study, a total of **30 restaurants** were selected, located around Shkodra Lake. These restaurants were chosen based on their reputation as well-known and frequently visited by both locals and tourists (domestic and foreign ones). The

distribution of the sampled restaurants, offering a balanced food versus non local food, was as it follows:

- 10 Restaurants in Shkodra City
- 15 Restaurants in Shiroka.
- 2 Restaurants in Zogaj
- 3 Restaurants in Malësia e Madhe

3.1.2 Process of Collecting and Categorizing Menu Items

Menu data were gathered through direct observations conducted on-site during restaurant visits. Where available, additional information was obtained from online menu listings. Also face to face meeting were conducted with restaurants staff to ask about menus. The collected menu items were systematically categorized into two primary groups:

- Local food: Dishes identified as part of the Albanian culinary tradition, prepared using traditional recipes and/or locally sourced ingredients.
- Non-local food: Dishes inspired by international cuisines, modern adaptations, or those made with non-local ingredients.

4 Results and Discussion

The list of the bar-restaurants contacted for the menu were the following ones:
Shkodra city (10 restaurants): Rozafa, Windmill, Blini, Panorama, Troshani, Legjenda, Luani A, Buna Park, Tempulli i Shijes, Vataksi.
Shiroka (15 restaurants): Te Geni, Elite, Peshkatari, Arbri, Flaer, Te Simoni, Lembus, Aleks, Xhaka, Shkodra, Sunset, Real Te Hilmia, Te Zyda, Shiroka Te Dauti, Zum Rappen.
Zogaj (2 restaurants): Pelikani Kaçurrel, Labiatan.
Malesi e Madhe (3 restaurants): Lake Shkodra Resort, Hysaj Resort, Syni i Sheganit.

In the restaurants, the average distribution of dishes across the analyzed restaurants showed a slight preference for non-local dishes, with local dishes comprising approximately 46.7% and non-local dishes at 53.3%.

Menus are typically organized into distinct sections such as: Soups, Salads, Appetizers & Side Dishes, Meat Dishes, Fish Dishes, Pasta & Risotto, Pizza, Desserts, Beverages. This clear categorization helps customer navigation and enhances the dining experience. Local dishes are not highlighted in separate sections. Many menus are text-heavy, which may distract the attention of the customers. Descriptive language for local and non local dishes is often lacking,

which could diminish their appeal. Most menus feature local ingredients prominently particularly in fish and meat dishes, eventhough they do not include their descriptions. This reflects a commitment to regional culinary traditions.

4.1 Layout

All restaurants analyzed, have a well-structured layout with distinct sections dedicated for specific categories of food and beverages. In most menus are used clear headings and column format, which facilitate navigation and makes finding items easy through listings.

4.2 Item Placement

Approximately 92% of the restaurants (29 out of 30) group items correctly in respect to certain categories, orderly starting with lighter courses (e.g., appetizers, salads) and then passing to heavier dishes (e.g., meat, seafood). The way that popular dishes are positioned at the beginning of the menu is a typical strategy that is used to entice the customers and influence their decision making process.

4.2.1 Local and Non Local Dishes

The menu items are diverse and rich, incorporating both the local and non local items, highlighting the traditional local cuisine, especially for the soups, fish, and meat dishes. In the restaurants' menus it is quite impressive the number of fish dishes, especially the ones with carp and eel. Signature fish dishes are Carp Casserole, Grilled Trout, and Eel Casserole, Smoked Bleak that prove the fact that the area has a rich lake products. Focusing on meat restaurants, in particular the restaurants in Malesi e Madhe area have in common offerings like: Grilled meats, including Beef Steak, Veal Chops, Lamb Chops etc. Regarding desserts we find offerings mainly in Shkodra city area such as tespixhe, shendetlije, revani and sheqerpare and haxhimakulle. Regarding the non local food items, in common offerings are pasta, pizza, and sweet items such as tiramisu, trilece and cheesecake offered to meet the needs of different tastes especially of tourists. Many dishes are prepared with fresh and locally sourced ingredients such as lake fish, meat, vegetables, and other products, which emphasize authenticity and quality.

To sum up, while each area offers unique food. In the menus are found overlapped items in the offerings, especial the fish dishes, soups (Çorbe), and desserts, making these items a unifying feature of the regional cuisine.

4.3 Descriptive Language

About 65% of the restaurants (22 out of 30) use minimalistic description in their menus. The menus have just the list of items with no or little details about the ingredients or preparation method. Although some of the menus contain short

descriptions, many lack evocative language i.e do not have create a strong sensory impression or emotional connection. Only a minority (approximately 35%, or 9 out of 26) use engaging and descriptive language to appeal to their target customers.

4.4 Language Offerings:

A significant number of restaurants offer menus in multiple languages:

- About 33% of restaurants (10 out of 30) provide menus in both Albanian and English.
- 4 restaurants (about 13%) include Albanian, English, and Slavic languages.
- restaurants (about 7%) provide menus in Albanian, English, and Italian.
- 1 restaurant (about 3%) offers menus in Albanian, English, and Arabic.
- 1 restaurant (about 3%) has a menu in English and German.
- 12 restaurants (about 40%) provide menus in Albanian, English.
- 1 restaurant (about 3%) provide menus in Albanian, partially English.
- restaurants (about 6%) provide menus in English.
- 7 restaurants (about 2%) provide menus in Albanian.

4.5 Special Features

The menus for:

- 5 restaurants (about 17%) have a "Nice to Perfect Design"
- restaurants (about 10%) have a "Very Good Design".

4.6 Pricing Strategies

All the restaurants (30 out of 30) apply the tiered pricing strategy from low prices (e.g., salads, appetizers) to high prices (e.g., seafood, fish, premium meats), in order to attract all different target market. 93% of the restaurants (28 out of 30) restaurants) use the local currency (Albanian Lek-ALL), while 2 restaurants (about 6%) use the foreign currency in Euro.

Conclusions

Based on the analysis of the restaurant menus it seems that their menus provide a logical structure across various categories, with clear listings of food. While most menus offer just listing of items with little descriptions, a it would be more beneficial to integrate a more evocative description to better engage the customers. Pricing strategies are generally tiered, offering possibility to diverse clientele by offering both budget-friendly and premium options.

The analysis of the menus from various restaurants around Shkodra Lake reveal that local dishes comprise an average of 46.7% versus non-local dishes at 53.3%. Overall, the areas successfully balance good local with non local food, but it is important to emphasize the unique and authenticity of the local culinary.

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Cybersecurity challenges in digital payments: A case study of Alibaba and Revolut

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INTRODUCTION

This paper explores cybersecurity challenges in digital payments, focusing on the security measures of Alibaba and Revolut. Digital payments are becoming increasingly common in people's daily lives. However, worries about this payment method's security are growing along with its popularity. Cyber attackers constantly search for ways to breach the security defenses of digital payment systems in order to obtain, alter, or even destroy crucial data, posing a serious threat to personal privacy and property security. The majority of cyber-attacks are automated and aim to exploit common faults rather than specific websites or enterprises.

The purpose of this study is to explore the impact of cyber security incidents on the security of digital payment systems, user trust and willingness to use, as well as the effect of different cyber security measures on enhancing user trust and the stability of payment platforms. In order to determine the most effective cybersecurity strategies and measures in the current, constantly evolving cyber threat environment, the study focuses on analyzing which types of cybersecurity incidents have the greatest impact on digital payments and how different cybersecurity strategies shape users' trust in digital payment platforms.

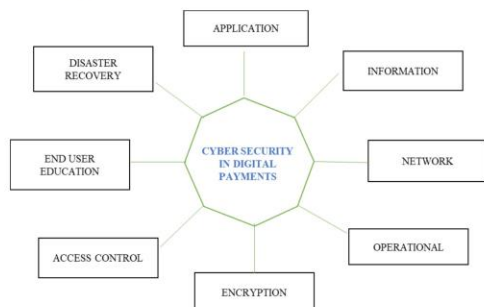


Figure 1: A schematic diagram of the techniques employed by cyber security as protective tools to curb the surge of internal and external cyber crimes

METHOD(s)

This study aims to explore in depth the connectivity of cyber-attacks and their impact on digital payment systems, with a particular focus on how these attacks evolve into different types of threats. By analyzing emerging threats, technological advances, and user behavior in the digital attack environment, this study identifies potential vulnerabilities in digital systems and explore how financial institutions can enhance their resilience and security against attacks by implementing effective mitigation strategies. This study adopts a quantitative research methodology that relies heavily on secondary data sources such as publicly released cybersecurity news, reports and academic articles for systematic analysis.

The major database searched was 'Scopus' using the required keywords, download bibliographic data and author data from Scopus to be able to run analytics on Alibaba's critical cybersecurity issues with the help of VOSviewer.

THE RESULT(S)

'network security' is at the center of the knowledge graph and is closely linked to a number of technologies and concepts, such as 'cloud computing security' and 'block chain', demonstrating its position at the heart of protecting information systems. Cloud services such as 'Google+' and 'Alibaba Cloud Platform' are closely related to cybersecurity, reflecting the importance of infrastructure and platform support in modern cybersecurity. In addition, the linkage of 'data security' with concepts such as 'data storage' and 'privacy' underscores the importance of protecting data in the cyberenvironment, which is not only a technical issue, but is also closely related to regulatory compliance and user privacy protection.

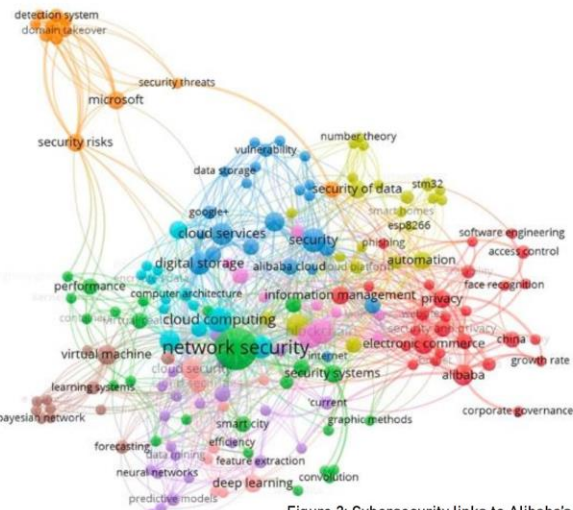


Figure 2: Cybersecurity links to Alibaba's web platform, Source: VOSviewer by sources from Scopus, 2024

Keyword	Occurrences	Total link strength
network security	29	172
blockchain	19	65
security	9	45
cloud service	8	67
cryptography	8	66
digital storage	8	41
Internet of things	8	60
alibaba	7	18
Cloud security	7	67
Cloud-computing	7	51
Electronic commerce	7	29
Cloud platforms	6	46
Virtual machine	6	49

Table 1. Main keywords from VOSviewer

CONCLUSIONS

This study systematically explores the dynamic and multifaceted impact of cybersecurity on digital payment systems, revealing vulnerabilities and robust defense mechanisms used to mitigate these risks. Through detailed analyses, primarily of the Alibaba platform, we identify key security measures such as encryption, access control, and disaster recovery as essential to protecting digital transactions. However, despite these advances, the ongoing evolution of cyberthreats continues to pose significant challenges that require continuous adaptation and improvement of security frameworks.

The main limitation of this study is its reliance on secondary data, which may not fully capture the rapidly changing cybersecurity threat and innovation landscape. In addition, the focus on specific digital payment platforms may not generalize to the wider fintech sector. Future research should aim to combine primary data collection and case studies to provide deeper insights into specific cybersecurity challenges and solutions.

Exploring the potential of emerging technologies such as AI and machine learning for predictive threat detection is a promising direction. Further development may involve the creation of real-time security systems that can dynamically adapt to new threats as they emerge. Collaboration between financial institutions, technology providers and regulators are essential to create a resilient digital economy that can withstand the complex cyber threats of the future.

Maximum of seven references from the scientific paper

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Aspect	Alibaba	Revolut
Focus	Online payments; Wealth management; Credit; Insurance.	Currency exchange; Online payment; International transfer.
Key Security Features	Advanced encryption; Centralized key management.	End-to-end encryption; single-use virtual card; real time fraud
Integration	Shopping payments; public service.	Mobile-first approach; innovative financial products
Technology	Incorporates advanced encryption methods; user-centric financial ecosystem.	Utilizes GPS for transaction verification; virtual cards; real-time fraud detection.
Unique Offerings	Focus on Chinese market; e-commerce	Cryptocurrency transactions
Innovation	To improve user experience, financial services are continuously integrated into their environment.	Consistent innovation with new financial products and data-driven personalized services
Preventing Fraud	focuses on transaction security and encryption	Sherlock anti-fraud system with real-time monitoring; alerts based on location and transaction behavior

Table 2 : Comparison between Alibaba and Revolut

Is Digitalisation affecting Bank Performance?

The Results of a Questionnaire with Albanian Commercial Banks

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INTRODUCTION

This work attempts to shed light on the impact of digitalisation on bank performance in Albania, based on a questionnaire conducted with bank representatives from 10 commercial banks, representing over 94% of the Albanian market by assets.

The survey assessed several dimensions, including digitalisation's influence on operational performance, customer experience and adoption, cost efficiency, security, and regulatory adaptation. Overall there exists a positive perception of digitalisation, but the early phases of adoption for Albania, make it difficult to pinpoint the isolated influence of digitization and digitalisation of the products.

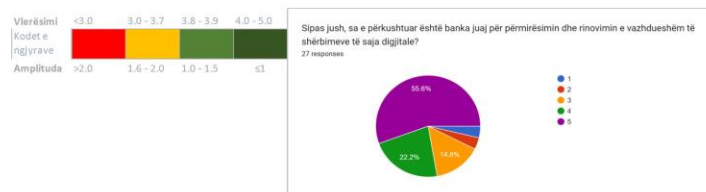
By a quick survey in the bank's annual reports for the period 2018 -2022, an increase in the frequency of the words digitization and digitalisation is observed

METHOD(S)

The questionnaire was conceived as an 11-question format, distributed to 27 participants from 10 out of 11 banks (representing 94% market exposure). The questionnaire was distributed via Google Forms to 27 interviewees, part of the middle management, representing IT & Financial departments. Data were automatically analyzed for frequency by Google Forms, and processed by the author for means and range. The means were used to check for direct score comparison while the range was used to check for consistency or divergence in the responses.

A range of <1, was considered a high agreement, 1-1.5 was good agreement, 1.6-2.0, some agreement, and >2.0 low agreement

A value of 4.0 - 5.0 was considered - highly agree, 3.8-3.9, agree, 3.0-3.7 as somewhat agree, and <3.0 as do not agree. Results are tabulated on the results section. A typical score distribution is given below:



THE RESULT(S)

The questionnaire results divided by bank size (GI & GII)

BANK	Group (I/II)	% market exp. to assets customer experience?	How would you rate the impact of digitalization on your bank's overall operational efficiency within your bank?	How would you rate the impact of digitalization on your bank's customer services and fraud prevention strategies?	What level of customer digital adoption usage of digital banking services have you observed?	How has your bank's security measures and fraud prevention strategies affected customer experiences and competitive ness?	How has digitalization affected your bank's competitive ness?	How has digitalization affected the banking system?	How would you evaluate the legislative framework for digitalization training and development in your bank?	How would you rate the impact of digitalization on employee skills and cost reduction in your bank?	In your opinion, how committed is your bank to one of the future impact of digitalization and on improvement of services?	What are your expectations for the future of digitalization in your bank?	Average per bank
BKT	I	24.7%	4.0	4.0	3.0	4.0	4.0	3.0	4.0	3.0	5.0	4.0	3.8
CREDINS	I	16.4%	4.4	4.4	3.8	3.8	4.5	4.2	3.4	4.2	2.3	4.5	4.0
RBAL	I	15.3%	4.0	5.0	3.0	5.0	5.0	2.0	5.0	4.0	5.0	5.0	4.4
ISPB	I	10.2%	4.0	4.0	4.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0	4.5
OTP	I	9.2%	5.0	5.0	3.0	4.0	5.0	3.0	5.0	4.0	5.0	5.0	4.4
Group I	I	75.8%	4.3	4.5	3.4	4.3	4.5	4.4	3.3	4.6	3.5	4.9	4.2
Range			1.0	1.0	1.0	1.4	1.0	1.0	1.0	1.7	0.5	1.0	0.7
FIBANK	II	2.8%	3.0	3.0	3.0	3.0	4.0	4.0	3.0	3.0	3.0	3.0	3.3
UNION	II	5.0%	3.8	4.3	3.3	4.0	3.5	3.0	3.0	3.8	3.0	4.3	3.7
UBA	II	5.0%	3.0	3.0	4.0	4.0	2.0	2.0	4.0	3.0	3.0	4.0	3.2
PCB	II	2.2%	3.0	5.0	3.0	3.0	5.0	3.0	3.0	4.0	3.0	4.0	3.7
ABI	II	6.6%	4.0	4.0	4.0	5.0	3.0	4.0	3.0	3.0	2.5	4.0	3.7
Group II	II	21.6%	3.4	3.9	3.5	3.8	3.1	3.2	3.4	3.4	2.9	3.7	3.5
Range			1.0	2.0	1.0	2.0	1.0	1.0	1.0	0.5	1.3	1.0	0.5
ALL BANKS			3.6	3.9	3.2	3.9	3.6	3.6	3.3	3.8	3.1	4.0	3.6
Range			2.0	2.0	1.0	2.0	3.0	3.0	2.0	1.7	2.0	1.0	1.4

CONCLUSIONS

Banks report a relatively positive effect on customer experience and competitiveness (mean: 3.82/5), and very positive operational efficiency (mean: 4.17/5). Security measures (mean: 4.06/5) and employee training (mean: 4.00/5) were also perceived as significantly enhanced.

Strong commitment to digital transformation (mean: 4.28/5) and high optimism for future impact (mean: 4.56/5) indicate the strategic importance of digitalisation initiatives. However, moderate effects were observed in areas such as customer adoption (mean: 3.41/5), cost reduction (mean: 3.18/5), and Legislative frameworks received mixed evaluations (mean: 3.34/5), suggesting room for improvement in regulatory alignment.

Key similarities

Adoption of digital services by customers 3.4 GI /3.5GII

Expectations for the future 4.7 GI /4.5GII

reflecting a shared belief in the potential of digitalisation to transform the banking sector.

Key differences

Operational efficiency 4.5 GI /3.9GII

Cooperation with Fintech 4.5 GI /3.1GII

Impact on cost reduction 3.5 GI /2.9GII

These differences suggest that large banks perceive digitalisation to affect performance more than small banks.

Although GI & GII recognise the importance of digital transformation, small banks (G II) show a less uniform impact, highlighting the need for specific support and resources.

The results point to new strategies for digital literacy & financial education, an accelerated legal framework to approach EU legislation (i.e. EU Directive on Digital Finance, aka DORA,) and other legal initiatives

This work contributes to understanding the recent dynamics of digital banking in Albania and provides some insights for decision-makers and financial institutions.

Maximum of seven references from the scientific paper

1. Annual Reports, Albanian commercial banks 2018 - 2022
2. https://www.eiopa.europa.eu/digital-operational-resilience-act-dora_en

The words "digitization" & "digitalisation" as counted in annual bank reports

