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FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Presented papers contain result of researches conducted by various universities. The number consists of 36 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: big data in management; sustainable development; Industry 4.0; the implementation of artificial intelligence in management; logistics; economics; waste management; project management; public management; knowledge management; safety management; finances; human resources management; e-commerce; marketing; CSR; circular management; smart cities; social welfare and quality management.

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BIG DATA – ETHICAL CONSUMPTION NEXUS: A MULTI-STUDY APPROACH

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Purpose: This study investigates the interplay between big data and ethical consumption nexus to identify research themes, gaps, and future directions aligned with SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production).
Design/methodology/approach: The study adopts a multi-study approach. Study 1 conducts a systematic literature review of 51 articles using the PRISMA framework, complemented by VOSviewer keyword co-occurrence analysis to derive three thematic clusters. Study 2 triangulates these findings through seven problem-centered expert interviews with researchers and practitioners from developed and emerging economies.
Findings: Three thematic clusters emerge. The Red cluster reveals that SDG-focused management decisions, circular economy models, and robust supply chains accelerate ethical consumption. The Green cluster shows that AI and machine learning significantly improve ethical consumption, though cross-country longitudinal evidence and causal links between technology integration and behavioral outcomes are lacking. The Blue cluster demonstrates that dynamic capabilities enable mass ethical consumption via e-commerce platforms, but limited empirical evidence connects analytics-driven reconfiguration to circular economy practices.
Research limitations/implications: The study draws on two databases and a small expert panel; future research should expand data sources and conduct longitudinal experiments across diverse cultural contexts.
Practical implications: Managers should invest in real-time big data analytics, emotion-sensing tools, and Industry 4.0 infrastructure to close the ethical consumption intention–behavior gap and reconfigure supply chains for sustainability.
Social implications: Big data democratizes access to sustainable product information, strengthens supply chain transparency and accountability, and empowers underserved communities to participate in ethical consumption, collectively advancing SDG 9 and SDG 12.
Originality/value: This study is the first to combine a systematic review with problem-centered expert interviews to map the big data–ethical consumption nexus through the dual lens of SDG 9 and SDG 12, producing six actionable research propositions and a validated thematic typology for scholars and practitioners.
Keywords: Big data, ethical consumption, expert interview, SDG 9, SDG 12.
Category of the paper: Literature review.

1. Introduction

Big data (BD) is now an integral part in human decision making and has multifaceted impacts on human behavior (Merendino et al., 2018). BD encompasses massive and diverse datasets produced rapidly to support business decision-making (Fattahi, Ura, Noor-E-Alam, 2022; Ye, Lu, Lu, 2022). It draws on sector-specific analytical tools to identify patterns and relationships with different stakeholders (Jin, Zhao, 2021).

Big data analytics reveals seasonal consumption trends, the impact of promotions on buying habits, and consumer preferences for specific food attributes like organic or locally sourced products (Katare et al., 2025). Researchers also use big data from social media, transaction records, and wearable devices to segment consumers based on behavior and preferences, enabling more targeted and effective interventions (Huang, Sun, Long, 2025; Xia, Lai, Khaskheli, 2025). Also, real-time data from social media and mobile applications allows retailers and policymakers to monitor consumer behavior as it happens and intervene promptly to encourage healthier eating habits (Huo et al., 2024; Zakharova et al., 2025).

Big data analytics identifies consumer preferences, purchasing patterns, and responses to sustainability cues, that push consumers toward more ethical consumption choice (Cochoy et al., 2020). Machine learning (ML) tools mine data from diverse digital platforms to personalize ethical preferences and hold business organizations accountable for promoting ethical consumption (Munir et al., 2025). Big data innovation builds the analytical infrastructure that industries need to drive smarter, resource-efficient production, directly advancing SDG 9's goal of inclusive and sustainable industrialization (Dubey et al., 2018; Yang et al., 2024). Big data equips businesses with real-time consumer insights that accelerate the shift toward responsible consumption and production, placing it at the core of SDG 12 (Arman, 2025; Jiang et al., 2024; Peng et al., 2024). Big data influences multiple SDGs, but it produces its most concentrated impact on SDG 9 and SDG 12 because it directly reshapes industrial innovation processes and consumer decision-making simultaneously, two domains that sit at the structural core of sustainable development (Kristoffersen et al., 2020; Zakharova et al., 2025).

To analyze the interplay, the study adopts a multi study approach, consisting of systematic literature review, followed by problem based expert interviews. While the systematic literature review maps existing knowledge at the intersection of big data and ethical consumption (Arman, Sayeed, Rahman, 2025), it cannot capture emerging, practice-grounded insights that have not yet entered academic discourse. Problem based expert interviews therefore complement the review by drawing on the lived experience of practitioners and domain specialists who navigate these issues in real-world settings (Inês, Moreira, 2025). Together, this multi-method approach strengthens both the theoretical grounding and practical relevance of the study's findings. To achieve this research objective, the study draws the following research questions.

RQ1. What are the major research themes within big data and ethical consumption?

RQ2. What are the research gaps in terms of academic and business perspectives?

RQ2. What are the avenues for future research in addressing SDG 9 and SDG 12?

The study's novelty lies in conducting a multi-study approach, not limited to an SLR; the SLR findings are further validated by experts. This multi-study approach pinpoints the actual research and practice gaps that may hinder implementation of SDG 9 and SDG 12.

The subsequent chapters shall be outlined as follows: Chapter two elaborates on the theoretical background, while chapter three presents the methodology. Chapter four showcases the problem based expert interview process. Following this, chapter five presents discussion, and chapter six concludes the work with theoretical and managerial contributions.

2. Theoretical background

Big data (BD) refers to the enormous volumes of structured, semi-structured, and unstructured data that organizations gather, process, and leverage to facilitate decision-making processes (Kuo, Peng, Kuo, 2024; Munir et al., 2025). The BD concept encompasses five core dimensions: Volume, which captures the sheer scale of data generated; Velocity, which denotes the rate at which data is produced and processed; Variety, which reflects the wide range of data types collected; Veracity, which concerns the reliability and accuracy of the data; and Value, which represents the actionable benefits organizations derive from analyzing it (Naeem et al., 2022). Additionally, BD facilitates identifying market trends and consumer preferences to craft more informed and timely strategic business decisions in line with SDG implementations (Dubey et al., 2018).

Ethical consumption (EC) determines individuals' purchasing decision that account for the social, environmental, and health consequences and willingness to trade off price against the welfare of the society at large (Boman et al., 2026; Arman, Mark-Herbert, 2024). Ethical consumption complies largely with SDG 12, framing individual consumer choices as a moral responsibility toward both present and future generations (Guerra et al., 2022; Ivanov, Seyitoğlu, Webster, 2024). At the same time, ethical consumption also relates to SDG 9 to push industry and innovation toward safer, more inclusive, and socially accountable economic systems (Hoffmann et al., 2026).

Big data strengthens ethical consumption by helping firms identify what ethically minded consumers value, how they behave, and which sustainable offers align with their expectations (Sivashanmugam et al., 2022; Fosso Wamba et al., 2024). This interplay also enables firms to detect demand for eco-friendly products and improve supply chain transparency, which helps consumers turn ethical intentions into actual purchasing decisions (Butt, Ali, Govindan, 2024; Wu et al., 2023). This interaction supports SDG 9 by driving data-based innovation in

production and distribution systems that also advances SDG 12 by encouraging responsible consumption and more sustainable production designs.

3. Methodology

The study adopted the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to conduct the systematic literature review (Page et al., 2021). The study opted Scopus and Web of Science (WoS) to consider papers from curated set of journals, stronger control over source quality, and consistency (Arman, Ahmed, 2021; Martín-Martín et al., 2018). The author incorporates ethical consumption synonyms from his previous publication (Arman, Mark-Herbert, 2024) into its analysis. The document timeline is 2016-2025. The appendix contains the search query.

The study merged both databases' entries, 112 in total. Next, the study considered documents that were published and were written in English. The study considered 58 articles and excluded other scientific documents. Also, 6 more articles were added through the cross-check mechanism of another database and reference section (Paul et al., 2024). The study excluded 13 articles that were out of scope, for example, four of them were review papers, two articles explicitly focused on SDG 13 and did not discuss either big data or ethical consumption, and another paper on medical science applications and did not focus on ethical consumption. The SLR process is given below. The selected paper names present as a supplementary file.

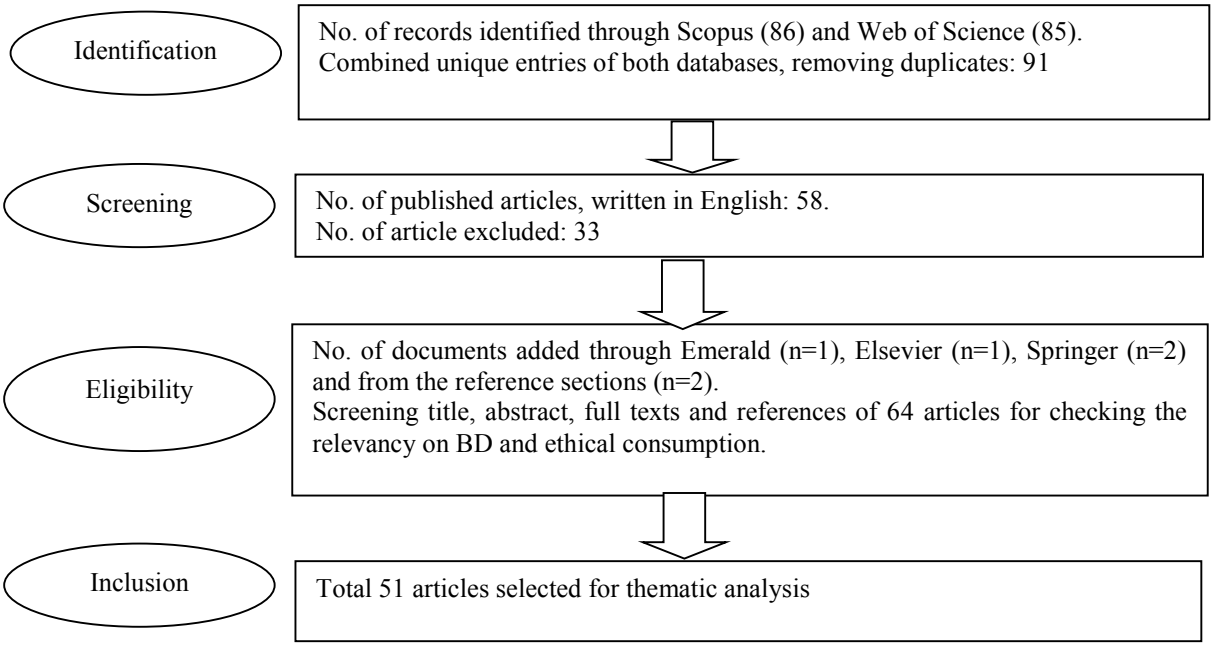

Figure 1. PRISMA protocol for systematic literature review.

Source: Page et al. (2021).

The study availed VOSViewer software to conduct the keyword co-occurrence analysis for portraying research themes. Three themes are emerged from the analysis which will be explained in the discussion section.

4. Expert interview

To triangulate the thematic analysis findings from the published literature on big data and ethical consumption, the study conducted expert interviews using a problem-centered approach (Döringer, 2021). The expert interview enables to collect data directly from individuals who are deeply involved in the concerned research area (Huang, Rust, 2022). such interviews complement the SLR findings with the view of experts in determining research gaps and future research directions (Mergel et al., 2019). The study adopted a multi-dimensional expert selection strategy that provide a balanced, comprehensive assessment of big data applications in ethical consumption for accelerating SDG 9 and SDG 12 (Meng et al., 2025).

The study identified potential interviewees through web searches for relevant publications and by verifying LinkedIn profiles. It recruited additional experts through snowball sampling, including the authors' professional contacts and referrals from earlier interviewees. The researcher approached to 10 individuals contacted by email and phone, 7 agreed to participate anonymously, producing a 70% response rate. The study offered no financial or other incentives. To provide a well-rounded view, the sample included equal representation from developed and emerging economies. This sample size aligns with prior studies that combined expert interviews with systematic literature reviews, including Inês and Moreira (6) (2025) and Meng et al. (7) (2025). Table 1 presents the expert details. In the coding scheme, the first letter indicates stakeholder group (P = Practitioner, R = Researcher), and the second indicates gender (F = Female, M = Male). The sample questions present in the appendix section.

Table 1.
Interviewee profile

Code	Interviewee expertise
RM1	A Big data researcher, with h index 35 and 17 Scopus Q1 publications related to Big Data.
RM2	A consumer behavior researcher, with h index 31 and 7 Scopus Q1 publications related to ethical consumption.
RF3	A business analytics researcher, with h index 27 and 6 Scopus Q1 publications related to big data, ethical consumption and SDG.
PF1	An SDG practitioner, with 5-year experience in big data applications.
PM2	A tech entrepreneur who sells refurbished electronics.
PF3	An IT expert with 6 years of experience in big data applications at a FMCG company.
PM4	A machine learning expert of an online secondhand product platform.

Source*:* Author's creation.

Interviews were conducted between January 20, 2026 to February 06, 2026 via online video meetings. For video interviews, each session lasted on average between 15 min to 20 min. Each interview was audio-recorded with participants' advance permission and subsequently transcribed using a transcription software to guarantee precise data analysis. After getting the transcripts, their views were triangulated with the thematic analysis findings to address research gaps and design future research propositions.

5. Discussion

The keyword co-occurrence diagram presents below.

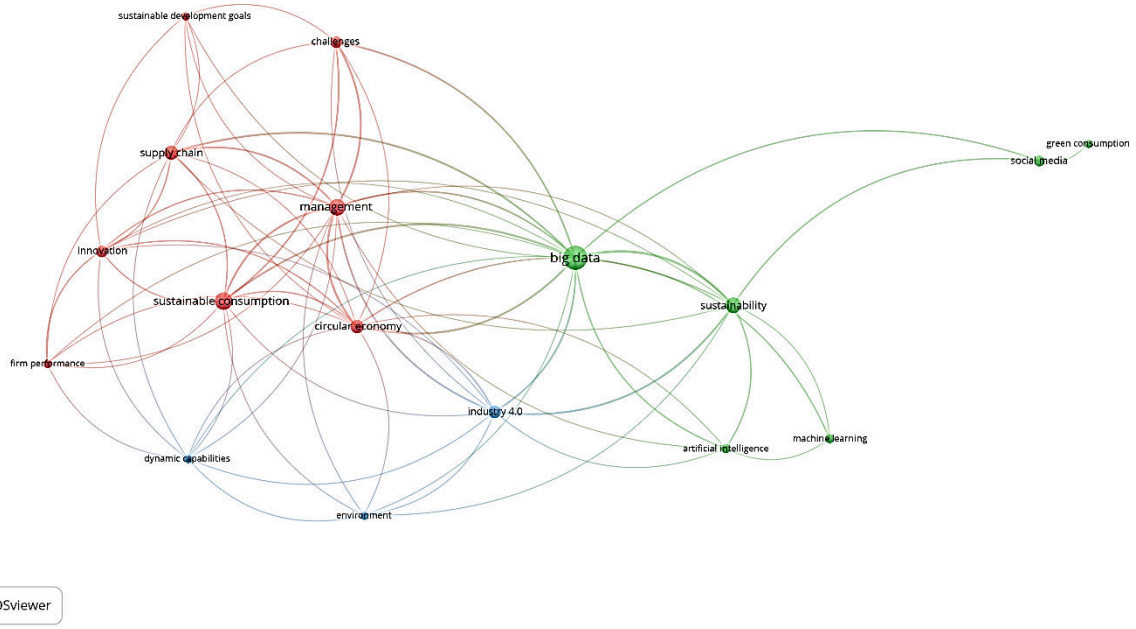

Figure 2. Keyword co-occurrence analysis.

Source: Author.

On the basis of the keyword co-occurrence analysis, the study discusses the major findings and research gaps from each theme, highlighted by the selected 51 articles, presented in Table 2.

Table 2.
Thematic findings and research gaps

Clusters	Major findings	Research gaps
Red	• SDG focused management decisions accelerate ethical consumption through innovation (Ivanov, Seyitoğlu, Webster, 2024; Zeqiri, Ben Youssef, Maherzi Zahar, 2025) • Sustainable farm performance positively influences ethical consumption (Huang, Sun, Long, 2025; Wang et al., 2025) • Business farm effectiveness depends on robust supply chain network (Bag et al., 2022; Cui et al., 2019; Huo et al., 2024) • Circular economy positively transforms ethical consumption intention to behavior in promoting ethical consumer awareness on social media (Bai, Zhou, Sarkis, 2023; Butt, Ali, Govindan, 2024; Xie et al., 2025) • Ethical consumer centric product designs increase consumer trust (Sharma, Singh, Tsagarakis, 2024; Xia, Lai, Khaskheli, 2025) • Management decisions in business innovation differs based on geographical locations and economic status (Moktadir et al., 2019)	• Emotional factors, related to ethical consumption decision making, remain underexplored (Cao, Liu, 2023; Huang, Sun, Long, 2025) • How institutional pressure put constraints in ethical consumption is not addressed (Bag et al., 2022; Moktadir et al., 2019; Sharma, Singh, Tsagarakis, 2024) • Green supply chain designs and its challenges require more research in farm innovation perspectives (Cui et al., 2019; Moktadir et al., 2019; Xia, Lai, Khaskheli, 2025)
Green	• Artificial intelligence capability significantly improves firm performance through data driven culture (Holzinger et al., 2023; Kuo, Peng, Kuo, 2024) • Machine learning reveals strong links between consumption decision and SDGs (Fosso Wamba et al., 2024) • Machine learning and big data management optimize consumer contribution to sustainable development (Dundulienė, Alzbutas, 2025; Katare et al., 2025) • Online communities disseminate practical knowledge and everyday eco-practices, such as recycling, zero-waste lifestyles, and eco-friendly purchasing (Ma et al., 2025; Wu et al., 2023; Zakharova et al., 2025) • Social media platforms produce massive datasets that can be analyzed using big data and AI techniques to understand environmental behaviors and attitudes (Armutcu, Zuferi, Tan, 2023; Xie et al., 2025; Zakharova et al., 2025)	• Limited cross-country and longitudinal studies on artificial intelligence capability (Ye, Lu, Lu, 2022) • Insufficient empirical research linking ethical consumption and technology integration (Fosso Wamba et al., 2024) • The interaction between social media influence, big data analytics, and behavioral outcomes in ethical consumption remains underexplored (Ma et al., 2025; Zakharova et al., 2025)
Blue	• Industry 4.0 technologies are the primary institutional mechanisms enabling mass ethical consumption through e-commerce platforms (Bag et al., 2022; Roszko-Wójtowicz et al., 2024) • Dynamic capabilities mediate the relationship between analytics capability and firm performance in sustainable supply chains (Munir et al., 2025; Peng et al., 2024) • Big data provides the informational foundation for company dynamic capabilities in response to ethical consumption choice by consumers (Huang, Sayed, 2025) • Industry 4.0 converts firms' dynamic capabilities into realizing ethical consumption by enabling circular economy transition (Sharma, Singh, Tsagarakis, 2024)	• There is a limited study on how improved volatility forecasting translates into reconfigured supply chain resources, better risk management, and enhanced sustainable consumption outcomes (Huang, Sayed, 2025; Munir et al., 2025) • Limited empirical evidence exists on how analytics-driven dynamic capabilities specifically enable circular economy practices (Sharma, Singh, Tsagarakis, 2024)

Source: Author.

The critical discussion of each thematic cluster, with triangulation of expert interview opinions, presents below.

Theme 1 - Red cluster: Big data empowers SDG-focused management decisions that accelerate ethical consumption through innovation in product design, supply chain optimization, and circular economy transitions (Ivanov, Seyitoğlu, Webster, 2024). The literature confirms that sustainable farm performance positively drives ethical consumption (Wang et al., 2025), yet business effectiveness hinges on robust, data-enabled supply chain networks (Huo et al., 2024). Such supply chain networks vary sharply across geographies and income levels (Moktadir et al., 2019). Circular economy frameworks, amplified by big data analytics on social media, convert ethical consumption intentions into actual purchasing behavior by raising consumer awareness (Xie et al., 2025). As RF3 noted: *Big data allows managers to track circular economy indicators in real time and redesign supply chains that genuinely promote SDG 12.* However, emotional factors influencing ethical decision-making remain underexplored (Cao, Liu, 2023), leaving a blind spot in understanding why consumers abandon ethical intentions at the point of purchase. Institutional pressures constrain ethical consumption have received almost no empirical attention in big data contexts (Bag et al., 2022). PF1 reinforced this gap: *We still do not understand how institutional pressures in different regulatory environments shape firms' ability to use big data for ethical consumption. This is a critical gap for SDG 9 implementation.* Green supply chain design for farm-level innovation also lacks sufficient research, particularly in emerging economies where SDG 9 infrastructure gaps are there. Ethical consumer-centric product designs increase consumer trust, yet the role of big data in personalizing such designs across different cultural segments remains unclear (Xia, Lai, Khaskheli, 2025). RM2 added: *We have no empirical model showing how big data tailors ethical product features to culturally diverse markets under SDG 12*. PM2 further observed: *In the refurbished electronics market, we see that consumers respond to data-driven trust signals differently in developed versus emerging economies, and no research captures this variation for SDG 9 scaling*. Based on the critical discussion on theme one, the study presents the first two research propositions.

Research Proposition 1: Big data–enabled institutional pressure mapping accelerates green supply chain innovation across diverse economic contexts, advancing SDG 9.

Research Proposition 2: Big data–personalized ethical product design increases consumer trust and purchase conversion across culturally diverse markets, strengthening SDG 12 outcomes.

Theme 2 - Green cluster: Artificial intelligence capability significantly improves firm performance by embedding data-driven culture into sustainability strategy (Fosso Wamba et al., 2024). Additionally, machine learning reveals robust links between consumption decisions and SDG targets. Big data and ML tools optimize consumer contribution by mining digital footprints (Katare et al., 2025). Such footprints derive from diverse online communities that disseminate eco-practices such as recycling, zero-waste lifestyles, and eco-friendly purchasing

(Zakharova et al., 2025). As PM4 observed: *Machine learning models trained on social media data can predict shifts in ethical purchasing.* Additionally, social media platforms produce massive datasets that researchers can analyze using big data and AI techniques to understand environmental behaviors and attitudes (Xie et al., 2025; Zakharova et al., 2025). RF3 pointed out a research gap: *we still lack frameworks that connect consumer sentiments to actual ethical purchasing.* Yet cross-country and longitudinal studies on AI capability remain scarce, and insufficient empirical research links ethical consumption directly to technology integration, leaving the causal pathways between big data tools and actual behavioral change unverified. Moreover, existing studies predominantly discuss AI and machine learning capabilities at a conceptual level without empirically operationalizing how these tools influence specific ethical consumption. The interaction between social media influence, big data analytics, and behavioral outcomes in ethical consumption is still poorly understood. RM1 stressed this concern: *We lack large-scale, cross-country longitudinal evidence on whether AI-driven recommendations actually sustain ethical consumption behavior or just produce short-term spikes.* PF3 echoed a practical concern: *In our FMCG operations, we collect massive consumer data but have no validated methodology to translate AI-generated ethical consumption insights*. On the basis of these insights, the study presents future research propositions three and four.

Research Proposition 3: Longitudinal, cross-country experiments test whether AI-driven personalized recommendations influence ethical consumption behavior over time.

Research Proposition 4: AI-powered social media sentiment analysis frameworks facilitate measurable ethical purchasing outcomes, advancing SDG 9 digital infrastructure goals.

Theme 3 - Blue cluster. Industry 4.0 technologies serve as the primary institutional mechanism enabling mass ethical consumption through e-commerce platforms (Roszko-Wójtowicz et al., 2024). In these platforms, big data provides the informational backbone for firms' dynamic capabilities (Huang, Sayed, 2025). Dynamic capabilities mediate the relationship between analytics capability and firm performance in sustainable supply chains (Munir et al., 2025). It facilitates business firms to sense, seize, and reconfigure big data insights outperform peers in ethically complied product delivery. PM2 and PF3 echoed this finding: *Big data captures consumer ethical preferences, and dynamic capabilities let firms reconfigure production to meet SDG 12 standards.* Industry 4.0 further converts these dynamic capabilities into circular economy transitions that align production with SDG 9 and SDG 12 targets (Sharma, Singh, Tsagarakis, 2024). Yet limited research explains how improved volatility forecasting translates into reconfigured supply chain resources and enhanced ethical consumption outcomes (Munir et al., 2025). Empirical evidence on how analytics-driven dynamic capabilities specifically enable circular economy practices remains thin. RM2 highlighted this shortcoming: *We have theoretical models linking dynamic capabilities to circular economy, but almost no field-level evidence showing how analytics-driven reconfiguration works in practice for SDG 9.* Additionally, RM1 raised: *Industry 4.0 platforms*

generate enormous big data streams, but we still lack standardized metrics to evaluate related to ethical consumption. PF1 also stressed: *From an SDG implementation perspective, we need evidence on how e-commerce platforms in developing countries build dynamic capabilities differently from developed markets. Because the infrastructure gaps under SDG 9 fundamentally change the equation*. On the basis of these discussions, the study presents the final two research propositions.

Research Proposition 5: Firms that integrate big data volatility forecasting into supply chain reconfiguration achieve superior sustainable consumption outcomes under Industry 4.0.

Research Proposition 6: Comparative studies across developed and emerging economies to determine how dynamic capabilities differentially enable circular economy practices.

6. Contributions and implications

This study extends the big data–ethical consumption nexus, from author's previous papers on ethical consumption (Arman, Mark-Herbert, 2024; Arman, 2025; Arman, Sayeed, Rahman, 2025), by introducing a multi-study framework that triangulates systematic literature findings with expert-validated insights. It establishes that circular economy, AI capability, and Industry 4.0 function as three interconnected mechanisms through which big data advances SDG 9 and SDG 12 simultaneously. The research identifies emotional factors and institutional pressures as theoretically underdeveloped constructs in big data–driven ethical consumption literature. It positions dynamic capabilities as a mediating theoretical lens that explains how analytics capability translates into sustainable supply chain performance. The study presents 6 research propositions that maps the intellectual structure of big data and ethical consumption combination for future theory building.

In terms of practical implications, investors should invest in big data analytics platforms that track circular economy indicators in real time to promote ethically complied production operations under SDG 12. Entrepreneurs should deploy machine learning models on social media datasets to predict and respond to emerging ethical consumption trends before competitors. Business development managers should build analytics-driven dynamic capabilities that enable rapid supply chain reconfiguration in response to ethical consumption demands. Organizations should integrate emotion-sensing analytics into customer journey mapping to close the persistent ethical consumption intention–behavior gap. Policymakers should leverage Industry 4.0 e-commerce infrastructure to scale ethical consumption access across developing economies, advancing SDG 9.

For social implication perspective, Big data democratizes access to ethically complied product information, enabling consumers in both developed and emerging economies to make informed ethical choices that advance SDG 12. Data-driven transparency in supply chains holds

businesses publicly accountable for labor practices, environmental footprints, and fair-trade compliance, which strengthens responsible production under SDG 12. Leveraging Industry 4.0 infrastructure to deliver big data insights to underserved communities promotes inclusive and sustainable industrialization at the core of SDG 9. Big data–enabled ethical consumption platforms empower marginalized consumers. This empowerment would reduce information asymmetry, and accelerate the societal shift toward equitable and sustainable development across both SDG 9 and SDG 12.

7. Conclusion

This multi study approach extends the justification of connecting theoretical advancement with practical standpoint. Also, the study triangulated the SLR findings, justifying its value to the company and the society. The study relies on Scopus and Web of Science databases, so future research should incorporate additional sources to capture a broader evidence base. The expert sample, though balanced across economies, remains small; larger, sector-specific interview panels would strengthen the generalizability of findings. Moreover, the study was purely relied on thematic analysis drives to gap analysis on the existing literature. So, it did not include bibliometric quantitative measures (e.g., cluster strength, centrality measures). Additionally, the reviewed studies do not distinguish between the predictive accuracy of machine learning models and actual behavioral change among consumers. Future studies should conduct longitudinal and experimental research to establish causal links between big data interventions and sustained ethical consumption behavior across diverse cultural contexts. Also, these future research methodologies should empirically test whether the predictive accuracy of machine learning models translates into actual ethical consumption behavior to track consumer purchasing decisions over time against algorithmic predictions.

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Appendix

Table 3.
Expert interview questions

Questions	Statements
1	Based on your experience, how does big data influence management decisions related to ethical consumption?
2	What role do emotional and psychological factors play in ethical consumption decision-making, and how can big data analytics address these factors?
3	How do institutional pressures in different regulatory environments shape firms' ability to use big data for promoting ethical consumption?
4	In your view, how effectively do AI and machine learning tools translate social media data into actionable insights for ethical consumption?
5	What are the main barriers to conducting cross-country and longitudinal research on the link between big data technologies and ethical consumption behavior?
6	What and how do Industry 4.0 technologies play role in big data – ethical consumption nexus?
7	From your point of view, what are the key differences between developed and emerging economies in building big data–driven dynamic capabilities for ethical consumption?
8	What specific research/practice gaps do you consider most critical for advancing SDG 9 and SDG 12 through big data applications in ethical consumption?

Source: Author.

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A NEW MODEL FOR DEVELOPING PUBLIC PROJECTS CONDITIONED BY REGIONAL RESILIENCE AND SUSTAINABLE DEVELOPMENT STRATEGIES

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Purpose: The purpose of the article is to develop a model of public projects co-financed from external sources that integrates the paradigms of resilience, sustainable development, and demographic conditions resulting from regional strategies.
Design/methodology/approach: The study applies a desk research method, including a qualitative analysis of academic literature as well as strategic documents at the European Union, national, and regional levels. The analysis has an exploratory–comparative character and is aimed at identifying and synthesising approaches to integrating resilience, sustainability, and demographic factors in public policies.
Findings: The findings indicate the key role of regional self-government authorities in reducing demographic disparities and reveal gaps in policy integration and in the assessment of project resilience. The proposed DRS Model is based on three pillars: demographic planning, an adaptive project structure, and institutional coordination.
Research limitations/implications: The limitations result from the conceptual nature of the study and the availability of data. Further comparative analyses, the development of forecasting modules, and research on the costs and effectiveness of adaptive solutions are recommended. Practical implications: The model constitutes a tool supporting the effectiveness and durability of public projects under conditions of uncertainty and demographic pressure.
Social implications: The approach fosters the development of inclusive and long-term regional development.
Originality/value: The originality lies in integrating resilience, sustainable development, and demography within an operational model of public project management.
Keywords: public projects, resilience and sustainable development paradigms, demographic change.
Category of the paper: Research paper.

1. Introduction

Under conditions of increasing macroeconomic uncertainty, demographic pressure, and the growing dependence of local and regional authorities on external sources of public funding, a significant research problem emerges, consisting in the limited capacity of existing public project planning systems to integrate the paradigms of sustainable development, resilience, and demographic conditions. In particular, an insufficient linkage between project processes and demographic diagnoses is observed, as well as a lack of operationalisation of adaptive mechanisms under conditions of high uncertainty (Kerzner, 2006; Podgórska, Pichlak, 2019; Zaskórski et al., 2015; Zespół ds. Polityki Regionalnej PWEiKPP, 2025).

In response to the identified research problem, the aim of the article is to develop a model of public projects co-financed from external sources that integrates the paradigms of resilience, sustainable development, and demographic conditions resulting from regional strategies, oriented towards increasing implementation effectiveness and the durability of public intervention outcomes. The achievement of this objective requires addressing the following research questions:

Q1: How, and through which mechanisms, does the integration of the paradigms of sustainable development and resilience influence the effectiveness, efficiency, and durability of public projects financed from external sources?

Q2: What systemic barriers (institutional, informational, and methodological) limit the linkage of project processes with demographic diagnoses and social forecasts?

Q3: What institutional and planning mechanisms can enhance the adaptability of public projects financed from external sources under conditions of crises and demographic pressure?

Based on the formulated research problem and research questions, the following research hypotheses were proposed:

H1: The integration of the paradigms of sustainable development and resilience at the regional level leads to a significant increase in the effectiveness, efficiency, and durability of public projects financed from external sources.

H2: Public projects based on demographic diagnoses and risk management mechanisms are characterised by higher adaptive capacity and greater implementation effectiveness compared to projects that do not take these factors into account.

2. Theoretical framework

2.1. Sustainable development and resilience as complementary paradigms of regional development under conditions of demographic change

The paradigm of sustainable development has been present in economic sciences and public policies for several decades, with its contemporary interpretation deriving both from the Brundtland Report (World Commission on Environment and Development, 1987) and from earlier analyses of the Club of Rome (Meadows et al., 1972, 1992, 2004). This concept was institutionally consolidated during the Earth Summit in Rio de Janeiro in 1992 and refers to a model of development that enables the needs of the present generation to be met without compromising the ability of future generations to meet their own needs, taking into account both intergenerational and intragenerational equity.

From an economic perspective, sustainable development has evolved towards sustainability economics, emphasising the efficiency of managing scarce resources under conditions of uncertainty, as well as the need to balance development capitals: economic, social, human, and natural (Baumgärtner, Quaas, 2010; Malik, 2011). This approach has a normative character and implies an active role of the state and local governments in correcting market failures, in particular through regional development policies, strategies, and instruments of public intervention. As indicated by Jastrzębska and Legutko-Kobus (2010) as well as Bedrunka and Malik (2014), the key challenge is maintaining a long-term balance between development capitals, which determines the sustainability of socio-economic processes.

In parallel, the resilience paradigm has developed, with its origins in ecological research on system stability (Holling, 1973), and subsequently expanded in psychology, sociology, and management sciences as the capacity of systems to adapt, absorb shocks, and transform (Bonanno, 2004; Bourbeau, 2013, 2015). In recent years, the concept of resilience has been adapted to public policies and regional governance (including, among others, the EU Strategy on Adaptation to Climate Change 2021+ and National Recovery Plans under the Recovery and Resilience Facility) (European Commission, 2024; EU Strategy on Adaptation, 2021), gaining particular importance in the context of economic, climatic, and geopolitical crises (Davoudi et al., 2013; Folke, 2016; OECD, 2025). Recent empirical studies further develop methods for assessing and applying resilience in territorial policies—from multidimensional approaches (governance, infrastructure, social capital) to indicator-based assessment tools at the regional and metropolitan levels—as reflected, among others, in the works of Bedrunka-Gudaniec (2023), Kapucu (2024), and Suárez et al. (2024).

The literature emphasises that the paradigm of sustainable development has a long-term and integrative character, whereas resilience focuses on the short-term adaptive capacity of systems under conditions of uncertainty (Meerow et al., 2016). As indicated by Czaja (2017) and Bedrunka and Malik (2014), these approaches are complementary but operate according to

different decision-making logics and time horizons. Contemporary research additionally highlights the growing importance of demographic processes-population ageing, migration, and depopulation—as key determinants of the resilience of socio-economic systems and the design of public services (Lv et al., 2024; European Commission, 2024; Śleszyński, 2025; Dolińska et al., 2023). Moreover, the results of recent empirical studies indicate an increasing scale of demographic and social pressure in Poland, manifested, inter alia, in high levels of stress among young people (approx. 60%), increasing social isolation (38-42%), instability of youth employment (58%), and delays in achieving independence (over 50% of individuals aged 25-34 remain in their parents' households), which points to an accumulation of developmental risks and the growing social and economic costs of these processes in the long term, thereby reinforcing the need for a systemic and integrated approach to the design of public policies (Polish Social Policy Association, 2026).

Despite the growing body of research on both sustainable development and resilience, an analysis of the literature and strategic documents indicates a significant research gap consisting in the limited integration of these paradigms with the demographic dimension at the operational level, particularly in the management of public projects. In the practice of regional policies, it is observed that although development strategies increasingly refer to resilience and sustainability, the mechanisms of their implementation within the project life cycle remain fragmented and inconsistent.

In particular, there is a lack of operationalisation of such categories as adaptive capacity, resilience to shocks, and long-term changes in population structure within the procedures of selection, monitoring, and evaluation of public projects. This is confirmed both by academic literature indicating difficulties in the practical application of the resilience concept (Meerow, Newell, Stults, 2016) and by institutional analyses highlighting implementation limitations of regional policies (OECD, 2025). Evaluation studies further indicate that the inclusion of sustainable development criteria in the project selection process increases the durability of their outcomes; however, the integration of these criteria with other dimensions of development remains limited (Instytucja Zarządzająca PO IR & CEAPR, 2017; Ministerstwo Rozwoju, 2017). At the same time, intensifying demographic challenges—including population ageing and depopulation of peripheral regions—affect the ability of regions to effectively absorb public funds and deliver public services (GUS, 2024; Rada Ministrów, 2021).

The identified research gap justifies the need to develop an integrated approach to public projects that would combine the paradigms of sustainable development, resilience, and demographic conditions within a coherent operational model. The integration of these dimensions may contribute to increasing the effectiveness and durability of public projects by better aligning interventions with long-term development objectives and enhancing the capacity of territorial systems to respond to uncertainty and shocks. At the same time, it can be expected that projects based on demographic diagnoses and risk management mechanisms will exhibit higher adaptive capacity and greater implementation effectiveness.

2.2. The EU budget for 2028-2034 and new directions for public projects in Poland

In the context of growing geopolitical, climatic, and demographic challenges, the European Union is preparing new Multiannual Financial Framework (MFF) for the period 2028-2034. Poland, as the largest beneficiary of cohesion policy, is expected to receive approximately EUR 123 billion, which means that the future architecture of public projects will largely depend on EU priorities and their implementation at the national and regional levels (European Commission, 2025 COM(2025) 558; European Commission, 2025 COM(2025) 558/1).

Table 1.
Proposed EU budget for 2028-2034 by areas of support and amounts (current prices)

No.	Area of financing	Amount [EUR bn]	Share of budget [%]	Remarks
1.	National and Regional Partnership Plans	865	44%	Main part of the budget: cohesion policy, ERDF, Cohesion Fund, ESF+
2.	European Competitiveness Fund[1]	409	21%	Including digital technologies, green technologies, biotechnology, and defence
3.	Global Europe	200	10%	Global partnerships, security, support for Ukraine
4.	Other[2]	293	15%	CEF, public health, internal market, Euratom, CFSP, "Pericles IV" programme
5.	Repayment of NextGenerationEU	168	8%	Debt servicing of the NGEU instrument
6.	Erasmus+ and AgoraEU	49	2%	Education, mobility, social innovation
	Total	**2000**	**100%**	–

Note. Table 1 presents the proposed allocation of the European Union budget for 2028-2034 in current prices, based on the draft presented by the European Commission in July 2025. The total budget amounts to EUR 2000 billion (EUR 2 trillion) over a seven-year period, representing approximately 1.26% of the EU's average gross national income (GNI) during that period.

Source: Author's own elaboration based on data from the European Commission.

The new financial perspective focuses on six strategic priorities: cohesion policy; investments in competitiveness, innovation, and the digital and energy transition; socio-economic resilience; security and defence; global partnerships; and the rule of law (European Commission, 2025). For Poland, this implies the need to adjust the project programming system not only to EU objectives but also to the actual demographic and economic challenges faced by regions.

From Poland's perspective, three areas will be of particular importance. First, cohesion policy and demographic transformation: the European Regional Development Fund (ERDF), the Cohesion Fund, and the European Social Fund Plus (ESF+) remain the core

[1] This includes Horizon Europe and the Innovation Fund (EUR 41 billion), which are not included in the above breakdown.

[2] It includes the Connecting Europe Facility (CEF), civil protection and public health, the Single Market Programme, the Euratom research and training programme, the Common Foreign and Security Policy (CFSP), justice, the decommissioning of nuclear facilities, overseas countries and territories (OCTs), and the "Pericles IV" programme.

of the budget. However, projects must better incorporate demographic diagnoses, such as adapting healthcare and care services to an ageing population or investing in education and internal migration. Second, socio-economic resilience and security: the European Union will allocate nearly EUR 400 billion to strengthening crisis preparedness (European Commission, 2025). Projects in this area should include early warning systems, critical infrastructure, energy transition initiatives, and local climate adaptation programmes. Third, competitiveness and innovation: the European Competitiveness Fund will support digital, green, and biotechnological technologies. Polish regions must align their smart specialisation strategies (RIS3) with EU objectives in order to compete effectively (Draghi, 2024) and ensure sustainable economic growth, while simultaneously strengthening their position within European value chains.

Based on previous experience in implementing projects financed from European funds, it can be concluded that future public projects in Poland should be demographically sensitive, taking into account depopulation forecasts, including population ageing; integrate sustainable development and resilience within a single operational model of project design and evaluation; link national and regional objectives with EU priorities in order to meet conditionality and efficiency requirements; and apply hybrid indicators (resilience × sustainability) as a basis for monitoring project effectiveness. Such an approach may enhance Poland's capacity to absorb EU funds effectively and to meet increasing conditionality and performance requirements, while simultaneously strengthening regional resilience to future crises and social transformations.

3. Methods

The study was conducted using a qualitative analytical–conceptual approach, combining a review of academic literature, an analysis of strategic documents, and comparative synthesis (Figure 1). The methodological objective was to identify conceptual and operational gaps in existing approaches to public projects and to develop a framework for a new model integrating demographic, resilience, and sustainable development dimensions.

A comparative policy document analysis was applied to selected strategic documents at the European Union, national, and regional levels. The analysis covered, inter alia, regional development strategies, draft programming documents for European Union funds for the period 2028-2034, the Demographic Strategy 2040, as well as regional demographic analyses and forecasts. It also included resilience and adaptation frameworks, encompassing the EU Strategy on Adaptation to Climate Change, the National Recovery Plan, and selected documents related to risk management and territorial resilience, including national and regional crisis management plans, risk assessment documents prepared for crisis management purposes, and strategies and

programmes concerning critical infrastructure security and the continuity of public service provision.

A key methodological component was a matrix-based analytical framework, involving the construction of a matrix integrating three dimensions: development resilience (DR), sustainable development (DS), and demographic conditions (D). This matrix was used to systematically assess the coherence of strategic objectives, financial instruments, and project logic, enabling the identification of areas of complementarity, tension, and implementation gaps.

Based on the results of the comparative and matrix analyses, a conceptual synthesis was conducted, resulting in the development of an original model for public projects. The modelling process was iterative and involved the step-by-step identification and refinement of project principles, governance levels, decision-making mechanisms, and evaluation indicators, ultimately leading to the formulation of the Demography–DR×DS (DRS Model).

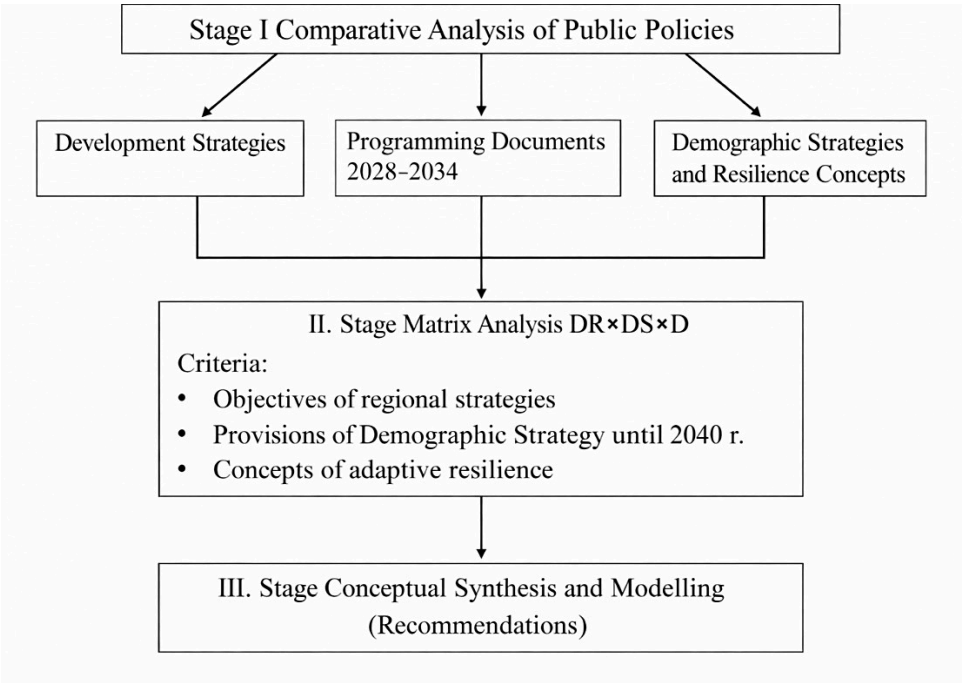

Figure 1. Research methodology.

Source: Author's own elaboration.

4. Results

The proposed model of a new approach to public projects, referred to as the Demography–DR×DS Model, constitutes a conceptual framework for the design, implementation, and evaluation of projects co-financed from external sources at the regional level. The DRS Model is a direct outcome of the analysis of the DR×DS×D matrix (Table 2).

It is characterised by three constitutive features: (1) the prioritisation of demographic diagnoses as the starting point for planning public interventions; (2) the integration of the paradigms of development resilience (DR) and sustainable development (DS) within project logic; and (3) the linkage of national and regional objectives with the priorities and conditionality of European Union policy.

The analysis of the DR×DS×D matrix demonstrated the necessity of simultaneously incorporating all three dimensions into project logic, which provided the direct basis for the construction of the DRS Model and the formulation of six guiding principles (6P).

Table 2.
The DR×DS×D analytical matrix underlying the construction of the DRS Model

Dimensions DS \ DR	Shock absorption capacity	Adaptive capacity	Transformative capacity
DS – social dimension	Ensuring the continuity and accessibility of basic public services under crisis conditions (age structure, depopulation)	Adjusting the scope and forms of social service provision to demographic changes	Transforming models of public service provision in response to long-term changes in population structure (migration, changes in demand)
DS – economic dimension	Maintaining the continuity of the local economy and labour market under shock conditions (labour resources)	Diversification of the regional economic structure and adjustment of competencies to demographic changes (labour mobility)	Transformation of the regional economic development model in response to demographic and technological trends
DS – environmental dimension	Resilience of environmental and municipal infrastructure to disruptions and crises (population concentration)	Adaptation of energy, transport, and spatial systems to changing demographic needs (population density)	Long-term environmental transformation towards climate neutrality and efficient resource management under changing population structures

Note. Table 2 presents the DR×DS×D analytical matrix forming the basis for the construction of the DRS Model. The matrix was developed through a comparative synthesis of strategic documents at the European Union, national, and regional levels, as well as findings from the relevant literature, and identifies the dominant patterns of integration between sustainable development objectives, development resilience, and demographic conditions.

Source: Author's own elaboration based on an analysis of European Union and Polish strategic documents and the relevant literature.

The model is based on six principles (6P), which function as meta-principles organising the entire life cycle of a public project:

1. Priority of population and demographic structure – demographic diagnoses, encompassing population ageing, depopulation, and migration processes, constitute the starting point for the planning and design of public interventions.
2. Project portfolio-level management – strategic decisions are taken at the level of the project portfolio, enabling the coordination of interventions, allocation of resources, and maximisation of development effects at the regional scale rather than at the level of individual projects.

3. Parity between resilience and sustainable development – the resilience of territorial systems and sustainable development are treated as complementary and equally important objectives in the planning and implementation of public projects.
4. Territorially differentiated (place-based) approach – project interventions are designed with due regard to the territorial specificity of regions and functional areas, including smart specialisations (RIS3), peripheral areas, and urban agglomerations.
5. Evidence- and impact-based evaluation – project effectiveness and durability are assessed using hybrid sets of indicators combining economic, social, environmental, and resilience-related measures.
6. Coherence of public policies and project interventions – project activities remain aligned with the strategic priorities of the European Union, national development documents, and the principles of financial conditionality.

The architecture of the proposed model is based on three interrelated levels, forming a multidimensional conceptual framework for the design and implementation of public actions aimed at achieving a regional development strategy grounded in the principles of resilience (DR) and sustainable development (DS):

- Strategic (regional) level – includes the mapping of demographic risks, the construction of the DR×DS matrix, and the contracting of objectives in relation to EU priorities.
- Programmatic (operational) level – involves the development of portfolios of public projects grouped into three clusters: (i) cohesion and demography, (ii) resilience and security, and (iii) competitiveness and innovation; this level employs conditionality matrices and financing maps.
- Project (implementation) level – assumes the use of a standardised project fiche with modules covering, inter alia, demography, energy transition risks, digitalisation, social inclusion, and finance.

The life cycle of public projects within the DRS Model is structured around decision gates. These include the following stages:

- G0-G1: concept and selection – preparation of a demographic diagnosis and an DR×DS analysis.
- G1-G2: conceptual design – definition of the intervention logic and theory of change.
- G2-G3: financing – construction of the financial model and assessment of project life-cycle costs.
- G3-G4: implementation – execution of the adaptive plan and monitoring of project indicators.
- G4-G5: closure – resilience audit, assessment of demographic impact, and preparation of the project sustainability plan.

A novel feature of the proposed model is the application of a hybrid project evaluation system based on key performance indicators (KPI DRS – Key Performance Indicators: Demography–Resilience–Sustainability), built around three criteria:

- resilience (R) – measured by service recovery time, the level of redundancy, and crisis preparedness,
- sustainability (S) – assessed through energy efficiency, environmental impact, and quality of life,
- demography (D) – indicators of service accessibility for the population aged 65+, migration balance, and educational dependency.

The integrated KPI DRS index enables continuous monitoring and the automatic activation of adaptive mechanisms when indicator values fall below predefined thresholds.

The model assumes the establishment of specialised governance structures, including a Project Portfolio Committee responsible for strategic decisions and indicator weighting, a Public Projects Office responsible for methodology, monitoring, and audit, and thematic leaders acting as custodians of project portfolios. In addition, the model provides for the establishment of citizens' panels within consultation processes. These institutional solutions constitute mechanisms that enhance the adaptability of public projects to crises and demographic pressures and are implemented in practice by regional self-government authorities as key actors in regional policy.

An integral component of the model is a risk register encompassing demographic, climatic, geopolitical, and economic scenarios. Each project undergoes resilience testing ex ante, mid-term, and ex post. Furthermore, the model assumes an adaptive reserve of up to 5% of project value to support actions undertaken under crisis conditions.

The proposed model enables the integration of the long-term logic of sustainable development with short-term adaptive capacity, while simultaneously incorporating the demographic dimension. As a result, it becomes a tool for enhancing the effectiveness, durability, and coherence of public projects co-financed from external sources, in relation to regional development strategies constructed on the paradigms of resilience and sustainable development. The adoption of this approach should contribute to strengthening the capacity of regions to respond to future economic, climatic, and social crises, as well as to building competitive advantages under conditions of intensifying competition for capital, innovation, and human resources.

The effectiveness of the proposed model is subject to several limiting factors. First, the implementation of hybrid solutions requires a high level of institutional coordination, which under conditions of multi-level governance may generate the risk of decision-making fragmentation. The analysis confirms that regional self-government authorities play a significant role in mitigating regional demographic disparities through the implementation of instruments aimed at strengthening local social, economic, and environmental resilience. As such, they constitute a key link between the strategic priorities of the European Union and regional development practice. Second, dependence on external funding sources, including European Union funds, renders the long-term stability of the model sensitive to changes in EU policy priorities. Third, the strong embedding of the model's logic in demographic

diagnoses requires reliable prognostic data, which are themselves subject to uncertainty, particularly in the context of increasing migration mobility and global shocks. While the model has the potential to enhance regional competitiveness by better aligning interventions with local resources and needs, it may also lead to the deepening of development asymmetries if appropriate mechanisms of redistribution and interregional solidarity are not implemented.

5. Discussion

The conducted research, encompassing a review of the literature as well as an analysis of Polish and European strategic documents at the national and regional levels, together with matrix analysis and conceptual synthesis, made it possible to demonstrate that the proposed DRS Model constitutes a coherent framework for integrating the paradigms of resilient development and sustainable development with a demographic sensitivity perspective across the project life cycle. From the perspective of public sector economics and institutional economics, the model provides mechanisms for reducing coordination failures and information asymmetries through the standardisation of decision-making stages in the form of decision gates (Gates), the introduction of a hybrid project evaluation system based on key performance indicators, and the institutionalisation of multi-level governance arrangements.

The obtained results should be situated more broadly within the existing body of research on territorial resilience, sustainable development, and public management. First, they are consistent with the findings of Davoudi, Brooks, and Mehmood (2013), who indicate that resilience should not be understood solely as the ability to return to a pre-crisis state, but rather as the capacity of territorial systems to adapt and transform. In this sense, the DRS Model develops this perspective by transferring the logic of resilience from the level of general adaptive strategies to the level of operational management of public projects, equipping it with concrete decision-making mechanisms, indicators, and management gates.

Second, the proposed approach corresponds with the conclusions of Meerow, Newell, and Stults (2016), who emphasise that one of the fundamental weaknesses of resilience research remains definitional ambiguity and the difficulty of operationalising this concept in planning practice. The results of this study confirm this diagnosis, demonstrating that in the procedures of selection, monitoring, and evaluation of public projects, resilience-related categories are still addressed in a fragmented manner. At the same time, the DRS Model constitutes an attempt to overcome this gap by linking resilience with measurable project components, namely the demographic diagnosis, the KPI DRS system, resilience testing, and the adaptive reserve.

Third, the results are consistent with the recommendations of the OECD (2025), according to which effective regional policy should adopt a place-based approach, integrate development objectives with resilience, and consider the differentiated institutional capacities of regions.

In this respect, the proposed model strengthens the existing approach, as it does not limit itself to indicating the need for territorial differentiation of interventions, but embeds it within the structure of project portfolios, conditionality mechanisms, and resource allocation rules. This means that the contribution of the article lies not only in confirming the importance of the territorial approach, but also in its operationalisation at the project level.

Fourth, the obtained results remain consistent with recent studies on the multidimensional assessment of territorial resilience. Kapucu (2024) emphasises the importance of integrating governance, infrastructure, and social capital, while Suárez et al. (2024) point to the growing role of indicator-based tools for assessing resilience at the regional and metropolitan levels. Compared to these approaches, the DRS Model adds value by incorporating the demographic dimension into the evaluation architecture, as well as by linking indicators to the life cycle of public projects rather than solely to the diagnosis of the regional condition.

Fifth, the results of this study are situated within the stream of research indicating the complementarity of the paradigms of sustainable development and resilience, while at the same time demonstrating that their real integration requires institutional mechanisms rather than merely strategic declarations. This is consistent with the findings of Bedrunka and Malik (2014) as well as the more recent approach to integrated resilience at the regional level (Malik, Szewczuk-Stępień, Bębenek, 2024); however, the article extends these findings by shifting the focus from the level of development policy to the level of public projects and programmes. Thus, the proposed model may be treated as an intermediate link between the strategic logic of regional development and the practical implementation of interventions financed from external sources.

In this context, it is important to relate the research results to the formulated research objective and hypotheses. Regarding hypothesis H1, which assumes that the integration of sustainable development and resilient development objectives increases the effectiveness, efficiency, and durability of public projects, the obtained results indicate its conditionally positive verification. The analysis demonstrated that the integration of both paradigms strengthens the internal coherence of intervention logic and supports the maintenance of the economic value of projects in the long term, particularly when projects are linked with risk matrices and adaptive mechanisms. At the same time, the effectiveness of this approach remains strongly dependent on the quality of institutional coordination and the stability of financing frameworks, which limits the possibility of unconditionally confirming hypothesis H1 across all regional contexts.

Stronger confirmation was obtained with respect to hypothesis H2, concerning the role of demographic diagnoses and risk management in shaping the adaptability and implementation effectiveness of projects. The inclusion of a demographic module and the application of resilience testing at the ex-ante, mid-term, and ex-post stages improve the alignment of public service supply with the changing demand structure resulting from population ageing, migration, and depopulation processes. Integrated KPI DRS performance indicators, combining resilience,

sustainability, and demographic components, support more targeted resource allocation and institutional learning processes. At the same time, significant risks were identified related to the quality and timeliness of prognostic data and the capacity of public administration to effectively operationalise such data at the project level.

The analysis also makes it possible to formulate several institutional and economic implications. First, it confirms the key role of regional self-government authorities in translating European Union priorities into regional policy. These entities act as intermediaries between EU and national strategic frameworks and the operational implementation of public interventions, contributing to the reduction of demographic disparities through instruments aimed at strengthening social, economic, and environmental resilience. Second, the 6P mechanisms enable a shift in the decision-making perspective from the level of individual projects to the programmatic and portfolio levels, strengthening the coherence of public interventions and reducing the risk of fragmentation of actions. Third, the economic rationale of the DRS Model is reflected in improvements in dynamic efficiency: the application of decision gates and an adaptive reserve reduce the costs of delays and decision-making errors, while simultaneously creating space for the reallocation of resources towards actions generating higher net social value.

At the same time, the analysis reveals significant limitations and implementation risks. First, the DRS Model is sensitive to the political and institutional cycle and to the variability of European Union funding priorities. Second, under conditions of low institutional maturity, there is a risk of decision-making fragmentation and a formal rather than real integration of resilience and sustainability objectives. Third, the implementation of the model may deepen territorial inequalities if it is not supported by mechanisms for equalising the absorptive and institutional capacities of regions. Finally, the effectiveness of the demographic and risk management components remains strongly dependent on data quality and the accuracy of forecasting models. This means that the proposed model has high potential utility; however, its effects depend on institutional conditions, data quality, and the stability of financing frameworks.

6. Summary

The article makes a theoretical and applied contribution by designing a coherent operational model integrating the components of resilience, sustainability, and demography at the level of public projects. The conducted analyses indicate that the proposed solution may constitute a useful tool for enhancing dynamic efficiency, the durability of benefits, and the adaptive capacity of public interventions, provided that appropriate institutional capacities and stable financing frameworks are ensured.

In light of the obtained results, hypothesis H2, relating to the importance of demographic diagnoses and risk management for the adaptability and implementation effectiveness of public projects, received stronger confirmation than hypothesis H1. Hypothesis H1, which assumed a positive impact of integrating the objectives of resilient and sustainable development on the effectiveness, efficiency, and durability of projects, was confirmed conditionally, with the quality of institutional coordination and the stability of financing mechanisms identified as key moderating factors.

However, the study has certain limitations. First, it is of a conceptual–analytical nature and is based primarily on the analysis of literature and strategic documents, without direct verification of the model on a large sample of implemented public projects. Second, the proposed model is embedded primarily in the conditions of the Polish institutional system, which limits the possibility of directly transferring its assumptions to other public management systems. Third, an important limitation remains the dependence on the quality of prognostic data, particularly regarding migration processes and demographic changes characterised by a high level of uncertainty.

Consequently, the following directions for further research are justified. First, comparative quantitative and qualitative analyses of the effects of implementing the DRS Model in an interregional context are needed, based on evaluation data, benchmarking, and limited counterfactual analyses. Second, it is advisable to test and periodically update the demographic module using forecasting scenarios applied in national and regional practice, with particular emphasis on migration and changes in age structure. Third, cost–benefit analyses of the use of the adaptive reserve in public projects within ex ante and ex post evaluations are warranted. Fourth, in-depth institutional studies on the functioning of multi-level governance in the management of projects and programmes are needed, aimed at identifying mechanisms for reducing decision-making fragmentation and disparities in absorptive capacity between regions.

In conclusion, the DRS Model provides economically grounded and methodologically coherent tools for strengthening the resilience of the public-sector project system. However, its effective implementation requires conscious management of institutional risk, stable financing frameworks, and an active policy aimed at equalising absorptive capacities between regions. Therefore, the model should be treated not as a closed normative solution, but as an open analytical and implementation framework requiring further empirical verification.

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EXTENDED BALANCED SCORECARD MODEL FOR MACHINE SAFETY WITH INTEGRATION OF INDUSTRY 4.0

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Purpose: The aim of this study was to develop and validate a model to support machine safety management by integrating an extended Balanced Scorecard (BSC) concept with solutions characteristic of Industry 4.0. A key aspect was the structuring of key factors influencing safety, their translation into key performance indicators (KPIs), and the demonstration of their interrelationships in terms of cause and effect.
Design/methodology/approach: The systemic approach employed was based on an expanded BSC model that incorporated an additional perspective: Industry 4.0. The research methodology included: the construction of a strategic model, the identification and operationalization of KPIs, a qualitative analysis of interdependencies using an impact matrix, a cause-and-effect analysis, and the development of a strategic map. The presented approach is hybrid in nature, combining elements of qualitative analysis and systems modeling.
Findings: An integrated BSC model for machine safety has been developed, identifying KPIs and their impact on the achievement of strategic objectives across the various perspectives. It has been demonstrated that the Industry 4.0 perspective acts as a catalyst, enhancing the effectiveness of initiatives in the areas of technical processes, employee safety and financial efficiency. The impact matrix and strategic map revealed strong correlations between competencies, the reliability of technical systems and economic performance
Research limitations/implications: A limitation of this study is the qualitative nature of the assessment of the relationships between KPIs and their relevance to the specific characteristics of a particular company, which limits the ability to directly generalize the results. Future research will focus on the quantitative validation of the model, its application across various industrial sectors, and an analysis of its impact on the long-term effectiveness of safety management.
Practical implications: When applied in industrial settings, the developed model can support decisions regarding maintenance, investments in digitalization, and improvements in workplace safety.
Originality/value: The key benefit lies in integrating the BSC model with the Industry 4.0 perspective in the context of machine safety, utilising performance indicators and digital technologies.

Keywords: key performance indicators (KPIs), technological security, reliability of technical systems, digitalisation of industrial processes, mechanical engineering.
Category of the paper: Research paper.

1. Introduction

Modern industrial enterprises operate in an environment of growing competition, characterised by rapid technological change and pressure to improve operational efficiency whilst ensuring a high level of workplace safety (Muller et al., 2021; Pietrewicz, 2019). The growth and development of automation, robotisation and the digitalisation of production processes have contributed to a significant increase in the complexity of technical systems, which, on the one hand, allows for higher productivity, whilst on the other generates new types of risks relating to the operation of machinery and equipment (Ingaldi, Ulewicz, 2019; Pacana, Czerwińska, 2023a). This state of affairs means that safety management ceases to be purely operational in nature and begins to function as an integral part of strategic enterprise management. This requires the use of tools enabling a comprehensive assessment and continuous improvement of safety systems, as well as taking into account regulatory and normative requirements regarding occupational safety and the operation of technical equipment (Ulewicz, Lazar, 2019; Ferrigno et al., 2023).

The complexity and dynamic nature of the contemporary operating environment for manufacturing companies necessitates the implementation of tools that enable the conduct of multidimensional assessments of a company's performance (Gajdzik, Wolniak, 2022; Pacana, Czerwińska, 2019). Among these tools, the Balanced Scorecard (BSC) concept deserves particular attention (Krylov, 2025). The classic BSC takes into account four fundamental perspectives: financial, customer, internal processes, and learning and development. Together, these perspectives form a coherent framework that enables the translation of business strategy into specific operational actions (Wolniak, Grebski, 2023a; Armijos et al., 2025). An important feature of this tool's concept is the inclusion of both financial and non-financial indicators, which enables a more comprehensive assessment of the company's performance. The BSC aids in identifying cause-and-effect relationships between the distinct perspectives, highlighting the mechanism of value creation and the links between investments in intangible resources and the results achieved (Alanazi, 2025; Quesado et al., 2025).

The effectiveness of implementing and applying the BSC depends to a large extent on the appropriate selection of measurement tools, particularly key performance indicators (KPIs). These indicators are a fundamental element of strategy operationalisation. They enable the monitoring of the degree to which objectives are being met, the detection of deviations, and the implementation of corrective actions (Martynenko et al., 2020; Pacana, Czerwińska, 2023b). In the context of machine safety management, it is crucial to consider both outcome

KPIs, reflecting the consequences of adverse events (e.g. number of accidents, downtime costs), and leading KPIs, enabling the identification of potential hazards before they occur (e.g. near-miss incidents, the competence level of operators) (Czerwińska et al., 2025). It is also important to include indicators that allow for the assessment of compliance with safety requirements, the reliability of technical systems, and the effectiveness of preventive measures (Hu et al., 2020). The implementation of such an approach supports the transition from a reactive to a proactive safety management model, which is based on monitoring, preventing the occurrence of hazardous events, and the continuous improvement of processes (Kasprzyczak et al., 2025).

At the same time, the rapid development of the Industry 4.0 concept—which encompasses technologies such as big data analytics, the Internet of Things (IoT), artificial intelligence (AI) and cyber-physical systems—is having a significant impact on changes in the way industrial enterprises operate (Hrosul et al., 2023; Czerwińska, Pacana, 2019). The integration of production systems with digital solutions enables the ongoing monitoring of machine condition, real-time data analysis, and the prediction of potential failures and risks, which facilitates the implementation of predictive maintenance concepts and intelligent decision-support systems for safety assurance (Wolniak, Grebski 2023b; Veile et al., 2022). More broadly, the concept of Industry 4.0 is driving a shift away from traditional production models towards autonomous, intelligent and interconnected manufacturing systems, within which digital twins play a key role, enabling process simulation and the detection of risks at the virtual stage (Grabowska et al., 2019; Cruzara et al., 2023; Ni, Li, 2024). Advances in data analytics and machine learning algorithms enable adaptive process control and, in turn, their continuous optimisation. The transition towards Industry 4.0 also has an organisational dimension, which encompasses a shift in the approach to knowledge management, the development of staff competencies, and the fostering of a safety culture (Yaqub, Alsabban, 2023; Nakhal et al., 2021). Consequently, the growing importance of data and its quality necessitates the integration of information systems and the establishment of coherent management structures. This contributes to increased operational efficiency and the reliability of technical systems (Ji et al., 2024; Marcon et al., 2022).

In response to the latest trends in the development of industrial enterprises, resulting from the implementation of Industry 4.0 principles, it is appropriate to extend the classic BSC concept to include an additional perspective relating to this paradigm. Furthermore, this perspective acts as a cross-cutting factor, integrating information and technology aspects with the company's other operational areas. This approach contributes to a more comprehensive reflection of the conditions of modern industrial activity and enhances the company's ability to adapt efficiently in the face of dynamic market changes. An expanded BSC incorporating the Industry 4.0 perspective allows data from digital systems to be linked to strategic objectives and performance indicators.

Taking into account the circumstances outlined above, the aim of this study was to develop and validate a model to support the safety management of machinery and equipment, based on the integration of an extended Balanced Scorecard concept with solutions specific to the Industry 4.0 framework. A key element of the adopted approach was the identification and systematisation of the determinants of safety levels in the production environment, followed by their operationalisation in the form of a set of appropriate key performance indicators, enabling a quantitative assessment of the achievement of strategic objectives. A key aspect of the analysis was also the mapping of relationships between individual factors and the model's perspectives in the form of cause-and-effect links. The adopted approach contributes to a better understanding of the mechanisms and levers shaping the level of machine safety. The developed model supports the construction of a coherent and adaptive safety management system in an industrial enterprise.

2. Method

The development of a machine safety management model based on the extended Balanced Scorecard approach, incorporating Industry 4.0 concepts, requires the formulation of a structured research methodology. The adopted approach is based on a sequential progression from defining the model's structure, through the parameterisation of its elements, to the analysis of the cause-and-effect relationships that occur between the perspectives of the extended BSC. This approach ensures consistency between the adopted strategic objectives, KPIs and the mechanisms of their mutual interaction. The research methodology adopted has been divided into six stages.

Stage 1. Development of an extended Balanced Scorecard model – development of the analytical structure of the machine safety assurance model based on the BSC concept. Definition of the four classic BSC perspectives and introduction of an additional Industry 4.0 perspective. This additional perspective acts as a cross-cutting factor supporting the digital transformation of the machine safety management system. At the same time, strategic objectives related to ensuring and improving machine safety are defined for each of the perspectives. The result is a coherent model structure that forms the basis for its further operationalisation, as well as for the selection of appropriate KPIs.

Step 2. Identification and operationalization of KPIs – selection of appropriate KPIs based on a previously defined BSC structure. This includes both outcome indicators (e.g., failure costs, number of accidents, MTBF, MTTR) and leading indicators (e.g., near-misses, competency level, degree of digitization) to enable a comprehensive assessment of machine safety. Defining KPIs with regard to units of measurement and their significance in evaluating the achievement of established goals. Additionally, defining how Industry 4.0 technologies will

be applied in data collection and analysis, which helps ensure the consistency of the measurement system and enables more effective monitoring.

Step 3. Development of a KPI impact matrix for the objectives of the extended BSC perspectives—conducting a qualitative analysis of the relationships between the selected KPIs and the objectives in the individual perspectives of the balanced scorecard. Application of a three-point rating scale to determine the strength of each KPI's impact on the achievement of strategic objectives. As a result, it is possible to identify direct and indirect relationships, as well as to identify the dominant areas of KPI influence, especially in the context of ensuring the safety and reliability of technical systems.

Stage 4. Analysis of cause-and-effect relationships—interpretation of the impact matrix from a systemic perspective, defining the relationships between KPIs and BSC perspectives. Based on this, cause-and-effect chains are identified, illustrating the relationships between individual perspectives—starting with employee competencies, through the stability of technical processes, to financial outcomes. Particular attention was paid to the role of the Industry 4.0 perspective as a catalytic factor that enhances the diagnostic, decision-making, and predictive capabilities of the safety management system.

Step 5. Development of the BSC strategic map – development of a strategic map illustrating the cascading relationships between the distinct perspectives of the expanded BSC. The map illustrates the logic of value creation across the perspectives: from learning and development to financial results. In the adopted approach, the Industry 4.0 perspective constitutes a horizontal layer that influences the other areas of the system.

Stage 6. Synthesis and interpretation of the model – integration of the results of all previous analyses and their interpretation in the context of machine safety management.

The procedure developed within the model enabled the systematic and coherent development of an extended BSc model in the area of machine safety, taking into account the concept of Industry 4.0. The adopted procedure, encompassing model construction, KPI operationalization, matrix analysis, and the identification of cause-and-effect relationships, enabled the transition from a conceptual approach to an analytical and decision-making model. As a result, a model was developed that enables a multifaceted assessment of machine safety, integrating organizational, technical, human, and digital perspectives.

3. Results and discussion

The research was conducted in close collaboration with an industrial company located in southeastern Poland and operating in the foundry industry. The company specializes in the production of metal products using partially robotized and automated production lines. The company is characterized by a high degree of complexity in its production processes,

a significant proportion of high-risk operations, and intensive use of its machinery, making the area of machine and equipment safety one of the key elements of operational management.

Adopting the presented research context allowed the work to be focused on issues closely related to the management and improvement of machine and equipment safety, including hazard identification, reducing failure rates, and improving operators' working conditions. This enabled the model structure (including the extended version of the BSC, the impact matrix, and the correlated strategic map) and the proposed set of KPIs to be tailored to the specific characteristics and objectives of the company under study. The adopted approach contributed to maintaining the model's practical applicability and ensured its alignment with industrial realities.

As part of the implementation of an expanded BSC model in the area of machine and equipment safety, KPIs were developed and assigned to the model's individual perspectives. Both standard BSC perspectives and an additional perspective related to the concept of Industry 4.0 were included, reflecting trends in industrial enterprises—the growing importance of digitalization, cyber-physical systems, and data analysis in safety management. The selection of KPIs was carried out in the context of a comprehensive assessment of the safety level of machines and equipment, covering technical, economic, organizational, and competency aspects, as well as the organization's ability to respond proactively and predictively to threats. Table 1 presents the company's objectives adopted for each perspective, the corresponding KPIs, the rationale for their selection, as well as proposals for the use of Industry 4.0 tools in the context of safety monitoring and improvement.

Table 1.
A summary of key performance indicators in the extended Balanced Scorecard model for machine safety, taking Industry 4.0 into account

BSC perspective	Objective of the framework (machine safety)	KPI	Justification for KPI selection	Applications of Industry 4.0
Finance	Minimizing costs associated with accidents and machine breakdowns	- Cost of unplanned downtime [EUR/year]. - Cost of workplace accidents [EUR/year]. - Prevention effectiveness (cost of preventive measures vs. cost of breakdowns) [%].	KPIs demonstrate the economic impact of safety deficiencies and the effectiveness of preventive measures	Integration with ERP and CMMS systems; real-time cost data analysis
Customer (internal)	Ensuring a safe working environment for operators	- Number of incidents [incidents/100 employees]. - Near-miss rate [incidents/year]. - Safety perception level [%].	They reflect the actual level of safety and safety culture	Incident reporting systems (mobile apps), behavioral data analysis

Cont. table 1.

Internal processes	Improving machine reliability and operational safety	- MTBF (mean time between failures) [hours]. - MTTR (mean time to repair) [hours]. - Number of unplanned outages [events/year]. - Percentage of machines compliant with safety requirements [%].	KPIs directly relate to technical condition and the risk of failure	Predictive maintenance, IoT, machine condition monitoring
Learning and development	Developing employee skills in safe machine operation	- Number of health and safety training sessions per employee [trainings/year]. - Operators' competency level [%]. - Number of safety improvement suggestions submitted [suggestions/year].	Employee competencies are key to preventing accidents	E-learning platforms, VR/AR for training, competency analysis
Industry 4.0	Digital safety management and hazard prediction	- Percentage of machines covered by IoT monitoring [%]. - Number of predictively detected failures [events/year]. - System response time to a threat [s]. - Level of security system integration [%].	KPIs measure the level of digitalization and the ability to proactively manage safety	IoT, Big Data, AI/ML, digital twins, cyber-physical systems

Source: own study.

The summary presented in Table 1 shows the structure of an industrial enterprise's objectives and the associated indicators within the framework of an extended BSC model focused on the management of machine and equipment safety.

The financial perspective (Table 1) focuses on identifying the economic consequences of the level of machine safety and the effectiveness of preventive measures taken. The KPIs included in this perspective enable an assessment of the relationship between expenditures incurred for the prevention of failures and accidents and the costs resulting from their occurrence. This approach supports the rationalization of investment decisions in the area of technical safety and indicates that preventive measures can be a significant factor that both reduces financial losses and improves the stability of the company's operations.

The internal customer perspective (Table 1) directly concerns employees as machine users and beneficiaries of a safe work environment. The assigned KPIs enable the assessment of the actual safety level and reflect operators' perceptions, which is crucial for building safety. Including the near-miss incident rate will help identify hidden hazards and take preventive measures before situations with more serious consequences occur.

The internal processes perspective (Table 1) refers to the technical and operational aspects of machine operation that directly determine safety levels. KPIs related to equipment reliability and uptime allow for the identification of areas requiring improvement and enable the assessment of the effectiveness of maintenance activities. This approach emphasizes the importance of systematically monitoring the technical condition of machines and implementing solutions that minimize the risk of failures and unplanned downtime.

The learning and development perspective (Table 1) highlights the role of a company's human capital in ensuring the safe operation of machinery. Indicators regarding competency levels, training activity, and employee engagement in improvement initiatives underscore the importance of continuously enhancing knowledge, qualifications, and building awareness of hazards. The development of staff competencies forms the basis for the effective use of modern technologies supporting risk management and is a prerequisite for the effective implementation of safety procedures.

The additional BSC perspective related to the Industry 4.0 concept (Table 1) reflects a shift in the approach to machine safety management, moving from reactive to proactive and predictive measures. The KPIs assigned to this perspective enable the assessment of the level of process digitization and support the evaluation of an enterprise's ability to utilize real-time (or near-real-time) data for the detection and mitigation of risks. The process of integrating modern technologies—including monitoring systems, data analytics, and AI-based solutions—facilitates the creation of advanced and effective safety management systems.

As part of the analysis of the relationships between the developed KPIs and the strategic objectives of the individual perspectives of the developed BSC, the strength of their impact was assessed. This analysis allows for a transition from a static list of indicators to a relational framework, in which individual KPIs are viewed as components of a system of interrelated interactions. The adopted approach enables the identification of key levers of influence within the management of machine and equipment safety and also facilitates the identification of indicators that have the greatest impact on the achievement of the adopted objectives.

The results of the analysis are presented in Table 2 in the form of an impact matrix, which illustrates the relationships between KPIs and the objectives of the extended BSC framework, taking into account the context of digital transformation resulting from the implementation of Industry 4.0 solutions. The analysis was conducted qualitatively, using an impact scale ("+++", "++", "+") that reflects the relative strength of the impact of individual KPIs on the achievement of strategic objectives in the individual BSC perspectives.

Table 2.
Matrix of the impact of key performance indicators on goals within the framework of the sustainable scorecard perspective

KPI \ Perspective (goal)	Finance	Customer (internal)	Internal processes	Learning and development	Industry 4.0
Cost of unplanned downtime	+++		++		
Cost of workplace accidents	+++	++			
Cost of prevention vs. breakdowns	++		+		
Number of accidents	++	+++	++		
Near-miss rate		++	++	+	
Safety perception		++		++	
MTBF	++		+++		+
MTTR	++		+++		+
Number of unplanned shutdowns	+++		+++		+
Percentage of machines compliant with requirements	++	+	++		+

Cont. table 2.

Number of health and safety training sessions		+		++	+
Operator competency level	+	++	++	+++	+
Number of improvements		+	+	++	+
Percentage of machines with IoT	+		++		++
Predictively detected failures	++		+++		+++
System response time	++	+	++		+++
System integration	+		++		++

Rating: +++ – very strong impact, ++ – strong impact, + – moderate impact, blank field – no significant impact.

Source: own study.

The matrix developed (Table 1) is a tool designed to facilitate the analysis of the relationships between KPIs and strategic objectives. This map enables the identification of areas with the greatest impact on the achievement of BSC objectives and the determination of potential avenues for optimizing the machine and equipment safety measurement system within the enterprise. The distinct perspectives within the BSC do not function autonomously but are interrelated and form an interdependent system that determines the level of safety under examination.

From a systemic perspective, changes within one perspective cause cascading effects in other areas. For example, improving employee competencies and intensifying training activities (activities within the learning and development perspective) helps reduce the number of operational errors, which directly translates into a reduction in the number of accidents and an increase in process stability (internal processes perspective) and, as a result, leads to a reduction in the costs of failures and accidents (financial perspective). Similarly, the implementation of Industry 4.0 solutions enhances diagnostic and predictive capabilities in technical systems, which simultaneously improves reliability, safety, and operational efficiency.

In this context, the BSC model should be viewed as an interconnected structure in which the distinct perspectives are interrelated, and the interactions between them are nonlinear and dynamic. This approach provides a more realistic representation of the complexity of the technical safety system, within which human, organizational, technological, and economic factors are interdependent.

The developed matrix (Table 2) aids in identifying the strength and direction of the impact of the identified indicators; however, it is static in nature and does not fully capture the cause-and-effect relationships between the perspectives. For this reason, it was appropriate to create a strategic map (Figure 1), which organizes the existing relationships into a logical sequence of values. The map's structure is hierarchical (from the learning and development perspective, through internal processes and the internal customer perspective, to the financial perspective), which illustrates the logic of value creation within the enterprise. The map also accounts for the role of Industry 4.0 solutions as an aspect that strengthens the entire system.

The arrows placed within the map (Figure 1) serve as a vehicle for analytical information, facilitating the interpretation of the model's dynamics, and fulfill a dual interpretive function:

- indicating the direction of influence (cause-and-effect relationships), reflecting the flow of values and effects between perspectives,
- the symbols used (for example, "↑", "↓") concisely describe the nature of the changes (increase or decrease) and specify their consequences for subsequent BSC perspectives.

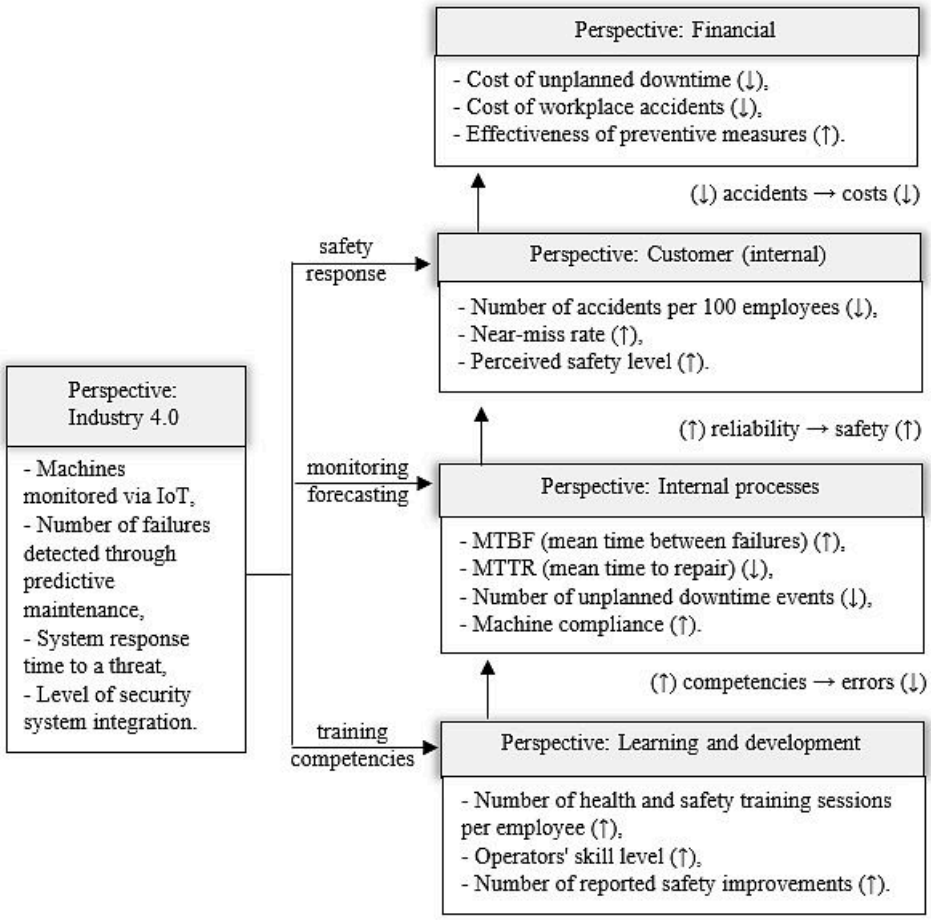

Figure 1. A strategic map of cause-and-effect relationships in the extended Balanced Scorecard model for machine safety.

Source: own study.

The learning and development perspective (Figure 1) forms the basis of the model, within which the development of employee competencies, the intensification of occupational safety and health training activities, and efforts to report improvements contribute to increased risk awareness and a reduction in human errors. These relationships are illustrated by upward-pointing arrows, indicating the transfer of effects to the internal processes perspective. From this perspective, increased operational competence results in improved technical reliability (increased MTBF, decreased MTTR), a reduction in the number of unplanned stoppages, and greater compliance of machinery and equipment with safety requirements.

Within the internal customer perspective (Figure 1), the result of stable and safe internal processes translates into a reduction in the number of accidents, an increase in the number of near-miss reports, and an improvement in the perception of safety among the company's employees. The arrows between the internal processes perspective and the internal customer indicate the direct impact of the quality of technical process execution on working conditions and personnel safety levels.

The financial perspective is positioned at the top level of the strategy map (Figure 1). This perspective aggregates the effects of previous actions. Arrows leading from lower perspectives indicate that improvements in machine safety and reliability contribute to a reduction in emergency downtime costs, a reduction in workplace accident costs, and a higher level of efficiency between prevention expenditures and failure costs. Consequently, the developed strategy map reflects the mechanism of the classic BSC (which includes four perspectives), according to which financial results are the outcome of operational and development activities.

The Industry 4.0 perspective plays a key role in the developed model; it is depicted on the strategy map (Figure 1) as an element that has a horizontal impact on other areas and acts as a catalyst for change. With regard to the internal processes perspective, technologies such as IoT and data analytics enable the monitoring of machine condition and a predictive approach to maintenance. This approach translates into fewer breakdowns and increased reliability. In relation to the internal customer perspective, these technologies improve workplace safety by enabling rapid identification of and response to hazards, and they also support the development of a safety culture. In the learning and development perspective, Industry 4.0 supports the process of enhancing employee competencies through the use of digital tools (such as e-learning or simulations). The use of these tools allows for better preparation for work in a high-tech environment. As a result, incorporating the Industry 4.0 perspective and implementing its characteristic technologies contributes to the simultaneous improvement of technical processes, increased employee safety, the development of digital competencies, and cost optimization.

Overall, both the impact matrix (Table 2) and the strategy map (Figure 1) confirm that the safety of machinery and equipment is the result of the interaction of human, technical, organizational, and digital factors. The relationships between these factors are systemic, multidirectional, and involve feedback loops.

4. Summary

The aim of this study was to develop and validate a model supporting machine safety management by integrating an extended Balanced Scorecard concept with tools and solutions characteristic of Industry 4.0. The integration of the classic BSC structure with the Industry 4.0 perspective enabled the analysis to be expanded to include issues related to monitoring, real-time data processing, and prediction, which served as a significant complement to machine safety assessment methods.

As part of the study, a set of key performance indicators (KPIs) was developed that are relevant to each of the BSC perspectives. The impact of individual KPIs on the achievement of strategic objectives was also analyzed using a dependency matrix. Based on this, key cause-and-effect relationships were identified, and the logic of interactions between the perspectives was defined, as reflected in the strategic map developed. The results obtained indicate the significant role of employee competencies and the stability of technical processes as determinants of machine safety levels, and also highlight the importance of Industry 4.0 technologies as a factor enhancing the effectiveness of decision-making and preventive actions.

The research findings can be applied in both the academic community and industrial practice, particularly in industrial enterprises with complex technological process structures. The developed model can support management and maintenance staff in making decisions regarding the safety and reliability of technical systems.

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THE IMPACT OF ARTIFICIAL INTELLIGENCE AND DIGITALISATION ON THE DEVELOPMENT OF INTELLECTUAL PROPERTY-BASED ORGANISATIONAL CREATIVITY

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Purpose: This article analyzes the evolution of organizational creativity in the context of digitalization and artificial intelligence (AI).
Design/methodology/approach: Traditional models based on individual competencies and social interactions are being transformed by AI-driven digital ecosystems, which enhance innovation efficiency and accelerate time-to-market. Through a systematic literature review and case studies of medium and large enterprises (2015–2025), the study identifies technological, organizational, and cultural factors influencing AI-supported creative processes and intellectual property (IP) management.
Findings: The findings indicate that effective AI integration requires developing digital competencies, transformational leadership, and a culture fostering innovativeness. The study also highlights emerging legal and ethical issues, including authorship, accountability, and data licensing. It proposes a conceptual model that integrates technology, knowledge management, and organizational culture to support sustainable innovation.
Practical implications: The article contributes to theory by extending classical creativity frameworks (Amabile; Nonaka and Takeuchi) to the digital and AI context, while offering practical guidance for managers and decision-makers on leveraging human-AI co-creation alongside IP protection.
Social implications: What will be the impact on society of this research? How will it influence public attitudes? How will it influence (corporate) social responsibility or environmental issues? How could it inform public or industry policy? How might it affect quality of life? Not all papers will have social implications.
Originality/value: The article presents an original integrative framework linking artificial intelligence, digitalization, and intellectual property management within the context of organizational creativity. Unlike prior research, which treats AI primarily as a technological tool, the article conceptualises AI as a co-creative actor embedded within organisational knowledge ecosystems. By extending classical theories of creativity and knowledge creation to AI-driven environments, the paper offers a novel interdisciplinary perspective that integrates management theory, digital transformation, and intellectual property governance, thereby addressing a significant research gap in contemporary innovation studies.
Keywords: Organizational creativity, artificial intelligence, digitalization, intellectual property, innovation, knowledge management.
Category of the paper: Research paper.

1. Introduction

The contemporary economy is increasingly based on knowledge and innovation, and intellectual property (IP) constitutes a key strategic resource for organizations. Innovation is no longer merely a source of competitive advantage; in many industries, it determines an organization's survival and its ability to respond dynamically to market changes. The rapid development of digital technologies, such as artificial intelligence (AI), big data analytics, the Internet of Things (IoT), and blockchain, is transforming traditional models of organizational creativity. These technologies enable more efficient idea generation, product prototyping, knowledge management, and intellectual property protection, while simultaneously introducing new challenges related to data security and the risk of IP infringement. Despite the growing body of research on innovation and IP management, there is still no comprehensive and integrative understanding of how digital technologies affect creative processes in organizations. Addressing this gap requires consideration of both technological and organizational dimensions, including knowledge management models, innovation culture, and the implications of increasing automation in creative processes. Accordingly, this article addresses the following research question: How do digital technologies, particularly artificial intelligence, transform the processes of creating, developing, and managing intellectual property in organizations? The subject of this study is to review and synthesize existing knowledge and to develop a conceptual framework explaining the role of digital technologies in shaping organizational creativity and IP development. The study adopts an exploratory and conceptual perspective, focusing on the integration of technological, organizational, and process-oriented dimensions.

Scope of the Research

The scope of the study includes:

- the characteristics of technologies supporting innovation and IP creation,
- the identification of relationships between technology use and the effectiveness of creative processes,
- the analysis of challenges related to the implementation of digital technologies in IP management,
- the formulation of practical recommendations for innovation managers and IP strategists.

The analysis covers medium and large enterprises with formalized innovation and intellectual property management processes in place between 2015 and 2025. The study deliberately excludes startups and country-specific legal frameworks. While this allows for a more focused analysis of mature and structured organizational environments, it also limits the generalizability of the findings, particularly in relation to highly dynamic innovation contexts and diverse regulatory regimes. These limitations should be taken into account when interpreting the results and highlight important directions for future research.

2. Research Methodology

The purpose of this article is to develop a theoretical and conceptual model that integrates classical concepts of organizational creativity with contemporary approaches based on digitalization and artificial intelligence (AI). The study adopts a qualitative and exploratory research design, drawing on a critical synthesis of the literature and an analysis of selected organizational cases. The objective is not to test causal relationships empirically, but to identify key mechanisms, relationships, and patterns linking digital technologies with creative processes and intellectual property (IP) management. Accordingly, the findings should be interpreted as analytical generalizations, providing theoretical insights and a foundation for future empirical research, rather than statistically generalizable results.

2.1. Research Approach and Strategy

A conceptual - analytical approach was adopted, typical of exploratory research in the management sciences and oriented toward theory development through the integration of empirical and conceptual contributions (Jaakkola, 2020). The study employs a two-pronged methodological strategy:

- Systematic literature review – aimed at identifying key theoretical constructs, relationships, and research gaps.
- Illustrative case studies – used to contextualize and exemplify the application of digital technologies in real organizational settings.

The case studies follow a pattern-matching logic (Yin, 2018), enabling the comparison of observed practices across cases and the identification of recurring mechanisms. This combination enables both a structured synthesis of existing knowledge and a theory-informed interpretation of practice.

2.2. Stage 1 – Systematic Literature Review

The literature review was conducted using a systematic and thematic approach, ensuring transparency and methodological rigor. The analysis included 68 peer-reviewed scientific publications indexed in the Scopus and Web of Science databases.

Search Strategy

The literature search was conducted using the following keywords:

- organizational creativity,
- digital transformation,
- artificial intelligence,
- knowledge management,
- intellectual property.

Inclusion Criteria

- peer-reviewed journal articles,
- publications in English,
- thematic relevance,
- publication period: primarily 2015-2025, supplemented by seminal earlier works.

Exclusion Criteria

- non-peer-reviewed sources,
- purely technical AI studies without organizational context,
- publications not directly related to innovation or IP processes.

The analysis focused on identifying relationships between technological, organizational, and outcome variables.

2.3. Stage 2 – Case Study Analysis

The second stage involved the analysis of eight illustrative case studies: Estée Lauder, IBM Watsonx, Chiesi, Ontex, Walmart, ARM Ltd, Dyson, and Spotify.

The selection was purposeful and theory-driven, based on:

1. documented use of AI,
2. availability of reliable data,
3. Sectoral diversity.

The cases are illustrative rather than statistically representative. Data sources included industry reports, corporate publications, and academic studies.

The analysis focused on:

- AI in creative processes,
- digitization of innovation,
- IP creation and protection,
- risk and ethics.

2.4. Stage 3 – Conceptual Model Design

Based on the results of the systematic literature review and the case study analysis, a conceptual and integrative model was developed to explain how digital technologies and artificial intelligence (AI) influence organizational creativity and the creation of intellectual property (IP). The model integrates four interrelated dimensions:

- Technological dimension – digital infrastructure, AI systems, and digital tools enabling data processing, ideation, and simulation.
- Organizational dimension – innovation culture, leadership styles, and collaboration structures shaping the environment for creativity.

- Process dimension – knowledge creation, knowledge conversion (tacit–explicit), and co-creation mechanisms.
- Outcome dimension – innovation performance and intellectual property value (e.g., patents, know-how, and commercialization outputs).

The model assumes that organizational creativity emerges from the dynamic interaction between these dimensions, rather than from isolated factors. In particular, digital technologies act as enablers and accelerators of knowledge processes, while organizational factors condition and shape their effectiveness. Importantly, the model specifies directional relationships between variables. Technological factors (e.g., AI intensity and digital infrastructure) are assumed to positively influence process efficiency, particularly in terms of knowledge creation, recombination, and iteration speed. Organizational factors (e.g., innovation culture, leadership, and collaboration structures) act as moderating variables, strengthening or weakening the impact of technological capabilities on process outcomes. Furthermore, process-related variables mediate the relationship between AI adoption and innovation outcomes, including intellectual property value and innovation performance. This structure reflects a mediated - moderated relationship between the key dimensions of the model. In this study, artificial intelligence is conceptualized as an augmentative socio-technical agent that supports and enhances, rather than autonomously replaces, human creativity. Its role is embedded within organizational and processual contexts, where it contributes to hybrid human–AI systems of knowledge creation.

The framework incorporates:

- feedback loops, reflecting iterative learning and continuous improvement in innovation processes,
- the non-linear nature of innovation, including parallel and cyclical development activities,
- the role of external actors (users, partners) in open innovation ecosystems, including crowdsourcing and platform-based co-creation.

To address the exploratory nature of the study and enable future empirical validation, the model is designed to be operationalizable in subsequent research. Potential indicators include:

- AI intensity – the extent to which AI supports tasks within innovation and creative processes,
- knowledge conversion efficiency – the speed and effectiveness of tacit–explicit knowledge transformation,
- IP value – measured through patent output, licensing revenues, or portfolio strength,
- innovation speed – reflected in time-to-market and iteration cycles.

The proposed model is conceptual rather than empirically tested and should be interpreted as a theoretical framework that organizes relationships between key variables. It provides a structured foundation for future quantitative and mixed-method studies aimed at testing causal relationships and refining measurement instruments.

2.5. Limitations and Nature of the Analysis

This study is a qualitative, exploratory, and theory-building investigation, based on a critical synthesis of existing literature and illustrative case analysis. The primary aim is to develop a conceptual framework that integrates technological, organizational, and process-oriented perspectives on creativity and intellectual property (IP) management, rather than to empirically test causal relationships. Several limitations should be explicitly acknowledged. First, the absence of primary empirical data limits the ability to validate the proposed relationships between variables, including the mediating and moderating effects identified in the conceptual model. As a result, the model should be treated as a theoretically grounded structure requiring further empirical verification. Second, the exclusion of startups reduces the applicability of the findings to highly dynamic, resource-constrained, and less formalized innovation environments. Consequently, the model may be more representative of medium and large organizations with established innovation and IP management systems. Third, the omission of country-specific legal and institutional frameworks limits the ability to capture regulatory influences on intellectual property creation, protection, and commercialization. This may affect the external validity of the findings across different legal and economic contexts. Fourth, the reliance on secondary data and illustrative case studies does not allow for statistical generalization or hypothesis testing. The case analysis follows an interpretative and pattern-oriented logic, which supports theory development but does not provide causal inference. Therefore, the results should be interpreted as analytical generalizations, offering theoretical insights and conceptual structuring rather than statistically generalizable conclusions. The proposed relationships between technological, organizational, process, and outcome dimensions remain indicative and require empirical validation. Despite these limitations, the study contributes to the literature by offering a systemic and integrative perspective on the relationship between artificial intelligence, organizational creativity, and intellectual property development. It advances existing research by proposing a multidimensional and operationalizable conceptual model. Future research should focus on:

- empirical testing of the proposed relationships using quantitative and mixed-method approaches,
- refinement and validation of measurement scales for constructs such as AI intensity and knowledge conversion efficiency,

- inclusion of startups and SMEs to assess the model's applicability in diverse innovation contexts,
- incorporation of institutional and regulatory variables to better capture cross-country differences in IP management.

3. Literature Review

3.1. Classical Approaches to Creativity and Innovation

Creative thinking and innovation have long been recognized as fundamental sources of competitive advantage in organizations, forming the basis for value creation in both private and public sectors. Classical theoretical frameworks provide a well-established foundation for understanding these processes. One of the most influential approaches is Amabile's componential model (1996), which conceptualizes organizational creativity as the result of the interaction between three key elements: individual competencies, intrinsic motivation, and a supportive work environment. This perspective highlights the importance of internal and contextual factors in shaping creative performance. Similarly, the SECI model developed by Nonaka and Takeuchi (1995) explains organizational knowledge creation as a dynamic and continuous process involving the interaction between tacit and explicit knowledge. Through the processes of socialization, externalization, combination, and internalization, individual knowledge is transformed into organizational innovation outcomes. While these models remain highly influential, they were developed in a pre-digital context. As such, they do not explicitly account for the role of contemporary digital technologies, particularly artificial intelligence (AI), in shaping knowledge creation and creative processes. This limitation creates a need to reinterpret classical frameworks in light of ongoing digital transformation.

3.2. Digital Transformation of Creativity and Innovation

The emergence of digital technologies has significantly reshaped traditional innovation paradigms. Artificial intelligence, in particular, enhances creative processes by enabling large-scale data analysis, pattern recognition, and predictive modeling, thereby increasing the speed and efficiency of innovation activities (Davenport, Kirby, 2016). From a strategic perspective, AI reduces uncertainty in decision-making processes and supports more precise resource allocation in product and service development (Agrawal, Gans, Goldfarb, 2018). When integrated with agile methodologies, such as Lean Startup (Ries, 2011), AI facilitates iterative experimentation, rapid prototyping, and continuous validation of innovation hypotheses. Recent studies also indicate that generative AI systems contribute to the transformation of tacit knowledge into explicit knowledge, extending the applicability of the

SECI model in digital environments (Secundo et al., 2024). In this context, AI supports knowledge codification, recombination, and diffusion, thereby accelerating creative processes. Importantly, AI should be understood not as a substitute for human creativity, but as an augmentative system that expands cognitive and analytical capabilities. This perspective aligns with the concept of human–AI collaboration, where creativity emerges from hybrid socio-technical systems rather than isolated human or technological inputs.

3.3. Critical Perspectives on AI-Driven Creativity

Alongside optimistic perspectives, a growing body of literature highlights the risks and limitations associated with AI in creative processes.

One of the key concerns is the potential homogenization of creative outputs. Since AI systems are trained on historical datasets, they tend to reproduce dominant patterns and statistically probable solutions, which may reduce diversity and originality (Sham, 2024; Manovich, Arielli, 2024; Staszewska-Jedynasty, 2025). This may limit exploratory and non-linear forms of innovation. Empirical evidence supports this concern. A meta-analysis by Holzner, Maier, and Feuerriegel (2025) indicates that while AI-assisted processes may increase efficiency, they may simultaneously reduce the diversity of generated ideas, suggesting a trade-off between efficiency and creative variety. In addition, AI introduces new challenges related to authorship, accountability, and intellectual property governance. The increasing involvement of algorithmic systems in content generation complicates traditional frameworks for assigning ownership and responsibility (Crawford, 2023; Lucchi, 2025; Mammen et al., 2024).

3.4. Organizational and Institutional Conditions of AI-Enabled Creativity

The effectiveness of AI in creative processes is highly context-dependent. Empirical studies suggest that technological capabilities generate value only when embedded in supportive organizational and institutional environments. From an organizational perspective, factors such as innovation culture, knowledge sharing, collaboration, and leadership play a critical role in enabling AI-supported creativity (Gazi et al., 2024; Florek-Paszkowska, Ujwary-Gil, 2025). At the same time, institutional and regulatory frameworks are increasingly important. The governance of AI-driven creativity requires clear rules regarding intellectual property rights, data licensing, and algorithmic transparency. These elements are essential for ensuring accountability, trust, and sustainability in innovation systems (Lucchi, 2025; Mammen et al., 2024).

3.5. Synthesis and Implications for the Conceptual Model

The literature indicates that artificial intelligence is reshaping organizational creativity towards hybrid human–technology systems. However, this transformation is characterized by both enabling and constraining effects, and its outcomes depend on contextual conditions rather than technological adoption alone. Three key insights emerge from the literature:

- Technological dimension – AI enhances data processing, knowledge recombination, and innovation speed.
- Organizational dimension – culture, leadership, and collaboration determine the effectiveness of AI use.
- Institutional dimension – legal and ethical frameworks shape the governance and legitimacy of AI-driven creativity.

These findings provide the theoretical foundation for the conceptual model proposed in this study. In particular, they support the assumption that organizational creativity results from the interaction between technological, organizational, and process-related factors, and that the relationship between AI adoption and innovation outcomes is mediated and moderated by contextual variables.

4. The Impact of Artificial Intelligence and Digitization on Creative Processes – Case Studies

Case studies of medium-sized and large enterprises demonstrate that artificial intelligence (AI) and digitization serve as important catalysts for change in organizational creative processes. The cases were analysed using a comparative and pattern-matching approach, aimed at identifying recurring mechanisms of AI-enabled creativity across different organizational contexts.

The analysis reveals several recurring mechanisms:

- Automation of analytical tasks – AI systems support data analysis, pattern recognition, and prediction, enabling faster and more informed decision-making in product development processes (e.g., Estée Lauder).
- Iterative learning and prototyping – AI-enabled environments facilitate rapid hypothesis testing and knowledge conversion, consistent with SECI and Lean Startup approaches (e.g., IBM Watsonx).
- Human–AI co-creation – organizations increasingly integrate AI tools into collaborative innovation ecosystems, supporting distributed creativity and IP development (e.g., ARM Ltd).

- R&D process optimization – AI systems enhance prioritization and efficiency in research and development activities, particularly in data-intensive sectors such as pharmaceuticals (e.g., Chiesi).
- Decision support in operational and strategic processes – AI applications support forecasting, personalization, and resource optimization (e.g., Walmart, H&M, Zara).
- Simulation and virtual prototyping – AI-based modelling tools enable faster iteration and reduced reliance on physical prototyping (e.g., Dyson, Tesla).
- Platform-based creativity – AI systems shape both content production and consumption in digital ecosystems (e.g., Spotify, Netflix, Electronic Arts).

These examples should be interpreted as illustrative cases supporting the identification of broader mechanisms, rather than as isolated empirical observations or statistically representative evidence. Importantly, the identified mechanisms correspond to the dimensions of the conceptual model proposed in this study, particularly:

- the technological dimension (AI systems and digital infrastructure),
- the process dimension (knowledge conversion and iterative innovation),
- the organizational dimension (collaboration, culture, and learning),
- the outcome dimension (innovation performance and IP value creation).

4.1. Synthesis and Conclusions

The comparative analysis indicates that artificial intelligence transforms organizational creativity across four interrelated dimensions:

- Epistemological dimension – redefining how knowledge is generated, structured, and recombined.
- Process dimension – accelerating innovation cycles and enabling iterative experimentation.
- Cultural dimension – increasing the importance of learning, collaboration, and openness.
- Strategic dimension – embedding AI within competitive strategies and resource allocation decisions.

However, these effects should be interpreted as context-dependent patterns rather than universally generalizable causal relationships. The effectiveness of AI in creative processes depends on the alignment between technological capabilities, organizational conditions, and governance frameworks.

To fully leverage AI, organizations must ensure:

- alignment between technology and organizational culture,
- continuous development of employee competencies,
- implementation of robust governance frameworks addressing legal, ethical, and intellectual property issues.

The findings provide empirical support for the conceptual model proposed in this study, reinforcing the assumption that organizational creativity emerges from the interaction between technological, organizational, and process-related factors. The case analysis therefore serves as an illustrative empirical foundation for theory development, rather than a basis for hypothesis testing.

5. Theoretical Research Framework / Conceptual Model

Organizational creativity is currently understood as the result of complex interactions between individual employee competencies, their internal motivation, and a supportive work environment (Amabile, 1996). The SECI model of Nonaka and Takeuchi (1995) indicates that knowledge generation in organizations is based on the dynamic exchange of tacit and explicit knowledge, enabling the transformation of individual experiences into product and process innovations. However, contemporary approaches need to be expanded in the context of the growing role of digital technologies and artificial intelligence (AI), which are redefining the nature of creative and organizational processes. In the proposed model, digital technologies—including AI, virtual and augmented reality (VR/AR), and online collaboration platforms—act as catalysts for creative and innovative processes. They enable the generation of ideas, automation of analysis, identification of patterns, and faster verification of hypotheses (Davenport, Kirby, 2016; Füller, Hutter, Krüger, 2020).The integration of these technologies with Agile and Lean Startup methodologies (Ries, 2011) promotes iterative concept testing and the effective creation of intellectual property, including products, services, and know-how. The effectiveness of creative processes also depends on a culture of innovation, transformational leadership, and the capabilities of dynamic organizations (Bass, Avolio, 1994; Teece, Pisano, Shuen, 1999).

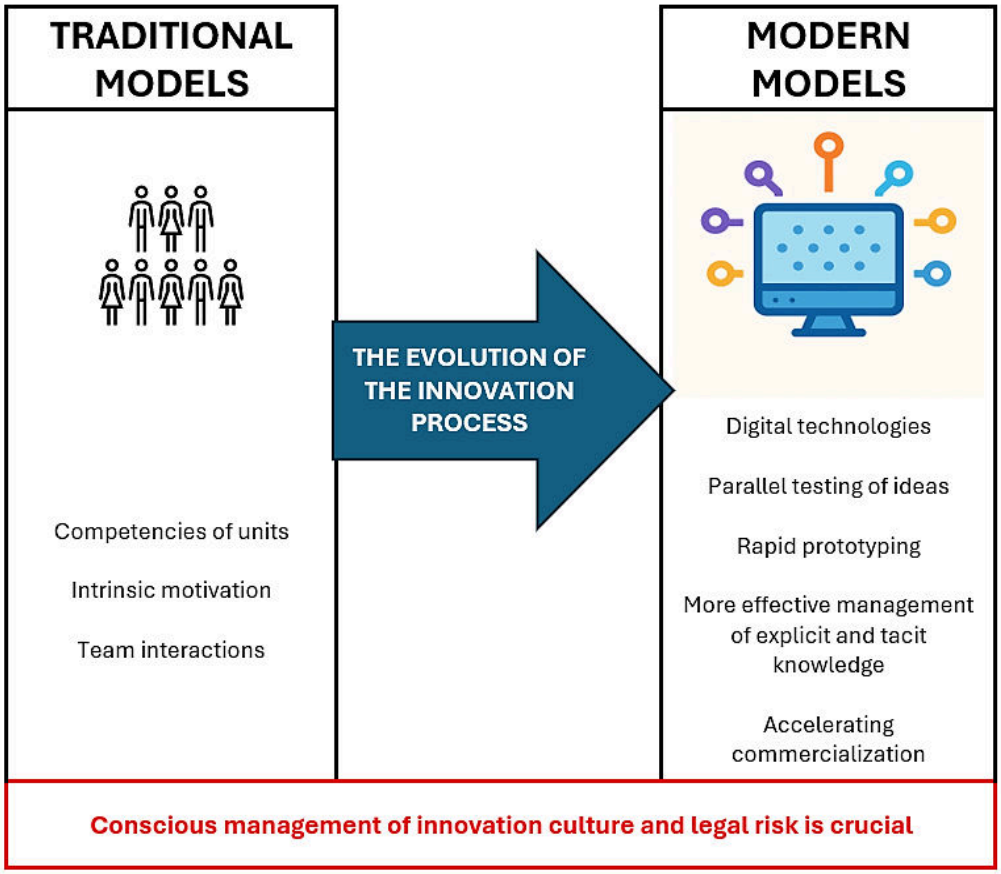

Figure 1. Conceptual model of the impact of digital technologies and AI on creative processes and organizational value creation.

Source: Prepared based on Amabile (1996), Nonaka, Takeuchi (1995), Teece et al. (1999), Davenport, Kirby (2016), Holzner et al. (2025).

The Conceptual Model views organizational creativity as a multi-level system in which digital technologies form the foundation and catalyst for creative activities. This foundation supports the development of processes for generating ideas, transferring knowledge, and co-creating in digital environments. The result of these processes is the creation of intellectual property—patents, products, services, and know-how which generate organizational value in the form of competitive advantage, improved operational efficiency, and the development of a sustainable culture of innovation. At the same time, these processes further strengthen the development of an organization's creative capabilities, creating a feedback mechanism between technology and organizational creativity. The model emphasizes the role of supporting factors such as leadership, knowledge management, and organizational culture, which strengthen the interactions between technology, processes, and the effects of innovative activity. The whole forms a coherent system in which the integration of people, knowledge, and digital technologies plays a key role in generating sustainable value in a knowledge-based economy. This model provides a theoretical foundation for further empirical research, including the operationalization of variables and the analysis of relationships between digital technologies, organizational factors, and innovation outcomes.

6. Analysis and Discussion of Results

An Analysis of literature and case studies indicates a significant impact of digital technologies, including AI, online collaboration platforms, and digital simulation tools, on creative processes in organizations. Generative AI systems enable parallel testing of multiple solution variants, reducing prototype development time by as much as 30-50%. Digital tools also streamline the collection of feedback from teams and users, improving the effectiveness of innovation processes and the quality of final products and services. The development of digital technologies opens up new opportunities for knowledge management and intellectual property protection. The use of cloud computing, blockchain, and advanced analytical tools enables the tracking of intellectual property rights and the identification of potential infringement risks.

At the same time, the implementation of generative AI presents legal and organizational challenges, especially in determining authorship and protecting the content created. Organizations must strike a balance between an open innovation model that fosters creativity and the protection of strategic intellectual resources. Digital technologies accelerate the commercialization of innovation, shortening the time from idea to market launch. Digital prototyping and predictive analytics support quick and accurate decision-making on Rand D priorities, increasing organizational flexibility and adaptability to change.

Case studies show that AI supports creative processes on several levels:

- Creativity catalyst – AI automates repetitive tasks and models data, freeing up the cognitive potential of teams.
- Learning by doing – digital tools support iterative testing of solutions in line with Lean Startup and SECI logic.
- Human-machine collaboration – humans contribute intuition and context, while AI provides computing power and data analysis, creating a hybrid creative process.
- The importance of culture and leadership – successful AI implementation requires an open, trusting culture and transformational leadership.
- A new paradigm of systemic creativity – creativity becomes a distributed capacity among people, data, and algorithms, with new roles such as data curator and co-creation architect.

Table 1.
Comparison of traditional and modern models of organizational creativity

Comparative category	Traditional model (SECI, Amabile, classical approaches)	Modern model (digital, AI, Lean/Agile, open innovation)	Effects and potential risks
Sources of creativity	Individual competencies, internal motivation, experience	Data, algorithms, simulations, human-AI interaction	Greater scalability of ideas, but the risk of dehumanizing the creative process
The nature of knowledge	The dominance of hidden knowledge (tacit knowledge), social communication	Integration of explicit and tacit knowledge supported by technology (AI, IoT , VR)	Faster knowledge conversion, but with the risk of losing context and uniqueness
The process of creating innovation	Sequential, linear (ideation → prototype → implementation)	Iterative, parallel, automated (Lean Startup, Agile)	Shorter innovation time, but higher risk of incorrect algorithmic decisions
The role of technology	Supporting (communication and analysis tools)	Central – AI, big data, VR/AR, blockchain, cloud	Automation and personalization, but also the risk of cyber threats and loss of control
Organizational culture	Hierarchical, based on experience and routine	Agile, based on collaboration, openness and experimentation	Greater adaptability, but with the risk of instability and dispersion of responsibility
Knowledge management	People-to-people exchange (meetings, mentoring, documentation)	Digital platforms, collaborative tools, generative AI	Increased access to knowledge, but the risk of information overload
IP Creation	The result of long-term RandD processes and individual creativity	The result of human-AI collaboration, automation of ideation and prototyping	The result of human-AI collaboration, automation of ideation and prototyping
The pace of commercialization	Slow – long project cycles	Fast – thanks to digital prototyping and data analysis	Increased market flexibility, but quality risk with accelerated implementation
Organizational effectiveness	Moderate, depending on employee competences	High – supported by data, automation and predictive analytics	Increased productivity, but potential risk of homogenizing creativity
Risks and limitations	Limited pace of innovation, dependence on key people	Excessive automation, copyright issues, ethical issues	The need for balance between technology and a culture of innovation

Source: Prepared based on: Nonaka, Takeuchi (1995), Amabile (1996), Davenport, Kirby (2016), Agrawal et al. (2019), Secundo et al. (2024).

In summary, the evolution of creative models is moving from individual competencies and social interactions towards digital and hybrid systems. Contemporary approaches increase efficiency and shorten time-to-market, but require the development of digital competencies, transformational leadership, and conscious management of organizational culture. Success depends on the ability to integrate technology with human creativity and to protect strategic knowledge assets, which is the foundation for sustainable innovation in the digital economy.

7. Conclusions and Recommendations

The analysis of the literature and illustrative case studies provides a coherent basis for understanding the role of artificial intelligence (AI) and digital technologies in shaping organizational creativity and intellectual property (IP) development. The findings suggest that AI and digital tools act as important enablers of change, influencing both the dynamics and structure of innovation processes. At the same time, their implementation introduces significant organizational, legal, and ethical challenges, requiring deliberate design of human–technology collaboration models. Importantly, given the qualitative and exploratory nature of the study, the conclusions should be interpreted as analytical generalizations, reflecting recurring patterns rather than empirically tested causal relationships.

7.1. Research Conclusions

The study indicates that digital technologies, particularly AI, contribute to the transformation of creative processes in several ways. First, AI acts as a catalyst for creativity by accelerating idea generation, supporting data-driven decision-making, and enabling rapid testing of alternative solutions. These effects are particularly visible in iterative and experiment-based innovation processes. Second, the effectiveness of AI-enabled creativity is strongly conditioned by organizational factors, including innovation culture, leadership, and collaboration practices. Organizations characterized by openness, learning orientation, and interdisciplinary cooperation are more likely to realize the potential of AI in creative processes. Third, the findings highlight the importance of human competencies in AI-supported environments. The development of digital, analytical, and interpretative skills is essential for effective human–AI collaboration and for the meaningful use of AI-generated outputs. Fourth, the study identifies emerging legal and ethical challenges related to authorship, accountability, and transparency in AI-assisted creativity. These issues remain underdeveloped and require further conceptual and regulatory clarification. Overall, the results support the assumptions of the proposed conceptual model, indicating that the relationship between AI adoption and innovation outcomes is mediated by process-related mechanisms and moderated by organizational conditions.

7.2. Recommendations for Management Practice

Based on the findings, several implications for management practice can be identified.

- Human-centered AI integration – AI should be implemented as an augmentative tool supporting human creativity, while strategic decision-making and evaluation processes remain human-driven.

- Development of knowledge management systems – organizations should invest in digital platforms that support knowledge sharing, learning, and interdisciplinary collaboration.
- Organizational culture and competencies – fostering a culture of experimentation, openness, and continuous learning is critical, alongside investment in digital and managerial capabilities.
- Governance and ethical frameworks – organizations should develop internal policies addressing intellectual property, transparency, and accountability in AI-supported processes.
- Interdisciplinary innovation structures – integrating technical, managerial, and legal expertise enhances the effective use of AI in complex innovation ecosystems.

These recommendations should be interpreted as context-dependent guidelines, rather than universally applicable solutions.

7.3. Recommendations for Public Policy and Future Research

The rapid development of digital technologies creates new challenges for public policy and research. From a policy perspective, there is a need to strengthen institutional capacities for monitoring and regulating AI-driven innovation. This includes the development of frameworks addressing intellectual property rights, data governance, and algorithmic transparency. Supporting collaboration between academia, industry, and public institutions is also essential for building sustainable innovation ecosystems. Public policy should additionally promote:

- access to digital technologies and innovation infrastructure,
- support for SMEs and diverse innovation actors,
- development of digital competencies at the societal level,
- alignment with broader sustainability goals, including responsible and inclusive innovation.

From a research perspective, future studies should focus on:

- empirical testing of the proposed conceptual model using quantitative and mixed-method approaches,
- development and validation of measurement instruments for constructs such as AI intensity and knowledge conversion efficiency,
- analysis of AI's impact on innovation performance, diversity of ideas, and organizational structures,
- exploration of legal and ethical dimensions of AI-assisted creativity across different institutional contexts.

8. Conclusion

This article provides a conceptual and integrative perspective on the role of artificial intelligence and digital technologies in transforming organizational creativity and intellectual property development. The findings indicate that AI contributes to faster idea generation, enhanced knowledge processing, and more iterative innovation processes. At the same time, its impact is not autonomous but depends on the interaction between technological capabilities, organizational conditions, and process dynamics. The study advances the literature by proposing a multidimensional conceptual model that captures these interactions and introduces a structured framework for analysing AI-enabled creativity. In particular, it highlights the importance of mediated and moderated relationships between technological, organizational, and outcome variables. However, due to the exploratory and qualitative nature of the research, the conclusions should be interpreted as theoretical propositions rather than empirically validated findings. Overall, the study suggests that effective creativity management in the digital era requires a balanced and context-sensitive approach that integrates technology, organizational culture, and governance mechanisms. While AI plays an increasingly important role in innovation systems, human actors remain central as interpreters, decision-makers, and creators of meaning.

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DISRUPTIONS IN SHORT FOOD AND COLD SUPPLY CHAINS IN FISH PROCESSING

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Purpose: Fish processing is one of the fastest growing sectors of the food industry in Poland. The aim of this article is to analyze and assess the impact of the COVID-19 pandemic on the production of fish products.
Design/methodology/approach: The main research question was formulated as follows: To what extent has the COVID-19 pandemic affected the production of fish products? A research gap has been identified, resulting from limited empirical data, concerning the functioning of the fish processing supply chain in terms of supply and distribution logistics in situations of emergency and prolonged disruption.
Findings: As a result of a diagnostic survey, it was established that during the COVID-19 pandemic, 65.85% of companies reported disruptions in the supply of raw materials and components, while only 34.15% did not feel the effects of the pandemic in terms of supply chain logistics. Deliveries of finished products from the distribution logistics side of fish processing companies were delayed in 43.9% of cases to customers.
Practical implications: Fish processing companies should strive for scenario three, as there are no negative aspects, and there are significant changes in supply and distribution logistics, which directly affect the company's functioning on the market.
Originality/value: The presented analysis and solutions are based on the experience of fishing industry companies and may be considered for application in other industries.
Keywords: fish processing, short food supply chains (SFSC), cold supply chain (CSC), disruption, quality.
Category of the paper: Research paper.

1. Introduction

An important task facing Polish enterprises, especially fish processing companies was to defend themselves against the negative effects of economic crises caused, among other things, by increased uncertainty, rapid climate change, the COVID-19 pandemic (2019-2020) (Olkiewicz, 2022) and the effects of the armed conflict in Ukraine (2022-). The food industry

is the largest manufacturing sector in the European Union in terms of jobs and added value. The strategic nature of the food sector is determined not only by the nature of the products manufactured, but also by the sector's share in global production and gross domestic product (GDP), as well as its importance for the development of the labor market and international trade. In 2022, the economic and financial situation of individual food industry sectors was good. Compared to 2019, there were only minor changes. This demonstrates the sector's high resilience to adverse macroeconomic conditions and its ability to adapt to a changing and unpredictable market environment. The real value of the sector's output accounted for 18.5% of the output of the manufacturing industry (GUS, 2022) and increased by nearly 53% between 2010 and 2021 (Szczepaniak, Juchniewicz, 2024; Drożdż, 2024). The food industry contributes significantly to gross domestic product (GDP), measured by gross value added (GVA) in economics; GVA generated in this sector ac-counted for between 2.2% and 3% of GVA generated in the entire national economy (GUS, 2023). In Poland, this sector is one of the most important branches of the economy, as in 2022 its share in global production and GDP amounted to 8.5% and 4.2%, respectively, and in the number of people employed in the national economy – 10.3% (Szczepaniak, Drożdż, 2023). The literature on the subject provides several classifications based on the location factors of food industry enterprises. Industries located in the immediate vicinity or as close as possible to the raw material base, which is related to a situation where the transport of raw materials is impossible or difficult due to their perishability, or possibly unprofitable. This group includes, in particular, the sugar, potato, fruit and vegetable, and fish industries (Hryszko, 2023).

Fish processing is one of the fastest growing sectors of the food industry in Poland. The fish and seafood processing sector in Poland is one of the most concentrated sectors of the food industry. Factors influencing changes in the supply chain of fish processing plants in the period 2022-2023 were diverse. The structure of the fish processing sector in Poland should be considered highly fragmented. Although the total number of entities is estimated at around 610-720, a dozen or so of the largest entities account for approximately 75% of total production value. These companies are largely financed by foreign capital. Most entities (around 80%) are small and medium-sized enterprises. The economic and financial situation of the processing plant was good or very good in 2010-2021, but it was highly volatile, mainly due to fluctuations in the purchase prices of raw materials on global markets. The average growth rate of the value of fish products sold in the analyzed period was 10.5% and was significantly higher than in other sectors of the food industry (average growth of 6.4%) (Silvestrini et al., 2023). However, this was accompanied by relatively low profitability. The aim of this article was to analyze and assess the impact of the COVID-19 pandemic on the production of fish products. Over the last two years, the fish sector in Poland has been under pressure from limited demand and declining consumer purchasing power observed both on the domestic market and on foreign markets. Deeper declines in consumption were mitigated to some extent by a reduction in VAT rates on food, and entities in the fisheries and aquaculture sector received financial support for additional

costs incurred as a result of market disruptions caused by Russia's war against Ukraine and its impact on the supply chain. The domestic supply of fish, seafood and processed products amounted to 514,500 tons (in live fish equivalent) in 2023, which was 1.8% higher than in 2022. This was solely due to an increase in net imports, with catches remaining similar to the previous year. The self-sufficiency ratio decreased by 0.5 percentage points.

2. Literature Review

2.1. Short food supply chains (SFSC)

Food trade is essential for achieving food security, and internationally traded food accounts for 19% of calories consumed worldwide (Topczewska et al., 2024). With the growing demand for diverse food products, transportation is a key link in global food supply chains (Tchonkouang et al., 2024; Chandan et al., 2023; Canfora, 2016). Short food supply chains (SFSC) are alternative agri-food systems that include various forms of distribution characterized by few or no intermediaries between consumers and producers, or short geographical distances between them (Szymańska, Lukoszová, 2019; Parker, 2005). SFSC are alter-native agri-food systems that include various forms of distribution characterized by few or no intermediaries between consumers and producers, or short geographical distances between them (Mancini et al., 2019). Short supply chains reduces the distance between the producer and the consumer, which can contribute to environmental protection (Bayir et al., 2022). Reducing the number of intermediaries needed to deliver the final product to the consumer ensures better quality resulting from the elimination of storage and repackaging, a lower final price of the product, and a higher share of the producer's profit from the production and sale of the product. Food travels thousands of kilometers thanks to more efficient means of transport, but this comes at a cost to the environment, measured, for example, in food miles (Li et al., 2017). This term refers to the distance food products travel from the place of production to the consumer, indicating the impact of this element of distribution on the environment (Akaichi et al., 2023). Hoehn et al. proposed the term “sustainable development” in short food supply chains. They pointed out that initiatives aimed at changing the food system focus mainly on food waste and circular economy strategies in food production. They emphasize the need to pay attention to the relocation of food markets and greater local consumption (Hoehn et al., 2021). This allows food producers to regain an active role in creating value for the chain and the product itself. The solution eliminates links and intermediaries and shortens the distance food has to travel to reach consumers (food miles).

In terms of logistics, short food supply chains reduce food transportation (Renkema, Hilletofth, 2022). This, in turn, leads to lower transport costs, reduced greenhouse gas emissions, slower wear and tear on local roads, and reduced congestion, i.e., local traffic overload. In this way, economic, environmental, and social benefits are achieved (Raszeja-Ossowska, 2017). The identifier of SFSC value can be quality, and the common feature is the emphasis on the relationship between the producer and the consumer and their role in such a relationship. Similar food products can be the result of both industrial and alternative (short) chains (Tundys, 2015). Identification is extremely important due to the intense competition between them, as well as between different retailers and processors participating in various types of chains, including fish processing companies.

This leads to some very interesting chain mutations. Corporate retailers, wanting to be closer to their customers, are developing distribution channels, for example by ordering goods via the Internet. Local food deliveries are based on short food supply chains, which are considered better from an economic, social, and environmental point of view. As Gonçalves and Zeroual (Gonçalves, Zeroual, 2017) have noted, from an economic point of view, the need for frequent deliveries is associated with high transport costs. One type of short chain is an extended chain involving partnerships in the form of cooperatives or producer associations. This category further extends the reach of the chain, both in time and space. The products are sold to consumers outside the production region, who have no direct or personal contact with producers from the locality or region. In most cases, the products are exported from local or even national markets (Galli, Brunori, 2013, Khodaee et al., 2022). In order to minimize the negative environmental impact of short supply chains, they should be seasonal in nature and use environmentally friendly production methods. The seasonal nature of these chains reduces the need for transport and storage.

2.2. Cold supply chain (CSC)

In recent years, the global market for chilled and frozen foods has been growing rapidly, generating demand for the delivery of these types of goods to the farthest corners of the world (Kaźmierczak, Szymczyk. 2019). These chains deal with the delivery of goods that are sensitive to temperature (especially heat). The organizers of the entire transport process for frozen and refrigerated goods face the challenge of not only ensuring on-time delivery, but above all ensuring the right conditions during transport so that the goods do not lose their quality (Reshetnikova et al., 2021; Awad et al., 2021; Kojder, Klepacki, 2021).

As early as the second half of the 18th century, ice began to be used to ensure longer storage of fish (Kumar et al., 2022). Raw fish, mollusks, and crustaceans are transported over short distances in melting ice or at the temperature of melting ice. Over longer distances, fish are transported as frozen products, foodstuffs that can be stored for long periods at temperatures below approximately –18°C. The freezing process inhibits fat rancidity and stops the growth of microorganisms. During transport of deep-frozen products, the temperature during transport,

loading, and unloading should not deviate by more than ±3°C, and in the case of frozen products, the deviation should not exceed ±4°C.

Organizing long-distance transport in the summer to and from countries with warm climates is a particular challenge. The distribution of these types of products therefore requires a cold supply chain. Dry ice is used as a cooling agent to keep frozen goods frozen during transport and transshipment operations. In the logistics of cargo requiring a cold chain, careful planning of the entire transport process is of paramount importance (Yu, Xiao, 2021). The cold chain is an organic combination of four interrelated systems: pre-cooling, storage cooling, refrigerated transport, and marketing, which differ in sequence and timing (Theophilus et al., 2021). A cold supply chain (CSC) is a logistics system that requires a range of equipment to ensure ideal temperature conditions during the transport of goods from their place of origin to their point of sale (Senguttuvan et al., 2021). The CSC also requires ap-propriate infrastructure, which consists of four main components. The first is the availability of premises where products can be stored for long periods of time, the second link is the facilities where production and preparation for distribution take place, followed by transport, which includes vehicles equipped with control devices and interiors adapted with temperature-maintaining materials. Refrigerated containers are the standard units used to transport frozen fish. They are standardized, thermally insulated containers equipped with a refrigeration unit (compressor or other) to ensure the necessary conditions for transporting perishable cargo. These containers are among the most demanding in terms of construction and handling, and therefore the most expensive of all container units (Sainathan, 2018). In terms of volume, however, they are the second largest group after conventional containers.

The cold chain is exposed to various dangerous situations. Possible events have been divided into four groups of factors according to the cause of the hazard: human, climatic, technical, and random (Mustafa et al., 2024). Chinese cold chain logistics companies emphasize the need to implement low-carbon strategies and smart innovations to address environmental challenges and market needs (Badia-Melis et al., 2018). Domestic policy and financial interventions play a key role in the modernization and standardization of infrastructure, highlighting the importance of the Chinese government's support in the pursuit of sustainable logistics in CCS (Han et al., 2021; Xie et al., 2022). Integrated Cold Chain Management (CCM) effectively demonstrates the complexity of relationships and the collective importance of various components in this category, highlighting their key role in the continuity of food supply, including fish (Alabi, Ngwenyama, 2023). CCM is proving to be a key factor in extending the shelf life of fish as a perishable product, reducing spoilage and ensuring safety.

2.3. Disruption and resilience of supply chains

In the fishing industry, the chain may be disrupted due to weather conditions and other reasons beyond the supplier's control. The supply chains of many companies have been disrupted during crises such as the COVID-19 pandemic (Ivanov, 2022; Han et al., 2023) or

have lost their previous capacity to operate (Michel-Villarreal et al., 2021). The loss of the supply chain's current capacity should be understood in terms of its effects, i.e., the value delivered to the end custom-er, or the level of customer service (Zhang et al., 2021). The loss of the existing ability to operate may therefore also take the form of incomplete delivery or extended delivery times (WEF, 2013). It should be noted that, in the face of such disruption, the supply chain may not only be unable to deliver value at the same level as before, but may even cause losses on the part of the recipient, which in quantitative terms can be treated as the delivery of negative value (Zamani et al., 2023). In a proactive approach, we deal with increasing the resilience of the supply chain in a manner adequate to the anticipated future threats, and the level of resilience directly depends on the accuracy (quality) of forecasts and is actually verified only during a crisis situation (Christopher, Peck, 2004).

Resilience can be viewed from both a reactive and proactive perspective. In the reactive approach, rebuilding the supply chain's potential after a crisis allows the sup-ply chain to achieve a higher level of resilience and move it to a more stable equilibrium (Sheffi, 2005; Shishodia et al., 2023). Supply chains resilient (SCR) adapt their strategies and operations to changes in the environment in order to reduce the risk of losing their ability to operate (Wieland, Wallenburg, 2013). They are resistant to various types of anomalies, perturbations, effects of failures or malfunctions resulting from a breach of existing operating conditions or disruption of the continuity of material and information flows (Boin et al., 2010). SCRs are those that can avoid disruptions or reduce their severity if they occur, and that adapt their strategies and operations to changes in the environment in order to limit the risk of losing their ability to operate (Välikangas, 2010). Supply chains resilient can be proactive, if appropriate measures are taken in the sup-ply chain before a crisis occurs, or reactive, when measures are taken to restore the original capacity to operate after a crisis has occurred (Szymczak, 2025).

The COVID-19 pandemic was the direct cause of many bottlenecks in supply chains, which manifested themselves in the form of supply shortages, limited or suspended production, and staff shortages (Lund, George, 2020). Research conducted by numerous authors suggests that in 2018, i.e. before the outbreak of the SARS-CoV-2 pandemic, the five largest disruptions to supply chains affected 2000 locations worldwide and caused factories to need as much as 22 to 29 weeks to return to full production capacity (Zaczyk, 2018). The high level of sensitivity of the fish processing sector supply chains, combined with a lack of focus on building resilience, may lead to disruptions in the continuity of basic supply chain processes, and thus to the failure to achieve the set objectives or, in less drastic cases, to their achievement to a lesser extent (Zhao et al., 2023). Resilience is one of the key elements influencing the competitiveness of the supply chain (Dubey et al., 2023). Supply chain resilience should be analyzed from the perspective of a total loss of operational capacity, but in the case of spectacular natural disasters or technical failures, where there is a problem with delivery to the end customer (Ozdemir et al., 2022; Choi et al., 2023).

Choi et al. determined that actions are possible through close cooperation with suppliers, which will enable the creation of buffer solutions, just-in-time segmentation, and increased visibility of resources in the supply chain, including those in transit (SYME, 2024). The transmission of disruptions means the emergence of negative risk effects in an in-creasing number of entities in the supply chain, which is a result of their mutual cooperation, and the channels of transmission of disruptions are determined by the relationships between entities. Preventing the transmission of disruptions and preventing them from amplifying in the supply chain therefore means modeling the cooperation between entities in these structures.

3. Methods

In 2020, there were 785 companies in Poland involved in the processing and preservation of fish and fishery products, which was an increase of 10.56% compared to 2019, where the decline to 2018 was 4.44%. Fish processing is mainly concentrated in the coastal belt – the West Pomeranian Province (184), Pomeranian Province (214) and Warmian-Masurian Province (35). In the following years, a decline was recorded: 652 entities in 2021, 645 in 2022, and 641 entities at the end of 2023, employing 18,831 people (SYME, 2024). According to data from the Central Statistical Office, however, these dozen or so large plants employed 67% of all workers in the sector and generated 69% of the industry's sales value. Approximately 45% of the plants are located in two coastal provinces. The vast majority (77%) were entities employing up to 9 employees (443 entities), and only 9% (54 entities) were large companies with more than 49 employees (including 9 with more than 249 employees). According to the ownership criterion, domestic capital clearly prevails, with only 28 entities characterized by exclusive foreign ownership and an additional 8 with a predominance of this source of financing. However, these entities are crucial for the sector, as they account for approx. 60% of revenues and employment. Most entities operate as sole proprietorships (231), followed by limited liability companies (182) and civil law partnerships (113). Only 8 entities are joint-stock companies. At the end of June 2024, the number of entities in the REGON register was 569 (9 fewer than in the same period of the previous year).

Breakdown of fish product manufacturing:

- frozen sea fish and fillets,
- salted fillets,
- smoked fillets,
- fresh or chilled sea fish fillets,
- fish fillets in breadcrumbs or batter,
- preserved, marinated or pickled fish and fish products.

Table 1.
Production of fish products in the period 2020-2023

Specification	2020	2021	2022	2023
Frozen & chilled fish (including fillets)	80.7	95.8	86.1	127.8
Salted fillets	15.3	15.7	17.9	16.9
Smoked fish (including fillets)	98.0	113.0	104.0	103.1
Filets of marine fish, fresh or chilled	113.4	102.9	97.0	99.3
Fish fillets in breadcrumbs, including fish fingers	12.0	15.6	12.9	14.1
Fish and fish preparations, tinned, pickled and preserved	189.5	159.6	171.7	166.6

In the first half of 2024, the production of fish and fish products in medium and large fish processing plants (with more than 49 employees) amounted to 269,600 tons and was 5.9% higher than in the previous year. The increase in production was mainly recorded in the range of frozen meat (by 39.7%), smoked fish (by 27.5%, including salmon by 35.2%) and fresh or chilled fillets (by 11.5%). The production of processed and canned products decreased by 1.4%, with a decline in the supply of marinades (by 10.0%) and canned and preserved products (by 1.9%), while there was a significant increase in products such as delicatessen and culinary products, salads, spreads, fish sticks and fish spreads (by 7.3%). The production of processed and preserved salmon decreased by 7.1%, and that of herring by 5.0% (Drożdż, Hryszko, 2024).

Table 2.
Exports and imports of fish and shellfish by the combined nomenclature (CN) in thousand tonnes

Specification	**2020**	**2021**	**2022**	**2023**
Export	214.16	234.71	224.74	210.94
Import	562.00	600.73	559.08	582.23

China remains the world's largest producer of fish and other aquatic organisms (catches and aquaculture, including aquatic plants), followed by Indonesia (9.9%), India (7.1%), Vietnam (3.9%), Peru (2.5%) and Russia (2.4%). With a turnover of approximately USD 3.5 billion in both imports and exports, Poland ranked 15th and 16th in the global ranking in 2023.

This study focuses on analyzing and assessing the impact of the COVID-19 pandemic on the production of fish products. The following stages were identified as part of the research process:

– Stage 1 – analysis of international literature on supply chains, with particular emphasis on the fishing industry.

- Stage 2 – identification of research methodology, including research gaps, hypotheses, selection of research tools, and research sample.
- Stage 3 – validation of the research tool.
- Stage 4 – conducting qualitative research using an opinion poll based on a proprietary survey questionnaire.
- Stage 5 – analysis, evaluation, and modeling of the obtained data.

An important element of the research was to identify disruptions in the fish sector supply chain in Poland and their attributes in the supply chain. The aim was to identify which elements affect the resilience of the supply chain and to develop an appropriate resilience framework in the context of the COVID-19 pandemic and future data analysis, e.g., the impact of military actions between Ukraine and Russia. The cognitive process involving the analysis of literature and statistical data allows us to conclude that, despite the growing interest in supply chains, there is still no significant data relating to the fish sector in the context of logistical disruptions. This has identified a research gap regarding the functioning of fish processing supply chains in terms of supply and distribution logistics in emergency situations and during prolonged disruptions. This is particularly important from the point of view of maintaining the resilience, safety, and continuity of cold supply chains for products that quickly lose their safety date for use and consumption. It is worth noting that the analytical research conducted on resilient supply chains is scattered and, to date, only a small segment of resilience related issues has been addressed, with individual cases indicating disruptions to a stable network. Therefore, the lack of adequate quantitative research led to the formulation of the following research question: To what extent did the COVID-19 pandemic affect the production of fish products? In order to achieve this goal, the main research hypothesis was formulated:

COVID-19 had a negative impact on the production of fish products.

The following auxiliary hypotheses were also put forward:

H1. Disruptions in the supply chain of raw materials occurred on the supply side regardless of the distance of the source of supply.

H2. Disruptions in the supply chain to customers occurred among all fish product manufacturers in Poland.

H3. There was a change in inventory levels in the surveyed fish processing companies.

To confirm the correct identification of the research methodology, a survey was conducted on five entities (fish processing) located in the Central Pomeranian region in the first quarter of 2022. As part of the evaluation and analysis of the survey data, weighted averages of the variables were indicated: new forms of sales (0.15), market position (0.07), delay/expedited order fulfillment (0.23), cooperation with industry players (0.15), company operations (0.2), growth potential (0.15), and quality of cooperation with suppliers (0.05) were identified, which allowed, in the final stage, to build scenarios (models) for assessing the impact of variables on the proper functioning of supply chains according to the balanced impact index BII = weight x (rating -3 (neutral)), where the rating of variables according to Likert: 1 – very negative impact,

2 – negative impact, 3 – no impact, 4 – moderate impact, 5 – very high impact, were defined as: 1-2 = BII negative (negative impact), 3 = BII = 0 (neutral), 4-5 = BII positive (positive impact).

The main elements of the research methodology defined in this way allowed for the appropriate selection of the method of obtaining primary data. The sample selection was purposive, as the authors decided to study fish processing entities and obtained their results using a diagnostic survey conducted via questionnaire in 2022-2023 in the West Pomeranian and Pomeranian provinces. The survey was sent to 96 entities, but 41 companies participated in the study: micro-enterprises accounted for 31.71%, small enterprises for 17.07%, medium-sized enterprises for 26.83%, and large enterprises for 24.39%, which constituted a representative research sample (6.4% of all fish processing enterprises). In terms of ownership, 4.88% were joint-stock companies, 41.46% were limited liability companies, 31.7% were sole proprietorships, 17.07% were general partnerships, and the remaining 4.89% were other types of companies. The research results obtained were evaluated, allowing for an assessment of the strength and direction of the impact of variables (BII) on the creation of scenario variants (models): current state, positive (after ad hoc changes), and target.

4. Results and Discussion

During the Covid-19 pandemic, 65.85% of companies reported disruptions in the supply of raw materials and only 34.15% did not feel the effects of the pandemic in terms of supply chain logistics. Figure 1 shows disruptions in the supply of raw materials across the country.

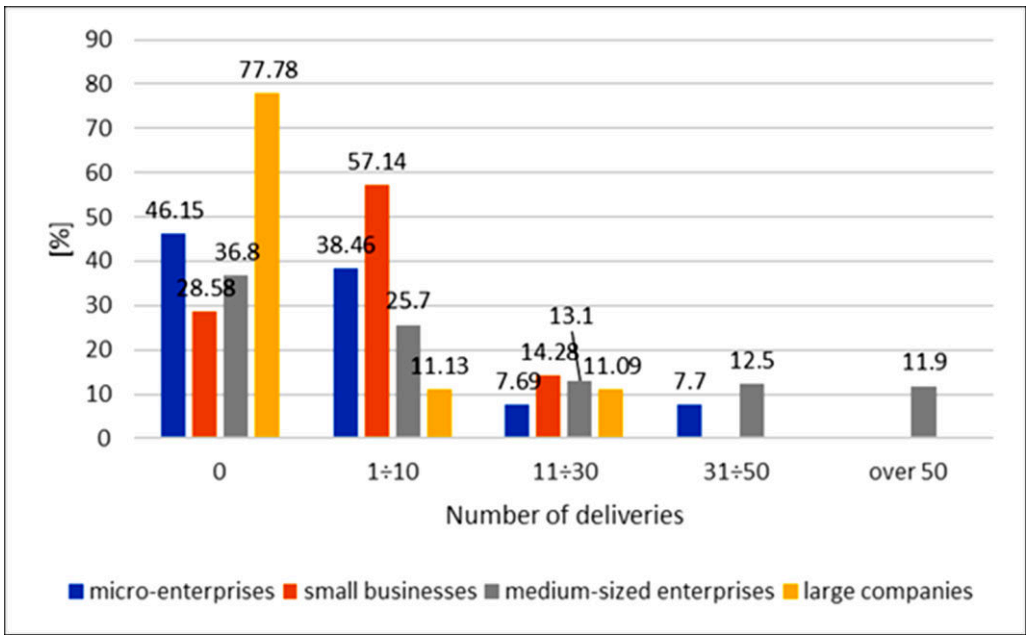

Figure 1. Disruptions in the supply of raw materials and other materials during the Covid-19 pandemic.

Above 30 deliveries, 24.4% were recorded by medium-sized enterprises, small companies with up to 10 deliveries recorded as much as 57.14%, and micro-enterprises in the same range recorded 38.46%. Large companies only recorded delivery delays of 22.22% in the range up to 30 deliveries. Figure 2 shows supply disruptions in the reference period for raw materials and materials from the European Union.

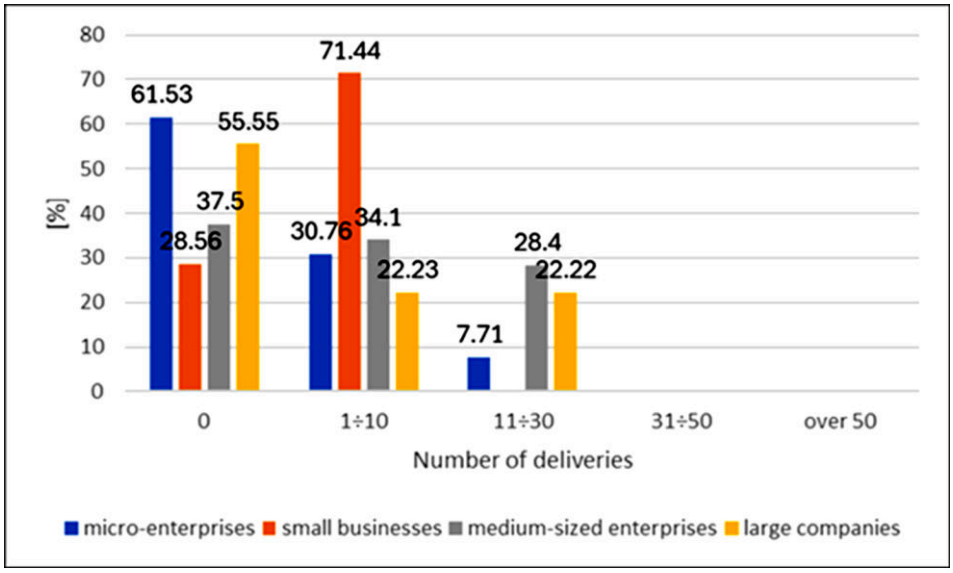

Figure 2. Disruptions in the supply of raw materials and materials during the Covid-19 pandemic from the EU.

Small enterprises in 71.44% had problems with up to 10 deliveries of raw materials and supplies during the pandemic. Micro-enterprises reported 30.76% of delayed deliveries up to 10 and 7.71% in the range above 30. Medium-sized companies in 62.5% reported delays from within the EU. Large enterprises in 55.5% had no problems with deliveries. Figure 3 shows disruptions in the supply of raw materials and supplies from outside the EU, mainly from China.

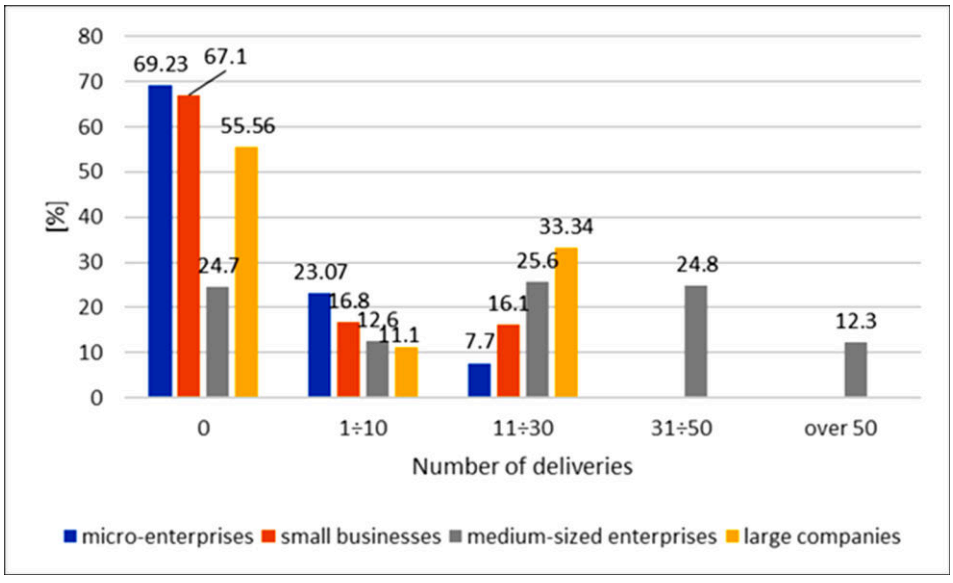

Figure 3. Disruptions in the supply of raw materials and materials from outside the EU during the Covid-19 pandemic.

Micro-enterprises in 30.17% had problems with raw material supplies, while small companies in 32.9% reported delays. Medium-sized enterprises had the most problems with raw material supplies, with as many as 37.1% reporting more than 30 deliveries, and 38.2% reporting disruptions in up to 30 deliveries. Delayed deliveries in large companies accounted for 44.44%.

When analyzing deliveries from the distribution logistics side, 43.9% of companies experienced delays to customers. Figure 4 shows the problems with deliveries to domestic customers.

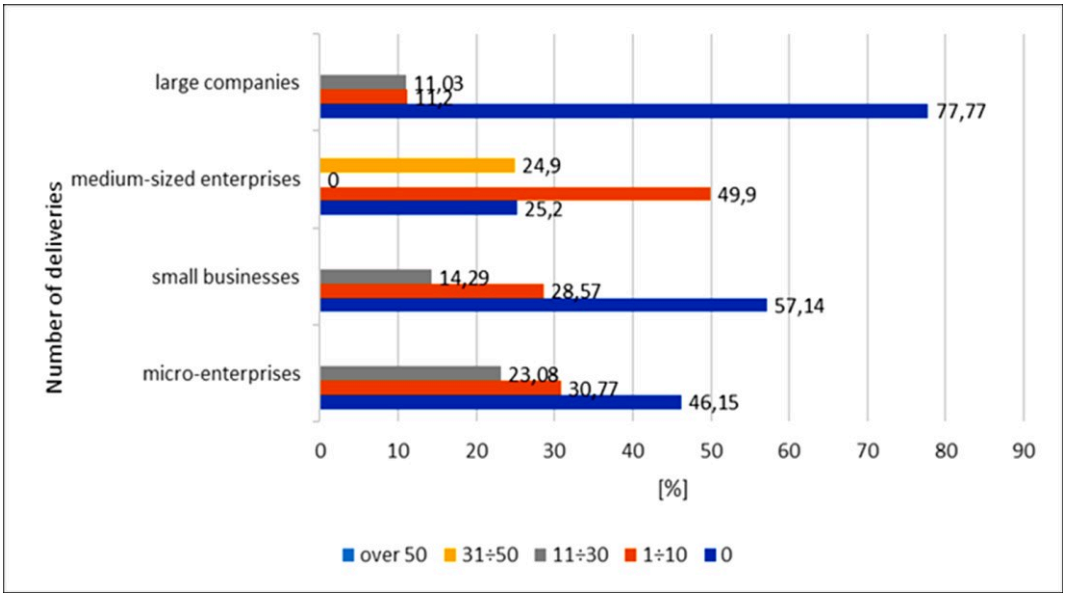

Figure 4. Disrupted deliveries of finished products during the Covid-19 pandemic in the country.

Micro-enterprises in 53.85% had problems with deliveries to their customers. Small enterprises in 42.86% of cases failed to deliver finished products to customers on time. Medium-sized enterprises reported the greatest disruptions in the supply of fish products, with 74.8% of deliveries to domestic customers affected. Large fish processing companies on the domestic market delivered 77.77% of their orders without any problems. Figure 5 shows disrupted deliveries of finished products within the European Union.

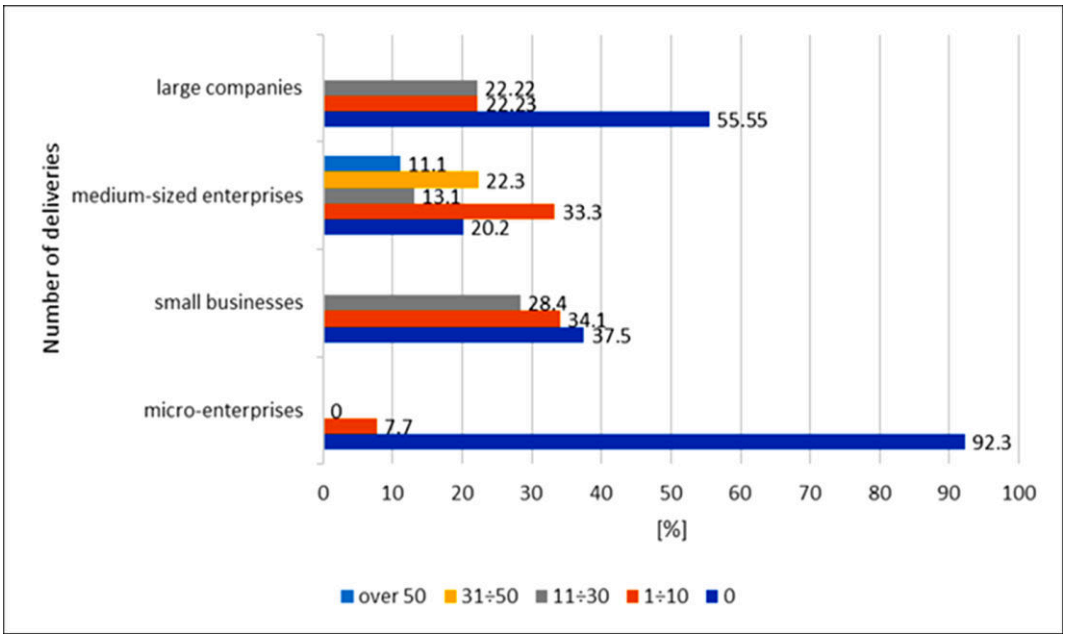

Figure 5. Disruptions Disrupted supplies of fish products in the EU during the Covid-19 pandemic.

Micro-enterprises delivered on time in practically 92.3% of cases, while small enterprises had problems with deliveries of their products in 62.5% of cases. Medium-sized enterprises recorded as many as 79.8%, and 11.1% made more than 50 deliveries to a single recipient. Large enterprises delivered their products late in 44.45% of cases. Figure 6 shows deliveries of fish products by companies operating in Poland to customers outside the EU, mainly to customers in the United States.

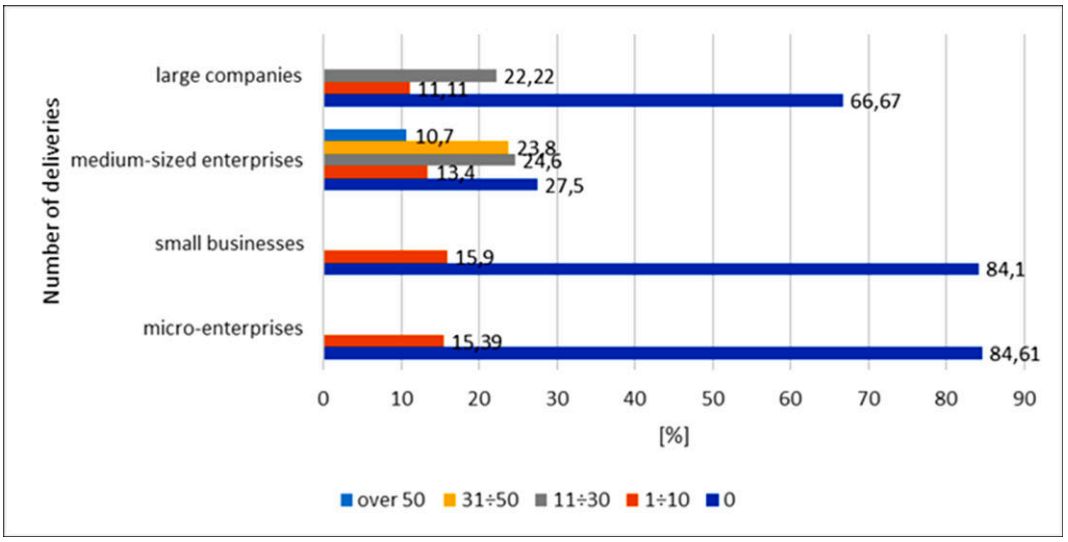

Figure 6. Timeliness of fish product deliveries to customers outside the EU.

Micro and small enterprises reported approximately 15% of disruptions in the delivery of their products. Medium-sized fish processing enterprises reported as many as 72.5% of disruptions, with 10.7% of deliveries delayed by more than 50 deliveries. Large enterprises delivered fish products on time to 66.67% of customers outside the EU, with delays accounting for 33.33%. The Covid-19 pandemic has caused changes in the operating model of many fish

processing companies. Figure 7 presents an analysis of micro-enterprises. Rating 1 – very negative impact, 2 – negative impact, 3 – no impact, 4 – moderate impact, 5 – very high impact.

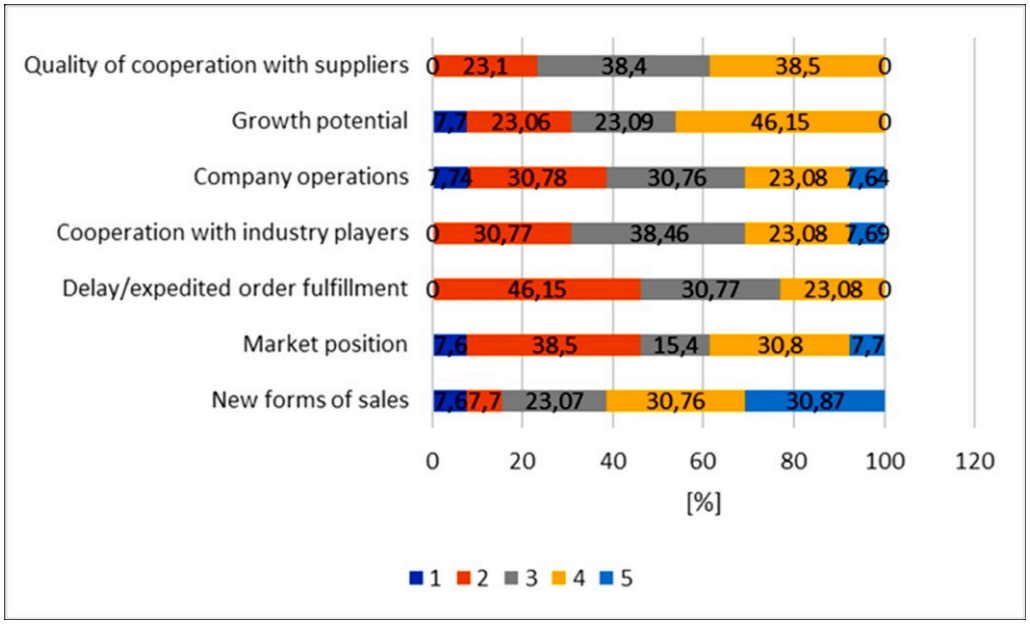

Figure 7. Impact of the Covid-19 pandemic on the functioning of micro-enterprises during the Covid-19 pandemic.

In the case of micro-enterprises, it had a positive impact on their development (30.87%). In 46.15% of cases, it affected their position on the local market, and 38.5% of micro-enterprises changed their form of sales to online sales. It had a negative impact on supply and distribution disruptions and the functioning of the company, as well as on cooperation with entities from the industry in 30.77% of cases. Figure 8 shows the impact of the Covid pandemic on changes in the functioning of small fish processing companies.

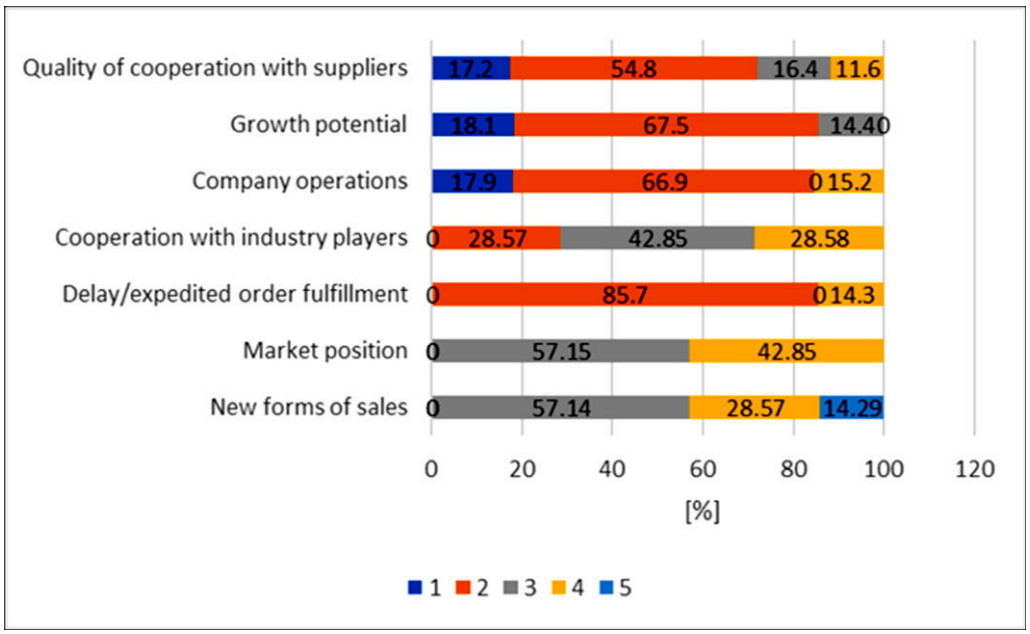

Figure 8. Impact of the Covid-19 pandemic on the functioning of small enterprises during the Covid-19 pandemic.

Small fish processing companies did not feel the impact of the Covid-19 pandemic on their market position (57.15%) or on the implementation of new forms of sales (57.14%), but 42.86% implemented changes in their sales. Delivery delays in 85.7% of cases had a negative impact on the quality of cooperation with suppliers (72%), development opportunities (85.6%) and disruptions in the functioning of the company (84.5%). Figure 9 shows the impact of the Covid pandemic on changes in the functioning of medium-sized fish processing companies.

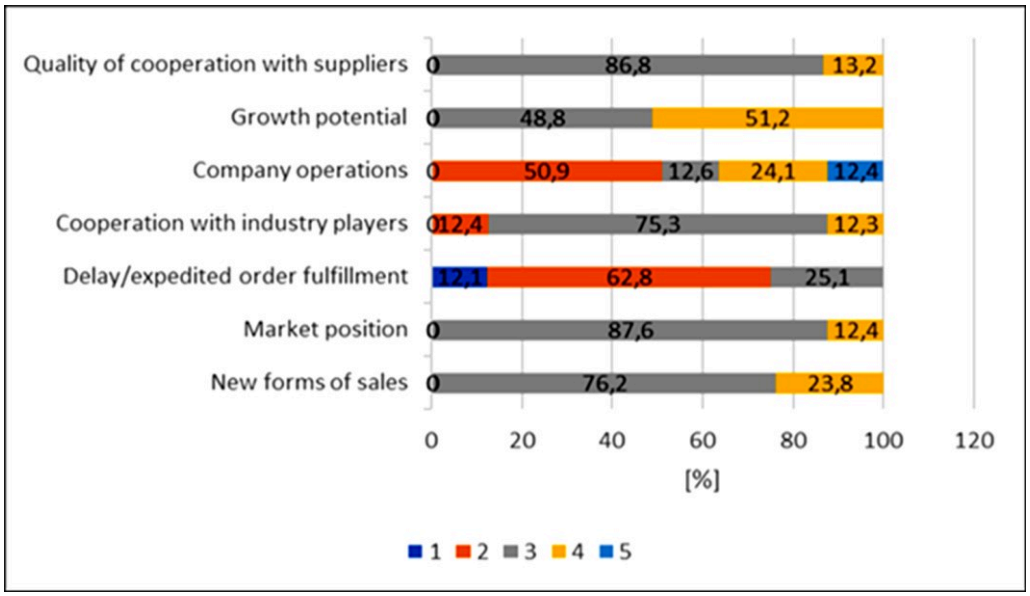

Figure 9. Impact of the Covid-19 pandemic on the functioning of medium-sized enterprises during the Covid-19 pandemic.

The COVID-19 pandemic had no impact on medium-sized enterprises in terms of the quality of cooperation with suppliers, new forms of sales, market positions (48.8%) and cooperation with entities from the fish industry. In 51.2% of cases, medium-sized companies stated that it had a positive impact on their market positions and in 36.5% on cooperation with entities from the fish industry. Figure 10 shows the impact of the Covid pandemic on changes in the functioning of large companies in the fish processing sector.

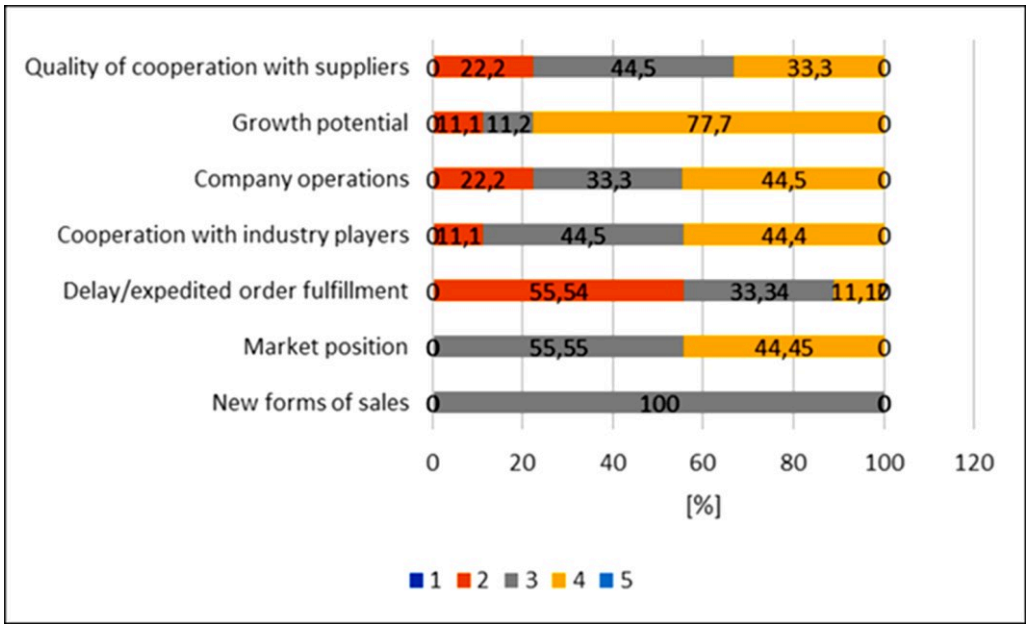

Figure 10. Impact of the Covid-19 pandemic on the functioning of large enterprises during the Covid-19 pandemic.

Large enterprises affected by the Covid-19 pandemic did not change their sales methods, assessed their growth opportunities positively (77.7%), strengthened their market position, improved their operations and cooperation with suppliers.

The analysis of the variables influencing the impact of the Covid-19 pandemic on the functioning of entities is the result of the functioning of fish processing supply chains in terms of supply logistics and distribution in situations of long-term disruptions. This allowed us to develop three scenario variants.

The first, identifying the current state, indicates a negative balanced impact index that arose suddenly and unexpectedly (Covid-19), as evidenced by the variables:

1. New forms of sales / -0.3 / strong negative.
2. Market position / -0.07 / neutral.
3. Delay/expedited order fulfillment / 0.46 / strong positive.
4. Cooperation with industry players / -0.15 / medium negative.
5. Company operations / 0.2 / medium positive.
6. Growth potential / -0.15 / medium negative.
7. Quality of cooperation with suppliers / -0.1 / neutral.

Data analysis indicates that two variables strongly determine the current functioning of supply chains and organizations. Almost all the others (except for neutral ones) have a negative impact on the current operations of organizations. It should be noted that new forms of sales have a strong negative impact, as in the current situation, changing to an untested, unprepared form of sales may increase costs and bring no benefits.

The second variant, presenting dependent variables that have a small but positive impact on the balanced impact indicator (BII>0, i.e., 0.49), results from ad hoc changes in the management of the organization, i.e., changes in short supply chains (or short periods), increased stockpiling, sourcing goods from new sources, etc., after the pandemic was confirmed to be continuing and developing. The variables were assigned the following values:

1. New forms of sales / 0 / neutral.
2. Market position / -0.07 / neutral.
3. Delay/expedited order fulfillment / 0.46 /strong positive.
4. Cooperation with industry players / 0 /neutral.
5. Company operations / 0.2 / medium positive.
6. Growth potential /0 / neutral.
7. Quality of cooperation with suppliers / -0.1 / neutral.

In the second scenario, despite delays in deliveries from fish processing companies, there are negative changes in market position and the quality of cooperation with suppliers.

The third scenario, generated for the purposes of the disruptions in supply chains that do not guarantee, among other things, the security and continuity of operations of entities, is the target variant. This is the variant that all entities under study should strive for in this particular situation. In the target variant, the variables positively shape a balanced impact index at the level of BII = 1.07, with the following variable values:

1. New forms of sales / 0.3 / strong positive.
2. Market position / 0.07 / neutral.
3. Delay/expedited order fulfillment / 0 /neutral.
4. Cooperation with industry players / 0.15 /medium positive.
5. Company operations / 0.4 / strong positive.
6. Growth potential / 0.15 / medium positive.
7. Quality of cooperation with suppliers / 0 / neutral.

Data analysis indicates that organizations should focus primarily on those variables that achieved the highest growth between variants 1 and 3, as they represent growth potential. In the case of delivery delays in the first scenario, new forms of sales have a strongly negative impact. In the case of the third scenario, the change will be due to the absence of negative options, the very positive functioning of the company, and new forms of sales.

Figure 11 is presented for a better presentation of the development of variants and dependent variables.

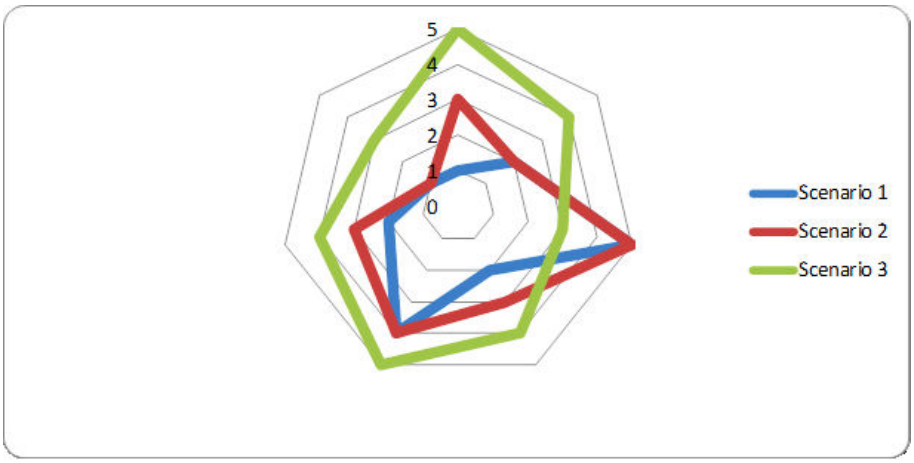

Figure 11. Comparison of impact assessment scenarios (provide data labels).

Analysis of the figure indicates that the best scenario for the companies surveyed would be option 3, which is also confirmed by the BII, in which new forms of sales are caused by the entry of e-commerce into the market, increasing the number of distribution channels. The changes may affect the functioning of companies in the fish processing industry.

5. Discussion and Conclusions

The processing of fish products constitutes a significant part of the food sector. Research on fish product supply chains has been conducted by researchers from various academic institutions and focuses on the implementation of new blockchain and IoT technologies (Ismail et al., 2023). Other authors characterize global supply chains in the fishing industry as an extensive network of artisanal fishermen, small-scale fish farmers, processors, exporters, importers, and wholesalers, including various distribution channels (Cromwell et al., 2025). The authors publish articles on the need to integrate tracking practices into fisheries improvement projects, where they highlight the importance of ensuring that companies operating in the global fisheries supply chain adhere to responsible sourcing policies (Rahman et al., 2021). Due to the pandemic, the fisheries sector has significantly expanded controls to ensure food safety (Jamwal, Phulia, 2021). The research findings presented in the article highlight changes in supply chains within Polish fish processing companies, a topic previously absent from both Polish and international publications. Although the research provides important information on the impact of the COVID-19 pandemic on the fish processing industry, several limitations can be identified:

– The analysis focuses primarily on the pandemic period and a brief comparison with the pre-pandemic situation. It lacks a long-term perspective that would allow for an assessment of the sustainability of the observed changes.

- Regional differences (e.g., access to ports and logistics infrastructure) that may significantly impact the operations of companies in the fish processing sector were not taken into account.
- The classification into small, medium, and large companies does not account for other important factors, such as the level of vertical integration, supplier diversification, or the degree of automation.
- Increases in inventory or delays in deliveries have direct financial consequences, which were not explored in depth due to a lack of information on the subject.

The research provides significant insights into the functioning of the fish processing sector. It confirms the high vulnerability of supply chains, and even the globally developed fish industry has proven susceptible to disruptions, regardless of the distance from raw material sources. Companies in the sector under study have begun to increase their inventory levels, marking a shift away from just-in-time models toward greater resilience. Medium and large companies have been particularly hard hit, which may be due to the larger scale of their operations and more complex supply chains.

The research findings are significant not only for the fish processing sector but also, more broadly, for the entire food industry, and they contribute to the development of resilient supply chains. The research reflects the growing importance of building resilient and flexible supply chains, which is crucial in the context of global crises. Problems with the availability of raw materials highlight the need to diversify supply sources and strengthen domestic production capacity in the fish processing sector.

For over a decade, the fish processing industry has been considered one of the fastest growing sectors of the food industry in Poland. It also plays a significant role in supplying the European Union market with fish products. However, there are many threats to its continued operation, which lie both in the fish and seafood market itself and in its environment. The current problems facing the domestic fish processing industry have very diverse origins, e.g. problems with raw material supplies, which were already apparent before accession to the EU and now seem to be decisive for the survival and continuity of many businesses. As the study shows, the COVID-19 pandemic has significantly affected the behavior of fish processing companies in terms of raw material purchases and deliveries to customers compared to the pre-pandemic period.

COVID-19 had a negative impact on the production of fish products due to significant delays in the supply of raw materials to fish processing companies. There were disruptions in the supply chain of raw materials regardless of the distance of the source of supply, with medium and large companies being particularly affected. All groups of fish processing companies experienced delays in deliveries of finished products to customers, prompting companies to increase their stocks on the supply and distribution side. Future studies should take into account changes in supply chains on the supply and distribution side under the influence of subsequent crises and the changes developed in response to them.

Fish processing companies should strive for scenario three (BII 3), as there are no negative aspects and there are significant changes in supply and distribution logistics, which directly affect the company's functioning on the market.

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WILL MANAGEMENT CONTRIBUTE TO THE IMPLEMENTATION OF THE ECONOMICS OF VALUE?

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Purpose: Emanations of neoliberalism—financialization and the maximization of shareholder value—have produced numerous negative effects. M. Mazzucato and R. Collington (2025, p. 184) argue that the pressure to maximize shareholder value has been particularly harmful to research-intensive industries, undermining their capacity for innovation. This makes it reasonable to search for alternative ideas that would enable changes capable of eliminating or reducing the negative consequences of neoliberalism. Such ideas include the value economy and the democratization of enterprises**.** The dissemination of the value economy is possible through the implementation of its principles by means of transformed management practices. Therefore, the aim of the article is to assess the extent to which actors professionally involved in management can participate in implementing the value economy.
Approach: This goal was achieved by identifying groups of management tools:

- those useful during the implementation of the value economy,
- those used to realize the assumptions of neoliberalism.

A bibliometric analysis was then conducted to answer the question**:** which of these tools attracts more interest among authors publishing on management?
Findings: The bibliometric analysis showed that publications related to neoliberalism are far more numerous than those referring to the value economy. This indicates that management can be used only to a limited extent to promote and implement the value economy.
Research implications: The findings suggest that it is difficult to expect that professionals associated with management—researchers, consultants, managers—will engage in disseminating ideas that oppose neoliberalism. This places responsibility on other social science specialists. The study also serves as a suggestion to authors writing about management to analyze their subject matter more thoroughly, especially from the perspective of potential, unintentional apologetics for neoliberalism.
Originality: The originality of the article lies in treating management as a tool for implementing the value economy. While critiques of neoliberalism are relatively common (e.g., David Gelles's *The Man Who Broke Capitalism [2023]),* the role of management in promoting its alternatives is considered far less frequently. The article is addressed primarily to management professionals and aims to encourage them to undertake a more comprehensive analysis of management instruments.
Keywords: management instruments, economics of value, critique of neoliberalism, financialization.
Category of the paper: viewpoint.

1. Introduction

This article is located in the field of economics and management and quality sciences. It aims to assess the extent to which those professionally involved in the research and implementation of management instrumentation can contribute to the implementation of economics of value and post-neoliberalism.

The text presents the genesis of neoliberalism. Its social and economic effects are indicated, focusing on companies and the negative impact on the situation of employees. Its impact on management is considered. In turn, financialisation as a consequence of neoliberalism is presented. It was pointed out how financialisation affects managers, motivating them to promote shareholder value. The effects of such behaviour are discussed at the macro level - the whole economy - and at the micro level, i.e. for the different stakeholder groups of companies.

In turn, the economics of value was presented: the rationale for interest in this trend and its essence. One of them - the growing problems of the market economy shaped in the period of neoliberalism - was developed. The view was cited that the desired changes - the restoration of economics of value - should occur through changes in enterprises. In the context of eliminating the negative effects of neoliberalism, the democratisation of companies was cited. In addition, the existence of post-neoliberalism, as a current contesting neoliberalism, was signalled and the similarity between the attitude of this current and economics of value was pointed out.

The thesis adopted in the article, that the elimination of the negative effects of neoliberalism can be achieved through the implementation of economics of value through changes in management, resulted in an analysis of the instrumentarium of business management. This implementation will at the same time contribute to the spread of post-neoliberalism.

In order to establish the potential of management in the implementation of economics of value, post-neoliberalism and the democratisation of companies, a group of management tools were identified that can be thought of as potentially useful in this process and those that are used to implement the assumptions of neoliberalism. For the purposes of this article, a review of management literature indexed in the JSTOR database was conducted. The analysis revealed that within management studies, publications addressing issues thematically related to neoliberalism are considerably more numerous than those that could be associated with the economics of values or the democratization of firms.

This disproportion can be interpreted as an indicator that management research and new instrumentation can to a limited extent be used to offset the effects of neoliberalism through the implementation of economics of value.

2. Neoliberalism

The term neoliberalism is used in at least two senses: a) to denote all orientations in political philosophy that refer to classical liberalism in the terms of A. Smith or J. Looke, b) to describe one of the schools of economic thought whose founders were L. von Mises, F.A. von Hayek and M. Friedman (Szachaj, 2015, p. 7). In the economics literature, the term neoliberalism is generally used as a category included in the second of the strands indicated as a theory referring to liberal assumptions, economic and social theories and free market theory, which has a real reflection in global politics, economy, culture and education (Michałowska, 2013, p. 17). Also according to Marek Jarzębowski (2014), the critique of neoliberalism as the main cause of the contemporary economic crisis actually refers to economic policies practised in the spirit of the recommendations of Milton Friedman and his disciples and followers from the Chicago school of economics. Such a presumption is confirmed by the fact that Alan Greenspan, blamed for directly contributing to the outbreak of the 2008 crisis, was heavily influenced by Friedman's thought.

The genesis of neoliberalism is situated in the 1970s (Knafo, Dutta, Lane, Wyn-Jones, 2018). At the time, there was a progressive crisis in economic policy, still based on the macro-policy principles developed by the followers of Keynesian economics, which was expressed, among other things, in expanding social programmes, rising taxes, while the consequences were stagflation and slow structural adjustment. The response to these phenomena was different in different countries. Wojciech Bieńkowski (1995, p. 11), in terms of the manner of reaction, distinguished two main groups of states: 1) adopting solutions increasing the role of the state in economic life, 2) limiting state interference in many areas of economic life. To the latter group, he included in particular the United Kingdom after Margaret Thatcher became prime minister in 1979 and the United States after Ronald Reagan took power in 1981, but also partly Chile under Augusto Pinochet, Russia during the presidency of Boris Yeltsin, and incidentally also Poland during the political transition.

According to Shoshana Zuboff (2020, p. 59), in the UK and the US, fear of seemingly inevitable economic decline, combined with demands for a democratic social compact, created confusion, anxiety and desperation among democratically elected officials who were inadequately prepared to diagnose the reasons why, in the past, successful Keynesian policies, had failed to prevent hardship. This was an opportunity for neo-liberal economists keen to promote their ideas, which flowed broadly, sucked in by the 'political vacuum' that was already plaguing the two governments (Jones, 2012, p. 215). Economists referring to F. Hayek and M. Friedman, promoted capitalism in its raw form, undisturbed by any other force and impervious to any external power (Zuboff, 2020, p. 60). Inequality of wealth and rights were accepted and even recognised as a necessary feature of the functioning of the market system and a force for progress (Mirowski, 2013, pp. 53-67). In this situation, neo-liberals supporting politicians in

elections who had previously suppressed a strong labour movement won. They privatised state-owned enterprises and marketised the welfare state (Mirowski, Plehwe, 2015). Neoliberal economists achieved what they framed as the stemming of the wave of 'Marxist and Keynesian planning that was going around the world' (Blakeley, 2024, pp. 13-14).

On this ground a new concept emerged, developed and published by Michael C. Jensen and William H. Meckling (1976). It became known as the 'shareholder value maximisation movement'. Jensen and Meckling, building on Hayek's work, challenged the pro-social principles of the twentieth-century corporation. By the turn of the century, maximising shareholder value had become widely accepted as an objective function of the company. Neoliberal views also led to the emergence of the so-called 'new public management'. Its aim was not to limit the power of the state or even to subordinate state institutions to the 'free market'. It was about replacing democratic rule with technocratic rule - about replacing rule by the people with rule by technocratic elites. In this way, neoliberalism became a 'monstrous regime of management by managers', permanently increasing surveillance and control (Knafo, et al., 2018).

The neoliberal paradigm has led to significant economic and social tensions (one example being the crisis that began in 2008). This is due to the fact that the market has become the only factor, rather than one of several (as in Keynesian theories), regulating the economy and social relations (Rąb, Rąb, 2016). One aspect of the aforementioned tensions is income inequality, which declined strongly in Europe in the twentieth century and increased significantly since 1980-1990. It is worth adding that the increase in inequality has been accompanied by a decline in economic growth (Piketty, 2022, p. 751). The mechanism of this process has been explained by Grace Blakeley (2024, pp. 87-88, 182 ff.).

With the advent of neoliberalism, crises became more frequent and capitalists figured out how to privatise profits during economic booms and then, when there was a crash, pass the losses on to society (S&P Buybacks, 2022). In practice, the new neoliberalism-referencing approach to crisis management meant that when the financial market recovered, capitalists raked in all the profits, but when the crash came, they were protected from them (Chamayou, 2021). Workers, on the other hand, were forced to suffer the consequences of the crisis - unemployment, low wages, cuts in public spending and social security (Blakeley, 2024, p. 87). Public spending has not declined, but is distributed differently - instead of financially supporting welfare or public services, states support big business and the rich with billions through subsidies, tax breaks and subventions. Neoliberalism has not changed the influence or power of the state, but it has changed the beneficiaries of state intervention. Investment in job creation, infrastructure programmes or public services serving workers has been abandoned. Instead, neoliberal states handed out huge amounts of cash to big business and the wealthiest, while claiming that in doing so they were supporting 'free markets'. Neoliberalism has failed to provide a less interfering, weaker state. In the era of neoliberalism, state spending increased as much because of lobbying for state aid to companies as demands for more state aid spending.

In the US, state spending (defined as a percentage of GDP) is higher today than it was in the 1970s, and much of this increase took place during the dominance of neoliberalism. In the UK, successive governments have reduced public spending, but it was raised to peacetime highs when they decided to urgently bail out banks that had made reckless decisions driven by neoliberal macroeconomic policies (Blakeley, 2024, p. 78).

Neoliberalism has come to be seen not only as an economic doctrine, but more importantly as an ideology designed to capture all human thinking. John N. Gray (2002) has equated neoliberalism with communism, treating these ideologies as faith-driven messianic movements. In addition to Gray, many other commentators on late capitalism also believe that neoliberalism is not born out of the necessity of social and political freedom (Rąb, Rąb, 2016).

Henry Giroux has identified neoliberalism as the most dangerous ideology of modern times, strongly present in contemporary culture, which is described in the language of commercialisation, privatisation and the free market (Michałowska, 2013, p. 17).

Capitalists are not scary monsters, but people driven by self-interest. The problem is that their interest is diametrically opposed to that of the majority. Even if every politician, financier or director were replaced by another person, the system would function much as it does today (Blakeley, 2024, pp. 88-89). There has been an unprecedented dehumanisation of political, social and economic life under neoliberalism. The individual was left to his or her own devices, without help or care from the state. The motto for this period became 'manage yourself as best you can'. Unfortunately, the majority of communities and citizens were unable to deal with their problems on their own. This exacerbated pathological phenomena - poverty, unemployment, corruption or debt (Szafarz, 2020).

3. The consequences of financialisation in companies

Jerzy Hausner (Mikołajczyk, 2020) stated that "Those who adhere to value economics argue against the model of the market economy, described by three concepts: globalisation, financialisation and digitalisation". Of this triad, it seems that the functioning of individual companies is most directly affected by financialisation, which should be seen as an emanation of neoliberal ideology. Financialisation is treated as one of the key factors in the economic transformations taking place over the last few decades. Gerald Epstein (2005, p. 3) defined financialisation as 'the growing role of financial motives for action, financial markets and their users, and financial institutions in the functioning of national and international economies'. The interest in financialisation was prompted, among other things, by the emergence of views that a focus on international competition overestimates the importance of the productive sphere in the economy. Instead, some authors have identified financial instruments, particularly shareholder value, as an important driver of change in the economies of developed countries

(van der Zwan, 2014). According to Paul H. Dembinski, financialisation has become an emerging organisational principle that gives the characteristics of coherence and efficiency to the socio- economic order. According to this thesis, the process of financialisation is not limited to the financial sphere alone, but extends its impact to the real economy and, through it, to people's everyday lives (Dembinski, 2011, p. 129).

Financialisation was approached holistically by Natasha van der Zwan (2014), who distinguished three strands in her study of this phenomenon:

a) the treatment of financialisation as a mode of accumulation,
b) a focus on the financialisation of the modern enterprise,
c) financialisation of everyday activities.

Due to the subject matter of this article, it focuses on the second of these currents. It deals with the dominance of the shareholder value orientation as a guiding principle for shaping corporate behaviour. It is a management approach in which the success of a company is expressed in the change in shareholder value. This viewpoint gained popularity in the 1980s and the former CEO of General Electric, Jack Welch, is considered the main precursor. The essence of this viewpoint lies in the assumption that the most important objective of a company is to increase the assets of its shareholders (owners) through the payment of dividends or an increase in shareholder value (Szczepanowski, 2016), which follows the views of Jensen and Meckling (1976) outlined previously. A consequence of the financialisation of the modern firm is to consider how financial markets influence non-financial firms and their managers to adopt business practices that promote shareholder value. Secondly, it examines how shareholder value-driven businesses 'transfer' the pressures of financial markets to other business stakeholders, in particular employees.

The impact of financialisation on the functioning of enterprises was addressed by Andreas Nölke and James Perry (2007), who argued that the financialisation of enterprises should be understood as a set of different activities carried out by non-financial actors in order to increase the share of revenues generated from financial operations or transactions, complementing those generated from the production of products or the provision of services. Other processes that are realised in enterprises are called channels of realisation of such financialisation. One of these is changes in the operational activities carried out. In addition to the financialisation of income, Nölke and Perry also identified the financialisation of management processes, which is expressed in the influence of owner value management concepts on the financial policy of companies. In this context, it is particularly relevant to analyse decision-making processes focused on any possible means of increasing returns on capital employed or instruments for increasing value for owners.

In connection with financialisation, Dembinski recognised the phenomenon that in Western countries there has been a kind of swapping of ends and means, involving the transformation of relationships, treated as a social and economic form of interaction, into a transaction that allows any relationship to be unilaterally and abruptly broken. Relationships are increasingly

established primarily to periodically take advantage of opportunities that arise and benefit through a particular transaction, which entails the sudden reversal of alliances and the breaking of ties of loyalty, sometimes at the expense of the partner. Such behaviour leads to the disappearance of trust. Both parties to the relationship seek to preemptively protect themselves from the partner's undesirable behaviour, which consequently weakens the relationship and destroys part of its creative and economic potential. "Living in constant fear of a blowback distracts from existing relationships, rendering them empty and meaningless" (Dembinski, 2011, p. 14). Soon after, when one partner perceives that the other is beginning to look for ways out of the relationship, insecurity may deepen, which violates trust and may even lead to retaliatory steps or strategies to counterbalance the partner's behaviour. Such behaviour deprives the relationship of some of its essence and potential for development (Dembinski, 2009). The described swapping of ends and means has been identified as one of the most important aspects of the phenomenon of financialisation. This confirms the validity of Hausner's postulate: a different conception of enterprise and business is required. An illustration of the scale of employee layoffs in companies guided by the idea of shareholder value is General Electric, where, within just two years of Jack Welch assuming the position of CEO, 35,000 employees were laid off, representing 9% of the total workforce. Corporate consolidation was estimated to reduce the average American wage by approximately $10,000 per year. At the same time, profit margins in the largest corporations increased from 7% to 18% (Gelles, 2023, p. 231).

The orientation of shareholder value in business management has affected the situation of different groups of business stakeholders, among others, shareholders, managers and employees. Research has shown that financialisation has particularly benefited managers of large companies (Martin, 2010). This is supported by the views of US researchers, who agree that the enrichment of shareholders and managers has been to the detriment of employees. Corporate restructuring motivated by shareholder value has been associated with job losses (Lazonick, O'Sullivan, 2000). Blakeley (2024, p. 91 ff.) gave a number of examples of financial restructuring combined with employee redundancies. In addition to redundancies, there were transformations in work processes - employees working longer but for less pay. Shareholder value is also 'blamed' for leading to a bifurcation of work: all employees experience increasing uncertainty and work intensity, but only skilled employees (e.g. managers, professionals) receive higher wages and more rewarding tasks. In contrast, the less skilled work for lower wages (Lin, Tomasovic-Devey, 2011). Shareholder value has become the most important goal of the company and also the norm for the transformation of capitalism (Aglietta, 2000, p. 149). This concept is taken as an excuse for practices that favour shareholders over other stakeholders, illustrated by the so-called 'quarterly capitalism', which is expressed in a focus on short-term financial performance. Its main source is the pressure from financial markets on public companies to maximise short-term performance. As a consequence, companies are less able to invest and build value over the long term, damaging economic growth and lowering

returns for savers (Barton, Wiseman, 2014). Wojciech Czakon (2024, p. 265) writes about an identical phenomenon, calling it short-termism. Savings on marketing and R&D activities and employee training, among others, have been identified as its manifestations. However, short-termism is supposed to result from the inclinations of individual managers, which seems to be a diagnosis that needs to be deepened. The phenomena indicated are illustrative of the processes described in the first part of the article leading to income inequality. M. Mazzucato and R. Collington (2025, p. 184) drew attention to another consequence of maximizing shareholder value, arguing that it has been particularly harmful to industries that rely heavily on scientific research, undermining their capacity for innovation.

Another consequence of financialisation is that modern corporations are expected to assume an increase in profits that is almost impossible to sustain in the long term. And when they fail to achieve such objectives through methods appropriate to operations (e.g. through incremental productivity growth, product innovation, better motivation of employees), they are forced to achieve profit growth objectives by other means: "They then employ choices that invariably lead to a diminution of the value generated by (...) society as a whole" (Bogle, 2009, pp. 122-123).

Many businesses perceived as productive have in fact become financial businesses that count rather than produce. They base their strategies "not on their knowledge of the business they are entering, but on the assumption that by snooping around for profitable deals, 'rummaging through the economic trash' and finding extraordinary treasures in it, they can allocate their financial resources with better success than they would through existing financial markets" (Bogle, 2009, pp. 125-126). A similar thought was expressed by Dembinski (2012): "The economy is driven by the principle of maximising the financial effect and not by efficiency or productivity gains. You can have a fantastic financial effect for years while making a good impression'.

Another theme explored in the stream described above is income inequality in modern economies. A major track record in this area is that of Thomas Piketty (e.g. 2015), in whose work this phenomenon has been exhaustively discussed. The remuneration of corporate managers has also been addressed by Ha-Joon Chang, among others, who has criticised in particular the size of executive pay in the United States and the United Kingdom (Chang, 2013, ch. 14). Pointing out his considerations, he stated that managers must constantly produce additional profit to distribute to shareholders so that shareholders do not raise the issue of excessive managerial remuneration. "This can be done by exploiting employees - by downward pressure on wages, by using atypical forms of employment and by reducing the number of full-time positions. The need to silence shareholder dissatisfaction by maximising dividends means that investment is reduced to a minimum, which undermines the firm's productive capacity in the long term" (Chang, 2013, pp. 205-206). When considering income inequality, in addition to the social or economic effects, it is important to see the effects in the functioning of

companies. These are exemplified by the reduction in product quality described by Douglas Cowherd and David Levine (1992), the greater the wage gap between managers and employees.

The comments outlined above leave no doubt about the impact of neoliberalism-induced financialisation on corporate management. The fundamental directions of this influence within companies are as follows:

1) a focus on all possible means of increasing returns on capital employed and instruments of increasing value for owners,
2) restructuring of company activities (motivated by shareholder value) leading to job losses,
3) exploitation of employees - downward pressure on wages, use of atypical forms of employment, reduction in the number of full-time positions,
4) transformation of work processes - working longer, for less pay,
5) reduction of wages for the less qualified (e.g. digital Taylorism).

The phenomena indicated are undoubtedly challenges to be met by implementing 'a different concept of enterprise and economic activity' (Hausner, 2021, p. 14).

As mentioned in part one of the article, neoliberalism was to lead to technocratic rule by technocratic elites, becoming a 'monstrous regime of management by managers' (Knafo et al., 2018). This governance regime is expressed in the described practices induced by the financialisation of companies.

The relations of companies with other actors, undertaken in the spirit of neoliberalism and financialisation, leading to appropriation or so-called value extraction, deserve separate treatment, but this is a topic for separate considerations.

As a summary of the comments on financialisation in the context of companies, let us use the opinion of World Bank vice-president Kaushik Basu, who stated that there is human dignity in addition to interests. Inequality can be accepted as long as it clearly benefits the general public. This level has clearly been exceeded. The suffering caused by such inequalities must not be condoned. Basu stated that the accumulation of wealth caused by financialisation, is bad because it harms the economy and businesses. Furthermore, the World Bank has data showing that inequality has slowed global economic growth, destabilises politics and conflicts societies and states (Żakowski, 2014).

4. The essence of the economics of value

The economics of value may be regarded as a component of an alternative order to neoliberal ideology—its implementation, alongside other post-neoliberal proposals, could help initiate the reduction of the negative effects of neoliberalism. Being aware of the extent of the negative effects of neoliberalism and the indications of its twilight, it is reasonable to ask:

what after neoliberalism? The rise of cloud capital and asset managers are two fundamental phenomena that are shaping contemporary capitalism. Perhaps it is these two types of corporations that will shape, at least to some extent, what comes (or came) after neoliberalism (Tsoukalis, 2024). Another putative phenomenon that will shape contemporary capitalism is post-neoliberalism. Szafarz (2020) identified its main assumptions as follows:

1. Increasing the role of the state in political, social and economic life, i.e. state interventionism, renationalisation of ('privatised') enterprises and banks.
2. Redistribution of income with a view to improving the livelihood of the most disadvantaged citizens and eradicating poverty and exclusion.
3. Freeing from the yoke of the so-called 'Washington Consensus', in particular those countries to which this yoke has been imposed. (There are practical applications of these ideas, particularly in Latin America).

However, doubts are being raised as to whether post-neoliberalism will stand the test of very difficult times because it is sometimes seen as a "poor substitute" - in the absence of a more serious systemic and anti-crisis remedy (e.g. an innovative social market economy) to the contemporary ills of civilisation. Post-liberalism, in its current form, is not yet considered a rational, optimal and forward-looking alternative to extreme neoliberalism, which is still vegetating and still damaging in some places (Laruffa, 2023).

Referring to the above concerns of Francesco Laruffa, it is possible to believe that the economics of value is the idea that will contribute to the realisation of the assumptions of neoliberalism, will become the path leading to its spread. Such a presumption stems, among other things, from the similarity of the premises that have contributed to the emergence of the two currents.

Economics of value is nowadays a popular and widely discussed concept. This interest, Hausner (Mikolajczyk, 2020) explained with two premises. The first premise is the growing problems of the market economy, shaped under neoliberalism. The second is the imbalance between mathematical economics and the tradition of treating economics as a social science, according to which the meaning of economic activity is beyond itself, referring to people's needs and quality of life. This trend creates so many distortions in the functioning of societies that it generates global risks and an anti-market trend in social and political action. In the context of the second premise, Monika Kostera's postulate seems important: (Bauman, Bauman, Kociatkiewicz, Kostera, 2017, p. 50) '... the world should again become a place to live, a place where there is hope and where people and the planet are more important than the interests of an anonymous investment fund and financial indicators. My impression is that most people I talk to agree with this belief...".

The market economy shaped under neoliberalism is characterised by macro and micro problems. The global threats indicated above, the anti-market trend in social action (populism), among others, are to be counted as macro problems. On the other hand, phenomena arising in enterprises caused by the implementation of the assumptions of neoliberalism are micro

problems. An assessment of these phenomena was formulated by Kostera (Bauman et al., 2017, p. 50), who believes that management has also become one of those domains that does not seem to be affected by a general code of ethics or even human conscience - it has been replaced by a creation called 'business ethics', which refers to ethical standards and moral choices in business that are fundamentally different from those in other spheres of life. This concept was explained by Dembinski (2012), pointing to the relationship between social systems and ethics. It is an approach characterised by the fact that, for a system (e.g. a business), ethics is an endogenous phenomenon. Businesses that refer to business ethics in their relations with other actors pursue their own benefits, seeing them as their supreme value. This is expressed in undertaking behaviour aimed at maximising their own economic efficiency.

According to Hausner, a turn towards economics of value is necessary if one wants to eliminate the pathologies of the modern market economy (Hausner, 2019, p. 404). The concept of 'economics of value' seems to Hausner "extremely necessary and timely in the context of the efforts being made to deeply revise neoclassical economics, which has become ossified and stuck in the shallows, with no current in it because there is no intellectual life in it" (Hausner, 2019, pp. 13-14).

To clarify what an economics of values is, Hausner (2021, p. 12) attributed the following attributes to it:

1. Accepting that values are produced, expressing a deep conviction that values exist because they are created in the process of human activity.
2. Recognition that value production is a social process, meaning that values (a) emerge through the communication and interaction of individuals, (b) emerge through joint discussion, and with the balancing of different views.
3. It is crucial to understand the distinction between existential and instrumental values. The former arise from and sustain community, and make survival possible. Instrumental values have a practical significance. They enable activity and serve to achieve set goals. The basis for the generation of instrumental values is the existence of existential values.
4. When creating instrumental values on the basis of existential values, care must be taken to ensure that the former do not override and destroy existential values. A potential danger arises from the fact that modern economics is a linear process, i.e. focused on achieving a surplus in relation to the costs incurred in conducting business. In such a situation, the only measure of success is profit, while the fact that value-destroying processes are set in motion, as it were, is overlooked. In Hausner's view, the goal of value economics should be to move from a linear economy to a circular economy in which resources are conserved, renewed and multiplied.

Referring to the given attributes of the economics of value, it can be stated in the most general terms that it is a strand of economics that emphasizes human activity in the process of generating value (rather than, for example, financial machinations or circumventing the law),

aiming to create a circular economy that cares for resources: preserving, renewing, and multiplying them.

The cited author believes that the restoration of economics of value, should take place primarily from the production side i.e. from the enterprise side. "And this requires a different conception of enterprise and economic activity. One that does not shy away from the axiological dimension of economics and does not limit economic analysis to the efficiency dimension only" (Hausner, 2019, p. 14). In a similar vein was Kostera (2014), who saw management science and the science of management as a key resource in what could be called the Mark III revolution, involving the elimination of corporate management structures and the real empowerment of workers.

Advocates of economics of value are opponents of the kind of market economy model characterised by the phenomena of globalisation, financialisation and digitalisation. A model in which the category of value has been reduced to profit and price. "That which does not have a good price is unprofitable and therefore worthless" (Mikolajczyk, 2020). The consequences of this understanding of economics are the negative social consequences, the financial crisis and the break-up of the eurozone. It is therefore necessary to find a balance between an economics that applies models drawn from the sciences and one that appeals to meaning and values. These strands of economics should be combined.

The caveats presented do not mean that value economics questions the existence of market mechanisms, on the contrary. It believes that market mechanisms are essential to business and therefore economics of value does not propose to eliminate them. It considers them to be valuable. The problem is that modern capitalism has taken a degenerate form - quarterly capitalism. Investors expect quick profits, managers are held accountable for short periods (to the rhythm of companies' quarterly reports), so it is mainly the quick result that matters.

Consumers and their behaviour have also influenced the development of the economics of value. They are important participants in the economic arena and shape its form with their behaviour. The tool used by consumers is, to use traditional terms, their wallets. Buyers may accept certain products and are even willing to pay more for products produced in accordance with *fair trade* principles. At the same time, they may be willing to forego products that are made by children or in countries that may be believed to have human rights violations and the production of certain products takes place in (variously called) camps.

The above comments confirm that value economics and post-neoliberalism are consistent in terms of the values they promote and the outcomes they expect.

The realisation of the assumptions of value economics would have to eliminate the premises that generated interest in this strand. Some of such endeavours would be related to the pursuit of a balance between mathematical economics and the tradition of treating economics as a social science. Other initiatives would relate to - most generally - enterprises and would concern changes in the approach to their nature and the conduct of business.

It seems that these transformations should concern at least two areas: a) the realisation of expectations formulated by stakeholders towards enterprises, b) the management of enterprises. Stakeholders constitute a diverse collective, the participants of which usually have different expectations towards the enterprise. Nowadays, one can observe the growing activity of at least some of them, consisting, among other things, in the increasingly intensive verbalisation of expectations towards enterprises. Noteworthy in this context are groups demanding a reduction in the negative impact of enterprises on the environment, equal treatment of employees regardless of e.g. gender, preferences or country of origin. Companies are also required to take ethical criteria into account in their decision-making processes and operations. Entities that do not meet these expectations risk losing legitimacy and may face boycotts from customers. It can therefore be thought that at least some stakeholders are increasingly pushing companies towards the implementation of value economics principles.

In addition to economics of value, which was formed in opposition to the negative effects of neoliberalism, it is worth recalling Blakeley's views, which are even more critical of capitalism in its neoliberal version. She recalls Philip Mirowski's (2013, pp. 53-67) observation that, outside the economy, the neoliberal state, using repression, has far more power than the social democratic state. The violence of such a state serves capital rather than acting against it (Blakeley, 2024, p. 81). This position leads to the conclusion that capitalism is not defined as the presence or absence of markets, but as the domination of capital over society. In contrast, socialism is explained by the democratisation of society. True democratic socialism proposes a project of collective liberation that would allow workers to take control of production and citizens to take control of government (Blakeley, 2024, p. 428). Therefore, policies leading to the democratisation of firms, finance, the state and international institutions can be seen as a way to offset the negative consequences of neoliberalism. Such policies can attempt to experiment with processes of democratic decision-making as well as block repressive laws enacted in the service of capital (Blakeley, 2024, pp. 435-436). Blakley (2024, pp. 436 ff.) proposed four spheres of such activity: 1) democratisation of labour and capital, 2) democratisation of finance, 3) democratisation of the state, and 4) democratisation of international institutions. Due to the subject matter of the article, only the first of these spaces is focused on.

According to Blakeley (pp. 436 ff.), a corporation is a political institution with power both over workers and, more broadly, over society, which has been granted to it by the capitalist state. The capitalist enterprise defines a class division between those who own and manage the enterprise and those who produce the products. The democratisation of the corporation requires abolishing this dichotomy and granting workers and citizens the right to control what drives production, in particular: a) committing to collective bargaining that takes into account a transnational perspective and workers from across the value chain, b) pursuing policies to free up workers' time and raise their wages (to be crucial in changing the balance of power between

workers and superiors), c) ensuring that workers have the right to refuse to work, d) developing public forms of ownership.

In parallel with adaptations to the expectations of stakeholders, there should be changes in the management and management instrumentation of enterprises, which would enable the transformation of enterprises' activities and even, in part, of their essence. It seems that changes in the spheres indicated should be aimed at eliminating those phenomena that neoliberalism and its inherent financialisation have brought about in enterprises and contributed to the emergence of post-neoliberalism. One may be concerned that this kind of transformation has so far been very limited in scope. It seems that as other, more concrete changes in the management of enterprises in the realisation of the assumptions of economics of value and post-neoliberalism, it is possible to point out: a) the consideration of existential values, b) the consideration of the generation of value by the employed in the course of the operation of enterprises, c) the creation of conditions in enterprises for communication and interaction of individuals, d) the creation of conditions for the establishment and maintenance of bonds between people in the course of the operation of the enterprise.

Comparing the directions of change in enterprises that would serve the implementation of the economics of value with activities serving the democratisation of corporations, it can be seen that, although the former are broader in scope than those related to the democratisation of enterprises, they are to a large extent compatible. For this reason, the view that ventures aimed at implementing the assumptions of value economics will simultaneously contribute to the democratisation of corporations and the spread of post-neoliberalism seems justified.

5. Expectations regarding management

Jack Welch, an emblematic figure in management over several decades since 1980, in practice applied the principles of neoliberalism, including the view advocated by Milton Friedman and other like-minded economists that companies should, at all costs, maximize profits for shareholders. The triad implemented by Welch—downsizing, mergers and acquisitions, and financialization—served a single purpose: enriching investors. “If this meant eliminating hundreds of thousands of jobs—so be it” (Geller, 2023, p. 15). A range of management instruments were used to realize these aims; for example, the concept of lean management and outsourcing served not only their declared goals but also functioned as justification for employee layoffs. Management consultants have long advised companies on, among other things, restructuring and the removal of entire management layers. This meant the elimination of jobs. Consultants are often hired so that managers can shift the blame for layoffs onto them, thereby limiting resistance from remaining employees and trade unions. In this way,

they justify and legitimize previously made restructuring decisions (Mazzucato, Collington, 2025, p. 182).

Hausner, already referred to, stated that a different concept of enterprise and economic activity is needed. A similar demand - the creation of an alternative economic theory - was formulated by Peter Beatie (2019). Also the cited Blakeley (2024, pp. 435-436) postulated policies leading to the democratisation of corporations. The ideas mentioned can be put into practice by corporate managers. However, it is important to bear in mind that they are so far operating in a context shaped by neoliberalism and financialisation. Managers have to demonstrate to shareholders and rating agencies an increase in the value of companies. This is a course of action calculated for the short term, and in the longer term it has negative consequences, not least for companies. Assuming that managers will behave rationally from their particular point of view, it can be assumed that the dominant attitude is and will be the desire to maintain a privileged position in terms of the remuneration they receive, coupled with limiting the risk of losing their positions as a result of failing to meet the expectations of business owners. As a result, managers are looking for assistance to help them solve the problems in their companies and are therefore so keen to use selected new management ideas. These are provided, among others, by modern management consulting, which emerged in the United States in the 1930s. Management consultants have a strong influence on the modern world (McKenna, 2006). They are seen as one of the driving forces behind the acceleration of social life in a capitalist society (Stein, 2018). Concretising this influence, Anna Canato and Antonio Giangreco (2011) stated that management consultants play four roles: information sources, standard setters, knowledge brokers and knowledge integrators. Efficiently playing the aforementioned roles can contribute to the legitimacy of the organisational and management studies research community (Hensel, 2017, p. 14 ff.). Therefore, consultants should not focus only on selected ideas, standards or approaches. However, as M. Mazzucato and R. Collington (2025, p. 184) stated, "Many large consulting firms have long promoted a model of corporate governance oriented toward maximizing shareholder value—and, more importantly, have provided managers and shareholders with the justification for doing so by using restructuring". This view is confirmed by W. Lazonick and M. O'Sullivan, who already in 2000 observed that maximizing shareholder value was becoming an increasingly widespread form of corporate management, while "consultants continually extol the virtues of this approach" (Lazonick, O'Sullivan, 2000).

The demands of managers have led to the fact that consulting and management education are nowadays a large industry, with a turnover of tens of billions of dollars[1] . On the demand side of the management market, managers or those who aspire to become managers are mainly situated. They acquire various types of knowledge about concepts or other management

[1] For example, the turnover of the four largest consulting firms in 2023 was: KPMG - USD 36 billion, Deloitte - USD 65 billion, Ernst &Young - USD 50 billion, PwC - USD 53.1 billion. Source: https://rankia.pl/wielka-czworka-audyt-przewodnik-po-big-four/, 26.03.2025.

instruments that sometimes only seemingly can simplify reality, reduce managers' anxiety while giving them a sense of security (Zimniewicz, 2009, pp. 169-170; Koźmiński, 2004, pp. 31-32). The supply side of the presented market consists of consulting companies, advisors or management 'gurus'. This side also includes, among others, university employees or publishers. They are participants in a market where knowledge is "traded" (Zimniewicz, 2009, p. 170). This knowledge, the instrumentarium of management, is often offered as a miracle recipe for successful enterprises.

Key features of management research and their implications for management researchers have been identified by Mark Easterby-Smith, Richard Thorpe and Paul R. Jackson (2012, p.13). Two types of implications of such research should be noted: a) managers will have academic interest in research process / results and may want to contribute to the direction of work, b) research results may both derive from and lead to, practical action. Both traditional analytic research and action research are legitimate activities. As a result - as already mentioned - academics have become part of the supply side of the management market, who - if limited to approaches based on only one ideology - can create the misconception among managers that there is only one right way in management.

The management research community provides products that are assumed to perform the same functions as those of consultancies. It is under constant pressure to be "oriented to the needs of practice" (which is one of the criteria of parametric evaluation of Polish universities), and this practice, as already pointed out, being under the pressure of neoliberalism and financialisation, expects tools facilitating the realisation of the expectations of, first of all, shareholders of companies, on which the professional and material situation of managers depends. Consequently, representatives of the management science community, wishing to gain acceptance of their offer by the practice and thus legitimacy on its part, propose products (management instruments) that are complementary to or secondary to the consulting offer. It is relatively rare to offer management instruments that are qualitatively different from the existing ones, aimed at achieving qualitatively new effects. The academic community's engagement with practice was addressed by Michael Rowlinson and John Hassard (cited in Hensel, 2017, pp. 22-23), who noted that academics convinced that organisation research is too closely linked to business represent only a small proportion of all organisation researchers.

The views presented lead us to believe that there are two main groups in the management science research community: the first focuses largely on the needs of practice, being more or less influenced by neo-liberalism, regardless of axiological assessments of the effects of applying the results of its work; the second anticipates the needs of organisations, focusing more on their participants and their aspirations, not being influenced by neoliberalism, guided by concern for employees rather than the interests of e.g. investment funds, and it is from them that a commitment can be expected to implement the tenets of the value economy.

6. The instrumentality of management: an outcome of neoliberalism and a potential tool for the implementation of economics of value

Contemporary companies, driven by the motto “lower labor costs mean higher profits”, are constantly inventing new ways to marginalize their employees, going beyond routine downsizing. They aim to outsource as much work as possible to external providers, freelancers, and the gig economy sector. Supporting this objective is the emergence of infrastructure that facilitates precarious forms of employment, normalizing the lack of economic security (Gelles, 2023, p. 222). In this way, neoliberalism as a "monstrous system of management by managers" (Knafo et al., 2018) has undoubtedly contributed to shaping the instrumentarium of management. The management theorist community and the so-called consulting business, when offering new management instruments to practitioners, often do so under very lofty, humanistic slogans. However, when assessing their real effects, one should be guided by the apt remark by Janusz Czekaj, Czesław Mesjasz and Bernard Ziębicki (2018) that when considering the applicability of management science concepts and methods, attention should be paid not to the declared effects of their application by the authors, but to the real effects that their application may bring, especially when only selected elements of these instruments are applied. Guided by this guideline, an analysis of some management instruments has been carried out. Table 1 presents selected[2] components of these instruments, which can be thought of as contributing to an above-average degree to the realisation of the assumptions of neoliberalism and financialisation in companies. Three of these tools (process management, lean management, reeingineering) are also among the twelve most frequently used management instruments in Poland (Kral, Hopej, 2011, p. 214).

Table 1.
The use of selected components of management instrumentarium to implement the assumptions of neoliberalism in enterprises

Lp.	Selected management instruments (concepts, methods)	Expectations towards management resulting from neoliberalism				
		Increasing rates of return	Restructuring of activities	Exploitation of employees	Transforming work processes	Reduction of wages
1	*2*	*3*	*4*	*5*	*6*	*7*
1.	Concepts for improving the efficiency of companies		+	+	+	
2.	The concept of lean management	+	+	+	+	+
3.	Reeingineering	+	+		+	+
4.	Process management	+	+	+	+	
5.	Virtual organisation	+	+		+	

[2] The selection of concepts and methods was made arbitrarily by the author of the article on the basis of the criterion of presumed applicability to the implementation of the neoliberal agenda in enterprises. A comprehensive review of management instrumentation, let alone a holistic one, is far beyond the scope of the article.

Cont. table 1.

6.	Self-management and self-organisation		+	+	+	
7.	Time-based management		+		+	
8.	Empowerment			+	+	
9.	Organisation - the cloverleaf ("multi-tasker")	+	+	+	+	
10.	Corporate value management	+	+		+	
11.	Agile organisation and holocracy		+		+	
12.	Digital Taylorism		+	+	+	+

+ - a specific management instrument makes it possible to fulfil the indicated expectation.

Source: own elaboration based on (Seroka-Stolka, 2014; Biesok, Jakubiec, 2019; Łobos, 2021).

In determining the alleged impact of the management instruments presented in Table 1 on the realisation of the neoliberal ideology, the effects resulting clearly from the objectives and essence of the individual instruments were guided. Table 1 unequivocally demonstrates that some of the management instruments unquestionably serve to realise, at company level, the assumptions of the neoliberal worldview and financialisation. Furthermore, a conclusion can be drawn from the above table as to which instruments, as serving the assumptions of neoliberalism, are unsuitable for the implementation of value economics.

As Hausner stated, the restoration of value economics requires a different concept of enterprise and economic activity. In order to achieve this, there should be changes in the management and management instrumentarium of enterprises, which would enable the transformation of their activities and even, in part, of their essence. Also, the democratisation of corporations, as postulated by Berkley (2024, p. 436 ff.), requires fundamental changes in them. For this reason, it seems that changes in both management and management tools should be aimed at eliminating those phenomena that neoliberalism has brought about in companies and at undertaking specific projects aimed at realising the assumptions of the economics of value mentioned in Part III of the article. Table 2 assesses how selected components of the management instrumentarium can contribute to the implementation of the assumptions of the economics of value. The instruments selected for analysis are those which, on the basis of their essence and theoretical assumptions, can be apriori believed to serve the realisation of the ideals of the economics of value to an above-average degree.

Table 2.
Possibilities of using selected components of the management instrumentarium to implement the assumptions of value economics and post-neoliberalism

Lp.	Selected management instruments (concepts, methods)	Desired changes in management				
		Elimination of the effects of neoliberalism in enterprises	Consideration of existential values	Creating conditions for the generation of value by the employed	Creating conditions for communica-tion and cooperation	Creating conditions for links between people
1	*2*	*3*	*4*	*5*	*6*	*7*
1.	Management by values	+	+	+	+	+
2.	Socially responsible business	+	+	+		
3.	Knowledge-based organisation	+	+	+	+	+
4.	Corporate social responsibility	+	+	+		
5.	Diversity management	+	+		+	+
6.	Positive organisational learning	+	+		+	+
7.	Sustainable enterprise	+	+		+	
8.	Inclusive management		+	+	+	+

+ - a specific management instrument is conducive to the implementation of the indicated changes.

Source: own elaboration based on (Seroka-Stolka, 2014; Biesok, Jakubiec, 2019; Łobos, 2021; Gulski, 2021).

The Eliminating the Effects of Neoliberalism in Businesses indicated in Col. 3 is a very broad category that could replace all other directions of change in management. Therefore, when analysing the potential of the instruments listed in Col. 2 in the context of the aforementioned elimination, it was limited primarily to the elimination of: exploitation of workers, transformation of work processes and reduction of wages.

The instrumentarium of management is so rich that it is possible to use it both to realise the assumptions of neoliberalism and to eliminate its effects and implement new currents in economics.

An expression of the preference and interest of the community of academics and management-related consultants can be seen in publications devoted to, among other things, the instrumentarium of management. Table 3 presents the number of publications relating to various management instruments.

Table 3.
Number of publications relating to selected governance instruments

Lp.	Management concept / method	Total	Of which:		
			Journals	Book chapters	Research reports
1	*2*	*3*	*4*	*5*	*6*
1.	Value management	1 247 664	882314	221086	32137
2.	Value based management	1 010 148	711265	191994	27758
3.	Business process management	747199	477695	161725	20084
4.	High-performance work systems	639 708	446471	123936	13817
5.	Diversity management	448 029	316906	91582	10503
6.	Managing by values	408 632	265773	82081	7786
7.	Socially responsible company	161 897	77018	55299	1356
8.	Sustainable company	129 001	76835	35651	9873

Cont. table 3.

9.	Lean management	86787	36403	19033	1402
10.	Positive organisational Scholarship	49 927	29753	12005	324
11.	Lean enterprise	43837	17176	12774	331
12.	Agile organization	17119	7625	5260	1097
13.	Reengineering	7670	5768	1656	153

Source: the publication figures in the table were taken from the JSTOR database. Access date: 23 May 2025.

In Table 3, the instruments listed in rows 1-4, 9 and 11-13 correspond to Table 1, i.e. they indicate the number of publications relating to instruments that can be thought to correspond to neoliberalism. In contrast, the instruments listed in rows 5-8 and 10 can be related to the tools that are useful during the implementation of economics of value included in Table 2. Despite the simplistic nature of the analysis in Table 3, it can be thought that it demonstrates that there is a significant disparity between the commitment of the governance community to the perpetuation of the dominance of neoliberalism and the concern for the values inherent in value economics or corporate democratisation.

Summary

Management sciences are practical disciplines. Knowledge derived from research can be used, among other ways, instrumentally (Beyer, Trice, 1982), which means that practitioners attempt to directly apply the findings with which they become acquainted. Publishers of management-related publications must respond to the expectations of their readers, who are stakeholders in management research. Thus, the predominance of certain content reflects the dominance of specific reader demands. If—consciously or unconsciously—they remain under the influence of neoliberal ideology, they expect publications that facilitate the implementation of its assumptions rather than alternative ideas.

As mentioned in the Introduction, the aim of this article is to answer the question: to what extent is it reasonable to expect contemporary professional management circles to engage in the implementation of economics of value and post-neoliberalism?

For reasons of specificity, the contribution of the two mentioned circles to the implementation of economics of value has to be considered separately.

For consultants and consulting firms, a new management concept, model or method is a product that is offered to the demand side of the 'management market', which, being under pressure from the expectations of financial markets and shareholders, seeks products that facilitate the fulfilment of these claims. Thus, consulting products are sought which, in the short term (e.g. a quarter), make it possible to increase revenues, the value of companies and, incidentally, the income of managers. It should also be borne in mind that the management

boards of consulting companies are also held accountable for financial results, and this motivates them all the more to meet the expectations of company managers. It is difficult to imagine the fulfilment of the aforementioned expectations through the implementation of value economics. For this reason, the potential contribution of typical commercial management consulting to the implementation of economics of value and post-neoliberalism appears to be marginal. However, it is conceivable that management consulting institutions that are sponsored by philanthropists or organisations that support social progress could make a significant contribution to the implementation of value economics.

The attitude of the management science community is not so clear-cut. It should be seen as a significant group that focuses on the needs of practice, providing, among other things, instruments that respond to the requirements of managers described in Part 5 of the article. This part of the scientific community largely follows the path set by professional consultants. This is evidenced, inter alia, by the data in Table 3. The other part of this group is more focused on developing and promoting new instruments that, leaving aside the directives stemming from neoliberalism, coincide with the values promoted by economics of value. The affiliation of individual representatives of management science to any of the groups indicated is not permanent. However, it can be thought that those associated with the first strand can hardly be expected to be significantly involved in the implementation of economics of value. One should also be aware that the second indicated part of the research community, according to Rowlinson and Hassadr, represents only a small part of all organisation and management researchers. It seems that they would primarily be researchers located in the critical management studies or positive organisation science streams.

Several reasons for this disproportion can be identified: 1) the editors of management journals are reluctant to accept for publication articles that do not meet the expectations of their reader-practitioners [more extensively on the motives of readers of management publications is written by Hensel (2017, pp. 112-114)], 2) the small number of possible citations - texts that do not fit into the neoliberal mainstream are less likely to be read and therefore cited, 3) the small number of those interested in value economics and post-neoliberalism affects the low interest in training courses on these topics.

When assessing the possibilities of the scientific community's involvement in the implementation of economics of value and post-neoliberalism, one should also bear in mind Hensel's (2017, p. 13) statement that the activities they undertake, in response to the expectations of the environment and methodological problems, do not take the form of a coherent programme, but are emergent in nature, giving the impression of being poorly coordinated or even contradictory.

The contribution of the described communities to the implementation of the trends analysed can be expressed primarily in the dissemination of knowledge about management instruments and the development of new ones. The participation of the two circles indicated in the text: academics and consultants in the implementation of these two currents consists, among other

things, in publishing the results of their work, thanks to which knowledge of this subject matter is becoming more widespread among practitioners. However, the data presented in Table 3 shows that publications that can be thought of as reinforcing the place of neoliberalism in management are many times more numerous than those publications that can serve to weaken its position.

Extrapolating the directions of activity of management circles, shaped under the influence of neoliberalism, to date, allows us to believe that their potential involvement in the implementation of the ideals of economics of value is highly limited. Increasing this involvement would require the dissemination of the concept of the economics of value and an increased interest in its implementation, which would trigger a demand for new or adapted management instruments. However, the contemporary spread of right-wing populism leads us to believe that the aforementioned extrapolation is extremely likely, which at the same time determines the very limited involvement of management circles in the implementation of the economics of value.

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CLASSIFICATION AND REDUCTION OF INDUSTRIAL WASTE AS PILLARS OF SUSTAINABLE DEVELOPMENT

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Purpose: The aim of the article is to compare selected traditional and circular economy based methods of industrial waste classification and assess their usefulness for supporting sustainable development oriented industrial waste management. The study also explores how modern classification frameworks can contribute to the implementation of circular economy principles by facilitating waste reduction, resource recovery, and improved environmental protection.
Design/methodology/approach: The research is based on a structured narrative literature review using comparative thematic analysis. The study examines traditional classification approaches, including classification by source, chemical composition, and environmental impact, and compares them with contemporary circular economy based approaches such as the 10R hierarchy, material value assessment, and industrial symbiosis potential.
Findings: The analysis indicates that effective waste classification significantly improves the efficiency of industrial waste management systems. Traditional classification methods support risk identification and regulatory compliance, while circular economy oriented classification frameworks enable the identification of waste streams with high recovery potential. Integrating these approaches helps reduce landfill use, improve resource efficiency, and facilitate cooperation between industries through industrial symbiosis.
Originality/value: The article provides a comprehensive overview of industrial waste classification methods and highlights their strategic importance in the transition toward sustainable and circular industrial systems. By integrating traditional classification approaches with circular economy frameworks, the study offers a broader perspective on how waste can be transformed into valuable secondary resources.
Keywords: industrial waste, waste classification, sustainable development, circular economy, waste management, industrial symbiosis.
Category of the paper: Literature review.

1. Introduction

The rapid growth of industrial sectors worldwide has led to an unprecedented increase in the generation of industrial waste, posing serious environmental, economic, and regulatory challenges. Efficient and sustainable management of these waste streams has become a critical priority in contemporary environmental policy and industrial practice. Industrial waste, due to its complexity and often hazardous nature, requires a multifaceted approach encompassing accurate classification, proactive reduction at the source, and advanced treatment methods. This paper presents a theoretical exploration of the classification, minimization, and processing strategies for industrial waste, with a strong emphasis on integrating sustainable development principles. By examining current methodologies and innovative technological solutions, this study contributes to a deeper understanding of how interdisciplinary and data-driven waste management frameworks can support circular economy transitions and mitigate the environmental impact of industrial activity.

Rapid industrial development and the intensification of global production processes have significantly increased the volume and diversity of waste generated worldwide. Industrial sectors are among the largest contributors to total waste streams, producing a wide range of by-products that differ in composition, toxicity, and environmental impact. According to international environmental reports, the growing scale of industrial activity has intensified pressure on natural resources and ecosystems, making effective waste management a critical challenge for modern economies (Kaza et al., 2018). Improperly managed industrial waste may lead to long-term contamination of soil, surface water, groundwater, and air, as well as pose risks to human health and biodiversity.

In response to these challenges, waste management has become an integral component of sustainable development strategies implemented at global, regional, and national levels. The concept of sustainable development assumes that economic growth should occur in a manner that ensures environmental protection and social well-being for present and future generations (United Nations, 2015). Within this framework, the management of waste streams particularly those generated by industrial activities plays a crucial role in reducing environmental pressures and promoting more efficient use of natural resources. Effective waste management systems contribute not only to environmental protection but also to economic efficiency through the recovery of valuable materials and energy (Ghisellini et al., 2016).

A fundamental element of modern waste management systems is the classification of waste, which enables the identification of its origin, composition, and potential environmental risks. Proper classification facilitates the selection of appropriate methods for treatment, recycling, recovery, or disposal. It also supports regulatory compliance, risk assessment, and the development of effective waste management policies. Without accurate classification,

it is difficult to design safe handling procedures or implement efficient resource recovery processes (Tchobanoglous, Kreith, 2020).

In recent years, the traditional perception of waste as an unwanted by-product has gradually evolved. Increasing attention is being paid to the potential of waste as a secondary resource that can re-enter the production cycle. This shift is closely related to the development of the circular economy concept, which promotes the transition from linear models of production and consumption toward systems based on resource efficiency, material reuse, and closed-loop processes (Geissdoerfer et al., 2017). In such systems, waste is minimized through strategies such as reuse, recycling, remanufacturing, and energy recovery, thereby reducing the need for primary raw materials.

Within this context, the classification of industrial waste becomes a key tool supporting the implementation of circular economy principles. By identifying the characteristics and recovery potential of different waste streams, industries can develop more efficient strategies for waste reduction and resource management. Moreover, classification systems enable the identification of waste streams that can be reused, recycled, or utilized in industrial symbiosis networks, where by-products from one sector serve as inputs for another.

The aim of this article is to analyze selected methods of industrial waste classification and to examine their role in supporting sustainable development and circular economy practices. The scientific problem addressed in this paper is the lack of an integrated analytical framework for comparing traditional industrial waste classification methods with circular economy oriented approaches in terms of their usefulness for sustainable industrial waste management. Particular attention is given to classification according to the source of waste generation, chemical composition, and environmental impact. Additionally, the study discusses emerging classification approaches derived from the circular economy perspective, including classification based on circular potential, material value, and opportunities for industrial symbiosis.

2. Literature review

Waste management is one of the most prominent and desirable aspects of sustainable development across all sectors of the economy (Rabe, 2020). Waste management must be considered in a broad context, because the way it is handled may stimulate or slow down the pursuit of the idea of sustainable development (Czekała et al., 2013; Biegańska, Ciuła, 2011). Both current legal frameworks and global initiatives aimed at minimizing waste production and harmful emissions—while preserving the natural environment in its existing state—necessitate the creation of systems grounded in three interdependent pillars: social, economic, and environmental development (Biegańska, Ciuła, 2011). Social and economic progress can

be evaluated, among other things, by the volume of waste generated, including both municipal and packaging waste. All forms of waste are potential sources of pollution, and when stored, they pose serious risks to soil, water, and air quality. Therefore, it is important to know the methods of waste classification, which in the further process will result in the proper way of its management (Szuma 2012).

When properly prepared, processed, and utilized, waste can serve as a valuable resource for raw materials. The sustainable development of waste management primarily involves minimizing the need for landfilling and maximizing the recovery of usable components. This principle is especially apparent in the handling of industrial waste. Industrial operations are increasingly shaping the waste policies of production companies, moving beyond the traditional role of merely collecting waste. Producers are now placing greater emphasis on ensuring that as much waste as possible is recycled, while waste handlers are actively supporting this objective. Their collaboration focuses on streamlining the entire waste management cycle—from the point of generation, through sorting and logistical coordination, to final disposal or reuse. This cooperative model encourages the development of environmentally friendly methods and systems. Assigning responsibility for waste management to the producer adds an additional layer of oversight, ensuring compliance with environmental regulations. Moreover, it helps reduce unethical behavior among waste handlers, thereby enhancing adherence to environmental protection standards (Rabe, 2020).

3. Methodology

This study adopts a structured narrative literature review approach. The purpose of the review was to identify and compare the main approaches to industrial waste classification discussed in the literature, with particular attention to their relevance for sustainable development and circular economy implementation. The literature selection process was based on publications addressing industrial waste management, waste classification, hazardous waste, circular economy, 10R strategies, material value recovery, and industrial symbiosis. The analysis included peer-reviewed journal articles, academic books, and selected reports from international organizations relevant to the topic. The following inclusion criteria were applied:

1. publications addressing industrial or production-related waste,
2. sources discussing classification criteria, waste management implications, or circular economy applications,
3. publications with clear conceptual, analytical, or practical relevance to sustainable development.

The following exclusion criteria were adopted:

1. publications focused exclusively on municipal waste without industrial relevance,
2. highly technical studies dealing with narrow treatment technologies without reference to classification frameworks,
3. duplicate or marginally relevant sources.

The collected literature was analyzed using comparative thematic analysis. The reviewed studies were grouped into four analytical categories: classification by source, classification by chemical composition, classification by environmental impact, and circular economy based classification approaches. Each category was assessed in terms of classification logic, practical applicability, environmental relevance, and usefulness for supporting waste reduction and resource recovery.

Despite the wide range of classification methods discussed in the literature, there is still a lack of a coherent analytical perspective that would allow for a systematic comparison of these approaches in terms of their practical applicability and contribution to sustainable development. In particular, it remains unclear to what extent traditional classification methods are sufficient in addressing contemporary challenges related to resource efficiency and waste reduction, and whether circular economy based approaches provide a more effective framework for managing industrial waste streams. To address this research gap, the present study is guided by the following research questions:

RQ1: What are the main criteria used in traditional and circular economy based industrial waste classification methods?

RQ2: What are the strengths and limitations of these classification approaches in the context of sustainable development?

RQ3: Which classification approaches offer the greatest practical value for waste reduction, resource recovery, and industrial symbiosis?

By answering these questions, the study aims to provide a structured comparative analysis of existing classification frameworks and to identify those approaches that offer the greatest potential for supporting sustainable and circular industrial systems.

4. Results

4.1. Classification by source

Industrial waste can be classified according to its source, which means assigning it to specific industrial sectors in which it is generated. Such classification allows for effective adjustment of waste management strategies to the characteristics of technological processes in a given industry and to the properties of the waste materials generated.

Waste from the chemical industry is one of the most demanding categories in terms of environmental management. It is characterized by the presence of hazardous substances, such as organic solvents, acids (e.g. sulfuric, nitric), bases (e.g. sodium hydroxide), as well as by-products of chemical reactions (Tchobanoglous et al., 1993). Depending on the chemical industry – e.g. petrochemistry, plastics production or pharmaceuticals – the composition of this waste can vary significantly. Its toxicity, reactivity and often flammability mean that it requires special supervision, appropriate storage and specialist methods of disposal. Improper handling of this type of waste can contaminate soil and water and pose a threat to human health (Slack et al., 2004).

Waste from the metallurgical industry is characteristic of metal ore processing and metal smelting and processing. They include, among others, metallurgical dust, sludge, slag and waste from galvanic processes and surface treatment. They often contain heavy metals such as lead, cadmium or mercury, which can cause long-term environmental pollution and accumulate in living organisms (Lottermoser, 2010). Due to the large mass and volume of metallurgical waste, their management requires significant logistical outlays. On the other hand, many of these materials can be recycled, e.g. in construction as aggregate or in metal recycling.

Waste from the food industry is characterized by high biodegradability, which results from the high content of organic matter (Gustavsson, 2011). They come from the production, processing and packaging of food and include components such as pomace, sludge from sewage treatment plants, fats, fermentation residues, technological wastewater or product residues. Although they are usually not hazardous, they can cause odor nuisance, rapid spoilage and attract pests. Their management most often focuses on composting, biogas production or use as feed. This waste is also the subject of numerous studies on its potential in the circular economy (Galanakis, 2015).

Waste from the textile industry is generated in the processes of weaving, dyeing, printing and finishing fabrics and during the production of clothes (Ellen MacArthur Foundation, 2017). It contains numerous chemical pollutants, including synthetic dyes, auxiliaries used to fix colours, microplastics and fibre residues. Dyeing wastewater is particularly problematic, as it contains difficult-to-decompose organic compounds and is often highly toxic. An additional threat is posed by microfibres from synthetic fabrics, which enter the aquatic environment and enter the food chain. Sustainable management of this waste requires investment in modern wastewater treatment technologies and the development of textile recycling methods (Kant, 2012).

Waste from the construction industry includes a wide range of materials generated as a result of construction, demolition and renovation works. It mainly consists of mineral waste – concrete rubble, bricks, plasters, but also wood, plastics, insulating materials (e.g. polystyrene, mineral wool) and scrap (Coelho, de Brito, 2010). Although many of these materials are not classified as hazardous, some may contain harmful compounds such as asbestos, PCBs or lead paints. Construction waste accounts for a significant portion of the total

waste produced in industrialized countries. Recycling and reusing construction waste is essential for a circular economy, as it reduces the need for new mineral resources (Tam, Tam, 2006).

4.2. Classification by chemical composition

Classification of waste according to chemical composition enables identification of its physicochemical and toxicological properties, which is crucial for selecting appropriate technologies for disposal, recycling or recovery. It also enables assessment of environmental hazards and effective planning of storage and transport of waste materials. There are three main groups of waste: organic, inorganic and mixed.

Organic waste is a group of waste in which the dominant component is carbon compounds (except for some inorganic forms of carbonates). This category includes, among others, waste from the food, textile, petrochemical and pharmaceutical industries (Christensen, 2011). Organic compounds can be natural (e.g. fats, sugars, proteins) or synthetic (e.g. plastics, pesticides, organic solvents). Many of them are easily biodegradable, but some – such as chlorinated hydrocarbons, PCBs or some dyes – can be persistent, toxic and difficult to decompose. Organic waste management includes biological technologies (composting, methane fermentation), thermal (incineration, pyrolysis) and chemical (oxidation, neutralization). Separating biodegradable fractions from non-biodegradable fractions is also particularly important.

Inorganic waste includes waste containing mainly non-carbon chemical elements and compounds, such as metals, oxides, acids, bases, inorganic salts or minerals. This group includes, among others, metallurgical waste, fly ash, sludge from industrial wastewater treatment, slag and sediments from galvanic processes (Wang et al., 2009). Although some of them have high recycling potential (e.g. recovery of metals from catalysts or cells), others - especially those containing heavy metals or toxic substances - must be properly stabilized or stored in special conditions. Processing inorganic waste often requires the use of chemical and physicochemical technologies, such as flocculation, neutralization or incineration.

Mixed waste contains both organic and inorganic components, which makes it the most diverse and difficult to manage group. These can include, for example, sludge, composites, used electronic devices (e-waste), waste from the chemical or pharmaceutical industry, which contains both carbon compounds and heavy metals (Buekens, Yang, 2014). Due to the variety of components, they require comprehensive analysis and complex processing methods - they are often directed to specialist plants, where advanced separation, extraction or thermal neutralization processes are used. Effective management of this type of waste requires strict chemical control and advanced environmental engineering technologies (Pichtel, 2014).

4.3. Classification by environmental impact

A third important method of classifying industrial waste is based on its potential environmental impact. This approach focuses on assessing the degree of risk that a given type of waste may pose to ecosystems, natural resources, and human health. Unlike classification based solely on origin or chemical composition, this method emphasizes the consequences of improper waste handling and its potential long-term effects on the environment.

The assessment of environmental impact is typically based on several key criteria. These include toxicity, persistence in the environment, bioaccumulation potential, flammability and reactivity, as well as the ability of substances to migrate into soil, water, or air. In addition, increasing attention is being paid to the potential of certain waste streams to generate greenhouse gas emissions, particularly in the case of biodegradable waste decomposing under uncontrolled conditions. The consideration of these factors enables a more comprehensive evaluation of environmental risks and supports decision-making in waste management systems.

Based on the environmental impact criterion, industrial waste can be divided into several main categories. Hazardous waste includes materials that exhibit toxic, flammable, reactive, or infectious properties. Examples include chemical solvents, heavy-metal-containing sludge, acid residues, and certain pharmaceutical by-products. These types of waste pose a significant threat to human health and the environment and therefore require strict control, specialized storage conditions, and advanced treatment technologies.

Neutral or inert waste is characterized by low reactivity and minimal environmental impact. This category includes materials that do not undergo significant chemical transformations and do not release harmful substances under standard environmental conditions. Such waste can often be safely stored or used in construction applications, provided that it meets regulatory requirements.

Biodegradable waste consists primarily of organic materials that can be decomposed by microorganisms. Typical examples include waste from the food processing industry or certain types of agricultural and textile residues. Although biodegradable waste is generally considered less hazardous, its improper management may lead to the emission of methane and other greenhouse gases, contributing to climate change. Therefore, controlled treatment processes such as composting or anaerobic digestion are recommended.

Recyclable waste includes materials that can be reprocessed and reintroduced into production cycles. This category is particularly important in the context of resource efficiency and circular economy strategies, as it reduces the demand for primary raw materials. Examples include metal scrap, selected plastics, and certain types of construction waste.

Finally, difficult to manage waste represents a heterogeneous group characterized by complex composition, contamination, or technological barriers to processing. This category often includes composite materials, mixed waste streams, or residues containing both organic and inorganic components. Such waste typically requires advanced treatment technologies and

may involve high economic and environmental costs. Table 1 presents the waste category along with its characteristics and potential impact on the environment.

Table 1.
Classifying waste by its potential environmental impact

Waste category	Characteristics	Potential environmental impact
Dangerous	They contain toxins, heavy metals, flammable or reactive substances.	Water, soil, air pollution; threat to human health
Neutral	No chemical reaction, low toxicity	Low environmental impact
Biodegradable	Decompose naturally	Can be used in composting; may generate methane
Recyclable	Suitable for reprocessing	Reduces the use of primary raw materials
Difficult to manage	Complex composition, heterogeneous	Requires expensive processing and special technologies

Source: Own study.

Hazardous wastes include those that are toxic, flammable, reactive or infectious, such as certain chemical or medical wastes (UNEP, 2007). Inert waste, on the other hand, does not exhibit reactive properties and can be safely stored. Biodegradable waste is decomposed by microorganisms, but under uncontrolled conditions can generate methane and other greenhouse gas emissions (Naqvi et al., 2021). Recyclable waste, on the other hand, has the potential to recover secondary raw materials, reducing the consumption of primary resources (Anuar et al., 2025).

From a practical perspective, classification based on environmental impact plays a crucial role in risk assessment and prioritization within waste management systems. It enables the identification of waste streams that require immediate intervention, supports regulatory compliance, and facilitates the selection of appropriate treatment and disposal methods. Moreover, this approach is closely aligned with environmental protection policies and international regulations, which increasingly emphasize the need to minimize the negative impact of industrial activities on ecosystems. At the same time, it should be noted that classification based solely on environmental impact may not fully capture the economic or circular potential of waste streams. For this reason, it is most effective when combined with other classification approaches, particularly those related to material value and circular economy principles. Such integration allows for a more balanced approach that considers both environmental safety and resource efficiency.

4.4. Classification of industrial waste in the context of the circular economy

In recent years, traditional approaches to waste classification have been increasingly complemented by frameworks derived from the concept of the circular economy. The circular economy (CE) promotes the transition from a linear model of production and consumption based on the sequence “take–make–dispose”—to a regenerative system in which resources remain in use for as long as possible (Winans et al., 2017). Within this framework, waste is

no longer treated solely as an undesirable by-product of industrial activity but rather as a potential resource that can re-enter the economic cycle through various recovery pathways.

The circular economy perspective emphasizes the preservation of material value, the extension of product life cycles, and the minimization of resource extraction. Consequently, the classification of industrial waste increasingly considers its potential for reintegration into production systems rather than focusing exclusively on its origin or chemical composition (Su et al., 2013). Several classification approaches have been proposed in the literature to support this transition, including classification based on circular potential, material value, and opportunities for industrial symbiosis.

4.5. Classification according to circular potential – the 10R framework

One of the most widely discussed frameworks in circular economy research is the hierarchy of circular strategies known as the 10R model. This concept expands the traditional waste hierarchy and describes multiple strategies for retaining the value of materials and products within the economic system (Reike et al., 2022). The model includes a sequence of strategies that differ in the degree to which they preserve product functionality and material value.

The hierarchy begins with strategies aimed at preventing waste generation, such as refuse (R0), which involves avoiding unnecessary production or consumption. Subsequent strategies include reduce (R1) and reuse (R2), which focus on minimizing resource use and extending the life of products without significant modification. Further strategies, such as repair (R3), refurbish (R4), and remanufacture (R5), involve restoring products or components so they can continue to serve their original function.

When the original functionality of a product can no longer be maintained, materials may still be recovered through repurpose (R6), recycle (R7), and recover (R8 or R9 depending on the classification system), including energy recovery processes. These lower levels of the hierarchy retain less of the original value but still allow resources to remain within the economic cycle instead of being disposed of (Pan et al., 2022).

From the perspective of waste classification, the 10R framework enables the categorization of industrial waste according to the most appropriate circular strategy. For example, high-quality production residues or defective components may be directed toward remanufacturing or reuse processes, whereas complex composite materials may be classified as recyclable or energy-recoverable waste streams.

4.6. Classification based on material value

Another important dimension of waste classification in the circular economy is the material value embedded in waste streams. This approach distinguishes between high-value waste and low-value waste, depending on the economic and technological feasibility of recovering valuable materials. High-value waste typically includes materials with significant recycling potential, such as metals, high-grade polymers, and electronic components. These materials

retain considerable economic value even after their initial use and can often be reintroduced into production processes with relatively limited processing. For instance, metallurgical slag or electronic waste may contain valuable metals such as copper, aluminium, or rare earth elements that can be recovered through advanced recycling technologies.

Low-value waste, by contrast, consists of materials that are difficult to recycle due to contamination, complex composition, or low market value. Examples include mixed plastic waste, contaminated construction debris, or composite materials. Such waste streams often require energy recovery or specialized treatment technologies, which may reduce their environmental impact but provide limited economic benefits. Classifying waste according to material value helps industries prioritize recovery processes and allocate resources more efficiently. By identifying high-value waste streams, companies can implement targeted recycling strategies and develop business models that support resource efficiency and circular material flows (Moscati et al., 2023).

4.7. Classification according to industrial symbiosis potential

A further dimension of circular waste classification concerns the potential for industrial symbiosis, which refers to the collaborative exchange of materials, energy, or by-products between different industrial entities. In such systems, waste generated by one company becomes a resource for another, thereby reducing overall resource consumption and waste generation (Holly, Schild, 2025). Industrial symbiosis is a central concept within industrial ecology and is often implemented in industrial clusters where companies operate in close geographical proximity. For example, waste heat from a power plant may be used in nearby manufacturing processes, while by-products from the food industry can serve as raw materials for bioenergy production.

From a classification perspective, waste streams can be categorized according to their compatibility with potential symbiotic applications. Some waste materials are easily transferable between industries due to their consistent composition and predictable supply, while others require additional processing before they can be utilized by external partners. This type of classification encourages the development of integrated industrial networks in which material flows are optimized across multiple sectors. By identifying waste streams with high symbiosis potential, companies and policymakers can facilitate partnerships that enhance resource efficiency and support the broader objectives of sustainable development.

5. Discussion

The results of this study provide a structured overview of industrial waste classification approaches and allow for a comparative assessment of their relevance in the context of sustainable development. The analysis reveals that both traditional and circular economy based classification frameworks play important but distinct roles in industrial waste management systems.

5.1. Comparison of traditional and circular classification approaches

Traditional classification methods based on source, chemical composition, and environmental impact remain essential for ensuring regulatory compliance, risk assessment, and operational safety. These approaches are well-established in the literature and widely implemented in industrial practice, particularly in the context of hazardous waste management and environmental protection (Tchobanoglous, Kreith, 2020). Their strength lies in their clarity, standardization, and direct applicability to existing legal and technical frameworks. However, the analysis indicates that traditional classification systems are primarily focused on identifying risks and ensuring proper disposal rather than maximizing the value of waste as a resource. As a result, they may be insufficient in addressing contemporary challenges related to resource scarcity, circular material flows, and sustainable production systems. This limitation has also been highlighted in previous studies emphasizing the need to move beyond linear waste management models (Ghisellini et al., 2016; Geissdoerfer et al., 2017).

In contrast, classification approaches derived from the circular economy perspective introduce new analytical dimensions, such as material value, circular potential, and industrial symbiosis opportunities. The 10R framework, in particular, provides a hierarchical structure that prioritizes strategies aimed at retaining product functionality and material value within the economic system (Reike et al., 2022). These approaches shift the focus from waste treatment to waste prevention and resource optimization. Nevertheless, circular economy based classification systems also have limitations. Their implementation often requires more detailed data on material composition, production processes, and supply chain interactions. In addition, they depend on the availability of technological solutions and cooperation between industrial actors, which may not always be feasible in all contexts.

5.2. Implications for sustainable development

From the perspective of sustainable development, the findings suggest that no single classification approach is sufficient on its own. Traditional methods provide a strong foundation for environmental protection and regulatory compliance, while circular approaches offer greater potential for improving resource efficiency and reducing waste generation. The integration of these approaches appears to be the most effective strategy. By combining risk-oriented

classification (e.g., environmental impact and chemical composition) with value-oriented classification (e.g., circular potential and material value), it is possible to develop more comprehensive waste management systems. Such integrated frameworks can support both environmental safety and economic optimization, aligning with the core principles of sustainable development.

Furthermore, the identification of waste streams with high industrial symbiosis potential highlights the importance of inter-organizational cooperation. As noted in the literature on industrial ecology, the exchange of by-products between industries can significantly reduce resource consumption and environmental impact (Holly, Schild, 2025). This confirms that waste classification should not be treated as an isolated technical activity but as part of a broader system of industrial collaboration.

5.3. Contribution to the literature and research limitations

This study contributes to the existing body of knowledge by proposing a comparative analytical perspective that integrates traditional and circular approaches to industrial waste classification. While previous studies have often focused on specific classification methods or individual aspects of waste management, this paper provides a more holistic framework that highlights the complementarities and trade-offs between different approaches. At the same time, several limitations of the study should be acknowledged. First, the research is based on a literature review and does not include empirical validation of the proposed comparisons. Second, the analysis is primarily qualitative and does not provide quantitative measures of effectiveness for individual classification methods. Third, the applicability of certain circular economy based approaches may vary depending on industrial sector, technological development, and regional conditions.

Future research should therefore focus on empirical case studies that test the practical implementation of integrated classification frameworks in real industrial environments. In addition, further studies could develop quantitative indicators to evaluate the effectiveness of classification methods in terms of environmental impact reduction, resource recovery, and economic performance.

6. Conclusion

Effective classification and reduction of industrial waste constitute fundamental components of sustainable development strategies in modern industrial systems. The findings of this study demonstrate that waste classification should not be treated solely as a technical or regulatory requirement but rather as a strategic instrument supporting environmental protection, resource efficiency, and economic sustainability. The analysis confirms that traditional

classification approaches—based on source, chemical composition, and environmental impact—play a crucial role in ensuring safe handling, regulatory compliance, and risk management. At the same time, circular economy based classification frameworks introduce additional dimensions related to material value, circular potential, and industrial symbiosis, which are essential for improving resource recovery and reducing waste generation.

The results indicate that the greatest practical value is achieved through the integration of these approaches. Combining traditional risk-oriented classification with circular, value-oriented perspectives enables the development of more comprehensive and effective waste management systems. Such an integrated framework supports both environmental safety and the transition toward circular industrial models. The study contributes to the literature by providing a structured comparative perspective on industrial waste classification methods and highlighting their complementary roles in sustainable development. It also emphasizes the need to move beyond linear waste management paradigms and to adopt more systemic approaches that recognize waste as a potential resource within industrial ecosystems.

Future research should focus on the development of standardized and integrated classification systems that incorporate environmental, economic, and technological criteria. In addition, empirical studies and quantitative assessments are needed to evaluate the effectiveness of different classification approaches in real industrial settings. The advancement of digital tools for waste tracking and data analysis may further support decision-making processes and accelerate the transition toward a more circular and sustainable industrial economy.

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USE OF PROJECT METRICS IN BUSINESS-BASED R&D PROJECTS

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Purpose: The purpose of this article is to analyse the use of metrics in R&D projects within business organisations and to formulate recommendations for their practical application.
Design/methodology/approach: First, a literature review was conducted to identify the metrics used in R&D projects within business organisations according to the literature. Subsequently, a multiple holistic case study was employed, with business organisations undertaking research projects serving as the units of analysis. Interviews were carried out with three research project managers. On the basis of the data collected from the respondents, recommendations regarding the use of metrics in business R&D projects were formulated.
Findings: R&D project managers in the business organisations focus primarily on quantitative, easy-to-measure metrics such as cost and schedule variance, and on customer-related metrics. They rarely employ human-centred or more complex metrics, which indicates a need for changes in R&D project management practices.
Research limitations/implications: The research was limited to three case studies. Clearly, additional case studies and a large-sample survey are required to draw definitive conclusions about the use of metrics in the management of R&D projects in business. Nevertheless, the research presented in this paper already demonstrates clearly that metrics-based project management should be further advanced by researchers, with particular consideration for business organisations as the ultimate end users.
Practical implications: Given the well-established importance of metrics in project management generally, and their limited use in the case studies analysed in this paper, R&D project leaders in practice should consider introducing more complex and human-related metrics to improve the success rate of their R&D projects. Appropriate infrastructure and support should also be provided, including training, software, templates, and other adequate resources.
Originality/value: This paper presents the first study in which a comprehensive list of different types of project metrics is compared with the everyday practices of R&D project management in the business sector. The findings indicate that many metrics described in the literature and recognised as valuable remain unused or even unknown in the practical management of R&D projects in business organisations.
Keywords: project metrics, business-based R&D projects, R&D project objectives, R&D project values.
Category of the paper: research paper, case study.

1. Introduction

Metrics in project management are indicators intended to provide selected information about a project's final outcomes as early as possible. They function as an early warning system, enabling the introduction of corrective actions within the project or its environment before it becomes too late to intervene. Metrics-based project management is sometimes compared to regular human health check-ups, whose purpose is to identify signs of illnesses before they fully develop (Kerzner, 2017).

The first fully developed metrics-based project control systems were built on the Earned Value Method (Fleming et al., 2016). In this method, the total cost and duration of the project are systematically re-estimated during project execution on the basis of past and current project information represented by selected metrics. The Earned Value Method has since been expanded to include metrics designed to control aspects of the project beyond time and cost, for example through the Earned Green Value framework (Koke et al., 2017). At the same time, numerous other metrics have been proposed to measure various project dimensions, reflecting the well-established understanding that many diverse factors influence project success (Kerzner, 2017). As the decisive role of people in projects has become increasingly recognised, people-related metrics have also been introduced (Rad et al., 2006). These metrics aim to identify human-related – often intangible – symptoms that may indicate a potential negative impact on project objectives and delivered value in the future.

It is widely acknowledged that metrics-based project management can be extremely beneficial, just as regular health check-ups are beneficial to human well-being. However, much like routine health check-ups, metrics-based project management is seldom applied in practice, both because it is time-consuming and because it is associated with certain psychological apprehensions. The authors' university-based experience suggests that this may also be true for R&D projects, where an R&D project is defined as follows: 'An R&D project consists of a set of R&D activities, is organised and managed for a specific purpose, and has its objectives and expected outcomes. An R&D activity is the sum of actions deliberately undertaken by R&D performers to generate new knowledge' (Eurostat, 2023). This intuition regarding the limited use of metrics in practice was corroborated by the authors' previous study on university-based research projects (Iwko et al., 2025).

The aim of the present paper was to replicate that research, but this time in the context of business-based R&D projects. More specifically, the objective was to determine whether, and to what extent, metrics-based project management is used in R&D projects within business organisations, and to develop recommendations for project managers in this sector. A secondary objective was to compare the situation across the university and business sectors.

To achieve the research objectives, a literature review was combined with a multiple holistic case study, with business organisations conducting R&D projects serving as the units of analysis (Yin, 2015). In-depth interviews were conducted with three research project managers from business organisations. The literature review provided the basis for developing a list of potential metrics, which was subsequently used during the interviews. Based on the data collected from the respondents, the extent of the use of project metrics in business-based R&D projects was established and recommendations were formulated. Finally, the results were juxtaposed with those from our earlier study concerning universities (Iwko et al., 2025).

2. R&D projects in business – literature review

A research and development (R&D) project in business involves investigating new ideas and transforming them into innovative products, services, or processes. Its purpose is to enhance a company's competitiveness by exploring and implementing emerging technologies, improving existing solutions, or creating entirely new offerings. Such projects typically include market analysis, experimentation, prototype development, and testing (Tidd et al., 2020).

The primary objective of project management is to deliver the required product, service, or process while meeting defined goals. In addition, as noted by Kerzner (2011), it has recently been recognised that the fundamental objective of every project is to deliver the values expected by its stakeholders. Metrics in project management are indicators used throughout the project lifecycle to help monitor its trajectory and to forecast potential problems as early as possible (Iwko et al., 2023; Kerzner, 2022) – where problems refer to situations in which the project fails to achieve the desired objectives or values. For this reason, the literature review conducted here focused on the objectives of business R&D projects, the values they are expected to deliver, and the metrics used to assess the likelihood of achieving these objectives and values.

2.1. Primary goals, objectives and values to be achieved in R&D projects in business

The primary goals of R&D projects in business include developing new products and services (Groen et al., 2011), enhancing existing solutions, and creating customer-specific offerings (Kreimeyer, 2010). Additional goals comprise the commercialisation of research results and the formation of new start-ups (Tung et al., 2013), increasing profitability (Kotlar et al., 2014), and investing in innovation (Ge et al., 2025). R&D projects also aim to initiate new strategic collaborations (Gamal et al., 2025), support talent development (Zhu et al., 2022), enhance economic and social welfare (Hariharan et al., 2024), and strengthen sustainability (Wiratmadja et al., 2025). Operational objectives include prototype development, feasibility studies and proof-of-concept activities, knowledge creation and documentation, and process optimisation (Tidd et al., 2020).

The values that stakeholders of business R&D projects expect to achieve include sustainable growth, infrastructure development, and the reduction of inequalities (Maddaloni et al., 2024; Thabrew et al., 2009), as well as improvements in human well-being (Picolli et al., 2024). Stakeholders also seek learning opportunities, career progression, recognition, and various user-specific benefits (Elias et al., 2002).

2.2. Metrics used in R&D projects in business

Metrics used in R&D project management, as described in the literature, are largely those that can be applied either as end-of-project or end-product metrics – after project completion – or during the project in the form of predicted values. These include metrics such as ROI, NPV, revenues, R&D intensity (R&D cost as a percentage of revenue), market share, product quality, stakeholder satisfaction, customer impact, environmental impact, time-to-market, and knowledge creation (He et al., 2023; Mack Institute for Innovation Management, 2020; Schwarz et al., 2011).

However, metrics that can be applied during project implementation and are based not only on forecasts but also on current values are equally important (Kerzner, 2022). They may possess strong early-warning potential, as they are often more objective – being grounded in current rather than predicted information. According to the literature, such metrics are not frequently employed by business organisations. Among the few that are used, we find the speed of new product development (Mallick et al., 2005); schedule and budget adherence (Mallick et al., 2005; Hughes et al., 2004; Shields et al., 2003); the effectiveness of project management and team productivity (Gün et al., 2020); resource allocation, milestone achievement, and continuous feedback (Lazzarotti, 2009; Rodríguez Gutiérrez et al., 2012). Research-specific metrics are also noted in the literature, such as the number of publications and patents (Munari et al., 2024).

Table 1 links these metrics to the relevant objectives and values.

Table 1.
Metrics used in R&D projects in business organisations related to objectives and values aimed at in those projects

Objectives / Values	Associated Metrics
Innovation	Time-to-market; Patents; Publications
Commercialization	ROI; NPV; Revenues; Market share
Customer-adopted Solutions	Customer impact; Stakeholder satisfaction; Product quality
Talent Development	Knowledge creation; Continuous feedback; Publications
Sustainability	Environmental impact; Resource use
Operational Excellence	Schedule adherence; Budget adherence; Team productivity
Social Welfare	Customer impact; Environmental impact

Source: own elaboration.

According to the literature, most metrics proposed within general metrics-based project management frameworks (Kerzner, 2022; Rad, 2006) are not widely used in the management of R&D projects in business organisations. Table 1 shows that, for some objectives and values

expected in R&D projects within business settings, no metrics are used at all. The aim of the study presented in the following sections was therefore to examine the current state of practice regarding the use of metrics in business, based on selected case studies.

3. Results of the study of metrics in R&D projects in business organisations

3.1. Research methodology

The aim of the study was to explore project managers' opinions on the use of metrics in research project management in business organisations. A qualitative research strategy – case studies – was employed for this purpose. The study followed a multiple holistic case study design, in which the units of analysis were organisations conducting research projects (Herriott, Firestone, 1983; Yin, 2015).

Three business organisations carrying out research projects were examined. A method typical of qualitative research, namely interviews, was used to collect information on the use of metrics in research project management. Individual structured in-depth interviews were carried out with three research project managers. The case study protocol (questionnaire) was developed on the basis of the literature review and the literature on metrics-based project management (Rad et al., 2006; Kerzner et al., 2017). It consisted of questions referring directly to individual metrics from a prepared list (see Table 4) and focused on their use in practice. The moderator clarified the meanings of less obvious metrics to ensure that the interviewees shared a common understanding with the authors of this paper. Each interview lasted approximately one hour and was conducted by a moderator via instant messaging between September and November 2023. All data were anonymised to prevent identification of the interviewees.

The metrics discussed during the interviews with research project managers from business organisations, addressed various aspects of research project management. Based on the literature (Kerzner, 2022; Rad, 2006), thirty-two potential metrics supporting metrics-based project management were identified. These metrics were divided into four groups according to the project areas they address and their level of complexity (Table 4):

1) Quantitative, easily measurable metrics (Group 1).
2) "Soft" or "sensitive" team metrics, fairly easy to determine (Group 2).
3) "Difficult", advanced metrics (Group 3).
4) Customer-related metrics (Group 4).

The above division reflects the different types of metrics. Some of them are easy to understand and should not pose difficulties for respondents when assessing their usefulness. Other metrics may be more challenging to determine, yet they may still be of high importance.

One of the mistakes in practical metrics-based management highlighted by Kerzner (Kerzner, 2022) is the elimination of metrics that are difficult to measure, which reduces the early-warning capacity of the entire system. In this paper, we decided to make the effort to avoid this mistake.

The full list of metrics used in the interviews is given in Table 4.

3.2. Description of the qualitative data analysis procedurę

The study was based on a qualitative approach, utilizing a multiple holistic case study. To achieve the research objective, interviews were conducted with three research project managers from business organisations. Each interview is treated as a separate case embedded in a specific organizational context. Due to the small sample size (n = 3), a strategy of in-depth analysis (within-case analysis) followed by comparative analysis (cross-case analysis) was adopted (Goertz, Mahoney, 2012), with particular emphasis placed on reconstructing the organizational context of each case. This approach enhances the research's insightful value despite the limited sample size.

Using a multiple holistic case study approach, the organizational contexts within-case were analyzed and the convergence cross-case was analyzed using three main dimensions of organizational context (industry and nature of the business, size and structure of the organization, and project management maturity) (Table 2).

Table 2.
Organizational context of the three analyzed case studies

	Project manager 1 (PM1) – Manager of EU projects	**Project manager 2 (PM2) – Manager of projects combining business with science**	**Project manager 3 (PM3) – Manager of projects conducted in the Design Thinking methodology**
Industry and nature of business	The respondent operates in a highly institutionalized environment, associated with the implementation of projects financed from public funds (EU funds). The organization operates at the intersection of various sectors (including industry, fashion, and manufacturing), which requires adapting to the specific needs of its clients, but the core of its operations remains unchanged – compliance with regulations and procedures.	The respondent operates in a hybrid environment— at the intersection of academic organizations and businesses. Projects are research and development in nature and are often co-financed by public funds, but their implementation requires collaboration between entities with different operational logics.	The respondent operates in an environment with a high level of flexibility, including projects implemented for private companies, public institutions and organisations from various industries (e.g. education, HR, medical sector).

Cont. table 2.

Size and structure of the organization	The organizational structure is rather formal and hierarchical, and the processes are strongly parameterized by project applications, schedules, budgets, and guidelines of financing institutions.	The organization is characterized by a moderate degree of formalization, high dependence on university procedures, and a dispersed decision-making structure.	The organization is flat and networked, project-based, with high team autonomy, focused on innovation and collaboration.
Project management maturity	The level of project management maturity can be described as high, but it is a "procedural" maturity resulting more from system requirements than from the autonomous development of the organization.	The project management maturity level can be described as medium – tools and procedures are present, but their use is selective and adapted to the situation.	The level of project management maturity is high, but informal – based on experience, team practices and iterative methods, not on formalized standards.

Source: own elaboration

In summary, in research based on a small number of interviews, in-depth contextual and comparative analysis, rather than the number of observations, is crucial. This allows us to capture the mechanisms behind metric selection in business research project management and their correlation with organizational maturity and industry specifics.

Additionally, profiles of the respondents were elaborated (Table 3).

Table 3.
Profiles of respondents from business

	Project manager 1 (PM1)	**Project manager 2 (PM2)**	**Project manager 3 (PM3)**
Description	Project manager of implementation projects in the research services sector	Project manager of high-value commercial projects (multi-million contracts)	Cross-industry project manager with experience in IT and services
Environment	service company implementing research and R&D projects	private technology company	consulting and technology sector
Work style	flexible, utilizing design thinking and agile methods	task-oriented and results-oriented, strongly focused on contract execution and budget control	analytical, but with a strong emphasis on empathy and team communication
Characteristics	creativity, openness to change, strong interpersonal skills	assertiveness, stress resistance, ability to negotiate with clients and partners	reflectiveness, adaptability, and the ability to combine hard and soft management methods
Problems	the need to combine an innovative approach with formal project requirements	maintaining a balance between client expectations and the team's capabilities and financial resources	transferring IT management practices (e.g., Agile) to humanities and organizational projects

Source: own elaboration.

In summary, the interviewed project managers focus primarily on efficiency, timeliness, and risk control. A common thread across all profiles is adaptability and a strong capacity to learn from experience.

4. Results of research on the use of metrics by project managers in business

The application of the protocol (questionnaire) within the multiple holistic case study made it possible to draw the following conclusions regarding the use of metrics in research projects in universities and business organisations, presented across the four metrics groups.

Table 4 summarises the use of metrics by project managers of R&D projects in business organisations, according to their own words.

Table 4.
Usage of metrics by project managers of research projects in business organisations

No	Name of metric	Project manager 1 (PM1)	Project manager 2 (PM2)	Project manager 3 (PM3)
	Group 1: quantitative, easily measurable metrics			
1	Number of resources allocated in relation to planned resources	usually uses, zero-one (are there or are not there)	usually uses	usually uses
2	Quality of allocated resources in relation to planned quality	usually benefits,	does not use, difficult to define	does not use, difficult to define
3	Number of hours (tasks) without human resources allocated	does not benefit	does not benefit	does not benefit
4	Percentage of total overtime worked	does not benefit	does not benefit	does not benefit
5	Cost variance	uses frequently	uses frequently	uses frequently
6	Schedule deviation	uses frequently	uses frequently	uses frequently
7	Number of changes to the project scope	not used, too much volatility	not used, too much volatility	not used, too much volatility
8	The extent to which it has been possible to invoice and obtain payment on time	controlled by an external body (e.g. finance department)	controlled by an external body (e.g. finance department)	controlled by an external body (e.g. finance department)
9	Quality of supplier monitoring (supplier relations)	does not use, difficult to define	does not use, difficult to define	does not use, difficult to define
10	Number of cost adjustments made	not used, too much volatility	not used, too much volatility	not used, too much volatility
11	Quality of implementation of the risk management plan	does not benefit	does not benefit	does not benefit
12	Number of tasks (work packages) completed according to plan	does not benefit	does not benefit	does not benefit
	Group 2: "Soft" or "sensitive" team metrics, fairly easy to determine			
13	Amount of wasted/unproductive time	does not benefit	does not benefit	does not benefit
14	Quality of project management by the project manager	not used, difficult to monitor	does not use, but considers important	not used, difficult to monitor
15	Opportunities for personal and professional development of team members	does not benefit	does not benefit	does not benefit
16	The degree to which the opinions of individual project team members were taken into account	does not benefit	benefits, qualitatively	does not benefit
17	Quality of definition and communication of roles to individual project team members	not used, difficult to monitor	benefits, qualitatively	not used, not understood

Cont. table 4.

	Group 3: "Difficult", advanced metrics			
18	Project complexity index	not used, not understood	not used, not understood	not used, not understood
19	Number of critical restrictions	happened to use	not used, not understood	could benefit from
20	Number of critical assumptions	does not benefit	does not benefit	does not benefit
21	Cost efficiency ratio	benefits in terms of quality	does not benefit	benefits in terms of quality
22	Schedule performance indicator	does not benefit	does not benefit	does not benefit
23	Degree of implementation of health and safety rules	monitored zero-one	not applicable	not applicable
24	Compliance with agreed quality indicators	does not use, difficult to define	does not use, difficult to define	does not use, difficult to define
	Group 4: Customer-related metrics			
25	Level of customer satisfaction with the project outcome	uses regularly	monitors qualitatively	does not benefit
26	Level of customer satisfaction with the project	depends on the customer, uses occasionally	monitors qualitatively	depends on the customer, uses occasionally
27	Level of customer satisfaction with project communication	uses regularly, important	monitors qualitatively	depends on the customer, uses occasionally
28	Number of commitments kept to the customer as a proportion of total commitments	does not benefit	not used, difficult to monitor	does not use, difficult to define
29	Quality of customer expectation management	sometimes used, difficult to define and monitor	not used, difficult to monitor	does not use, difficult to define
30	Level of understanding of the client and their industry by the project team	depends on the customer, uses occasionally	depends on the customer, usually does not use	depends on the customer, uses occasionally
31	The extent to which the project team looked after the client's interests	depends on the customer, uses occasionally	monitors qualitatively	depends on the customer, uses occasionally
32	The extent to which the project has contributed to establishing or strengthening the company's position in the industry (additional opportunity generation)	depends on the customer, uses occasionally	depends on the customer, uses occasionally	depends on the customer, uses occasionally

Source: own elaboration.

The rows highlighted in green indicate the metrics used by all three project managers in their routine practice of R&D project management. The rows highlighted in red represent metrics that are not used by any of the three project managers. The rows highlighted in yellow refer to metrics that are either used occasionally by all three managers or are considered useful or interesting by at least two of them.

5. Discussion of the results

The green and yellow marked metrics in Table 5 are those that are either already used by at least two project managers or are considered important and potentially applicable by at least two respondents. The red marked metrics are not used or considered interesting by any of the three respondents. Metrics without colour are considered useful by only one respondent.

The first striking observation from the results is that, out of the entire list of 32 metrics, only two were reported by all three interviewees as being used in routine project management practice. These are metrics no. 5 and 6 from Group 1 (quantitative, easily measurable metrics): cost variance and schedule deviation. These are very common indicators which, in many cases, provide limited insight into project progress in terms of value creation or the achievement of less traditional project objectives (Kerzner, 2022). Most of the metrics in Group 1 are not used at all, which is surprising given that their practical application is relatively straightforward.

In Group 2 (‘soft’ or ‘sensitive’ team metrics that are relatively easy to determine), there are no green or yellow metrics. This indicates that team-related issues are not monitored systematically in R&D projects, and project managers show limited interest in this area. One respondent noted that monitoring the quality of project management (metric no. 15) would be interesting, and the same respondent uses two metrics (no. 16 and 17) to monitor communication with the team. The other two interviewees stated that they did not use such metrics or believed they were too difficult to apply – although the metrics included in Group 2 are, in fact, not particularly difficult to operationalise.

In Group 3 (‘difficult’ or advanced metrics), half of the metrics are marked red. One metric, no. 18, was not understood by the interviewed project managers. This refers to the project complexity index, which is defined in various ways in the literature (Kerzner, 2022) based on project duration, size, dependencies in and of the project, number of stakeholders, and similar factors, and is considered an important determinant of project outcomes. Another metric (no. 24) was regarded by all respondents as difficult to define, and none expressed interest in using it. This is surprising, as this metric measures the achieved quality – n aspect that should be central in R&D projects.

Group 4 consists of customer-related metrics, most of which are marked yellow, meaning they are used or perceived as potentially useful by the respondents. The red metric (no. 28) and the uncoloured metric (no. 29) both concern communication with the customer: adherence to commitments and management of customer expectations. All respondents viewed these metrics as difficult to monitor or define, which may indicate that communication with customers is far from fully developed in their project management practice.

In several cases, interviewees provided explanations for not using certain metrics. The reasons included ‘difficult to define or monitor’, ‘too much volatility’, and ‘not understood’. The explanation ‘too much volatility’ is particularly noteworthy:

metrics are designed precisely to control volatility and therefore are inherently linked to it. This reason, alongside the others, highlights the need for training and knowledge sharing on metrics-based project management.

Table 5 provides a comparison between the respondents.

Table 5.
Numbers of metrics used by individual project managers interviewed

	Project manager 1 (PM1)	**Project manager 2 (PM2)**	**Project manager 3 (PM3)**
Nb of metrics used often or occasionally	14	11	9
Nb of metrics not used	16	19	21
Nb of metrics not used, but considered interesting	2	1	1

Source: own elaboration.

Respondent 1 is the most advanced in the use of metrics, whereas Respondent 3 employs the fewest. Overall, however, it must be concluded that the use of metrics seem not widespread among project managers of R&D projects in business organisations. This is surprising, given the profiles described by the respondents in the interviews (Table 3), which would suggest a much greater openness to non-traditional management methods.

6. Conclusions and Implications

The only two metrics consistently used by project managers in business organisations are schedule and cost variances, reflecting traditional project management practices. However, relying on only two metrics is far too modest even within a classical project management approach, where aspects such as quality and risk should also be systematically monitored. More advanced metrics – or those related to soft aspects, such as project management quality or team-related indicators – are not widely used. Yet, as highlighted in the literature, these types of metrics may be particularly valuable for the effective control of all projects, including R&D projects. Customer-related metrics are generally better accepted by project managers in practice, with the exception of a few that are essential for managing customer expectations and satisfaction. These rather limited results appear to stem from a lack of knowledge or understanding of metrics-based project management, as well as of contemporary value-based project management approaches.

R&D projects differ fundamentally from operational or engineering projects: they involve high levels of uncertainty, evolving knowledge, creative problem-solving, and close interaction with customers. They also rely on teams of researchers who have individual goals, ambitions, and personalities. As shown in Section 2, they pursue objectives and values of various types,

For this reason, effective use of metrics in R&D projects in the business sector must extend beyond simple cost–schedule tracking.

To enhance R&D project performance, business organisations should:

- invest in developing project managers' capability to use advanced and qualitative metrics,
- provide clearer guidelines and tools for measuring soft and complex aspects,
- encourage systematic customer and team-related metrics usage,
- integrate both qualitative and quantitative indicators into a balanced scorecard for R&D projects.

Comparing the findings of this study with those presented in the authors' previous publication (Iwko et al., 2025), several similarities and differences in the use of metrics in R&D projects can be observed. In both contexts, the maturity of metrics-based project management practice remains low. Overall, however, business project managers demonstrate a slightly higher level of metrics utilisation. In contrast, university project managers tend to engage with formal metrics more selectively and to a lesser extent, more frequently considering them difficult to define, inappropriate for research environments, or relevant primarily for external reporting obligations rather than for internal project management. This suggests that the recommendations formulated above are relevant for all organisations implementing R&D projects.

This study has several limitations. First, it is based on only three case studies. Therefore, the results are exploratory and interpretative, not representative. A substantially larger sample should be examined in future research, potentially employing additional methods such as surveys. Furthermore, interdependencies among metrics should be considered, as some metrics provide overlapping information. More specifically, coherent sets of metrics should be presented to respondents to allow assessment of the usefulness of an integrated system, rather than of individual metrics in isolation. However, such research should be preceded by a brief training session in which the principles of metrics-based and value-based project management are explained. Further, the reasons should be investigated for which several metrics were perceived as "not understood" or "difficult to define", and cross sector differences should be examined, especially with respect to academia.

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THEATRE ON THE GLOBAL STAGE: MANAGING INTERNATIONAL THEATRE COLLABORATION – AN EXPERT PERSPECTIVE

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Purpose: The aim of the study is to determine the importance of international cooperation for contemporary theatres, and the key elements determining its effectiveness, in the opinion of theatre sector experts.
Design/methodology/approach: Qualitative study. Empirical data was collected during an expert panel discussion entitled 'Theatre on the world stage: Managing contemporary theatre: International cooperation". Focus group interviews were used. An important aspect of the study is the combination of the expert perspective with the management practice of theatre managers.
Findings: The analysis of the research results made it possible to determine the importance of international cooperation for contemporary theatres, and the key elements determining its effectiveness. The focus was on the possibilities of internal theatre organisation, planning processes, financial challenges, legislative and organisational barriers, and the role of the theatre organiser.
Research limitations/implications: The limitations of the study may include the number of experts participating in the discussion and the limitations of the interview technique used. Furthermore, the deliberate selection of the research sample suggests caution when making claims about the entire population. At the same time, the results obtained may be useful in the context of designing quantitative studies on the general population.
Practical implications: The results of this study could inform the development of strategies for the internationalisation of artistic institutions. Long-term international partnerships may be more effective than one-off projects. Another practical implication of the study is that theatre managers can use its findings to argue for support from the organiser.
Originality/value: The research conducted explores a topic that is rarely addressed in the context of theatre management. The presented research results may be directly useful for theatre managers, other theatre executives, cultural organisers, researchers dealing with theatre and cultural management, as well as for artists themselves, enabling them to understand the conditions of cooperation in international projects.
Keywords: Theatre management, arts management, theatre internationalisation, artistic mobility.
Category of the paper: Research paper.

1. Introduction

Theatre as an institution operating on the market is an important subject of research in the field of management sciences, particularly in the context of arts management (Volz, 2017) and public management (Szulborska-Łukaszewicz, 2024). The traditional approach treats theatre as an artistic and cultural activity aimed at creating theatrical works. It is worth emphasising that theatre is an organisation whose main resource is its theatre ensemble, which faces problems with financing its activities (Gałecka, Smolny, 2017) and is subject to processes of digitisation and technologisation (Khattab, Elmeligi, 2023). Theatre therefore combines artistic, organisational, and business aspects.

Contemporary theatre management is based on a holistic approach to solving problems related to various aspects of these institutions' activities. In order to survive on the market, a theatre must produce artistically valuable products, often with limited financial resources. Theatre managers must effectively lead their employees (artistic, technical, administrative, etc.), which, in a situation where artistic and managerial dimensions are combined, is one of the key challenges of contemporary theatre management.

Furthermore, in the context of global intercultural interaction, artist mobility (Duester, 2014), the resulting intensification of intercultural exchanges, as well as the dynamic development of new-generation technologies and artificial intelligence (Karcz-Ryndak, 2025), the topic of the internationalisation of cultural activities (including theatres) is becoming increasingly relevant. The openness of theatres to international cooperation and adaptation to the operating models of other European institutions brings opportunities, but also possible tensions related to cultural differences or the specific nature of the work of teams due to the need to adapt to a multicultural environment on a daily basis (Byrne, Brugha, McGarvey, 2019). Consequently, there is a growing need to reflect on the strategic importance of the internationalisation of theatre activities and the management of this process.

Researchers indicate that long-term international cooperation can contribute to increasing the innovativeness of teams by enhancing their creativity (Somerville et al., 2015). The internationalisation of artistic practices can encourage the inclusion of controversial, global topics (e.g. armed conflicts), thereby prompting audiences to reflect on these issues (Walden, 2019).

Globalisation is directly linked to the issue of internationalisation, which is a more complex concept than internationalisation and also concerns a larger scale (Zakrzewska-Bielawska, 2009). Globalisation is understood as the growing interdependence of world economies, their cultures and populations, further stimulated by international trade (in goods and services), the widespread movement of people, investment and information (Schilirò, 2020). Globalisation is increasingly affecting various areas of life, including the culture and arts industry, thus creating new opportunities for development but also new challenges (Yuliia,

Al-Ababneh, Symonenko, 2025). Internationalisation promotes cultural exchange and the emergence of new forms by combining local traditions with international influences, while enabling the promotion of local projects around the world (Chung et al., 2025).

At the same time, despite the growing importance of the internationalisation of the cultural sector, the literature on the subject reveals a lack of research into international cooperation between theatres from a management studies perspective. Most of the research to date has focused primarily on the general conditions of the broadly defined cultural sector (Mandel, Lambert, 2020), local conditions (Grenda, 2023), case studies of specific institutions and theatre companies (Fillis, Lee, 2011), and the mobility of artists (Saro, 2015).

To a limited extent, this research focuses on the determinants of the effectiveness of the internationalisation processes of theatres, particularly regarding organisational and managerial conditions. There is also a lack of research incorporating the views of practitioners and experts in the theatre sector.

In view of the above, this study aims to determine the significance of international cooperation for contemporary theatres, as well as the key elements that determine its effectiveness, according to theatre sector experts.

In the context of this aim, the following research questions arise:

Q1: How important is international cooperation for theatres?

Q2: What elements determine the effectiveness of international theatre cooperation?

Answering these questions and achieving the intended objective are intended to serve as a starting point for further research on the internationalisation of theatre activities, from a management science perspective. Given the incomplete state of research in this field, the authors have adopted a qualitative approach and formulated the research questions in a more generalised manner.

2. Methods

This study presents research based on a qualitative analysis of interviews conducted with experts from the cultural sector and theatre managers. The data was collected during an expert panel entitled ‘Theatre on the world stage. Managing contemporary theatre: international cooperation’, which took place during the 16th International Scientific Conference ‘Knowledge – Economy – Society’ CMQ2024 on 21 May 2024 at the Krakow University of Economics.

The study applied a qualitative approach (Aguzzoli et al., 2024; Jemielniak, 2012; Lune, Berg, 2017) using a focus group interview with experts (Gillham, 2000; Kvale, 2023). The aim of the expert panel was to identify the factors influencing international cooperation among contemporary theatres, from a management studies perspective. The expert panel lasted 90 minutes and was led by two moderators with experience in conducting qualitative research.

The moderators supervised the dynamics of the conversation and structured the discussion, enabling each participant to respond to the topics raised.

The expert panel comprised four experts recognised within the theatre sector, each with many years' experience in theatre management and international artistic activities. The experts were selected deliberately (Palinkas et al., 2015), based on the knowledge of theatres cooperating on the international market. This approach allows for the elimination of problems related to the availability of the research sample, and at the same time, enables access to experts who are distinguished in the field of internationalisation.

The study was conducted based on a pre-prepared scenario that covered the main areas of research, which could then be explored in greater depth. The research questions concerned the internationalisation of theatre activities, with particular emphasis on the significance of international cooperation for contemporary theatres and the key determinants of the effectiveness of such cooperation. The event was recorded and transcribed before being coded and analysed. Coding was performed using the 'snowball' rule as new content emerged.

Among the methodological limitations of the study, the relatively small number of experts should be highlighted, although this is offset by the selection of a sample comprising representatives of organisations with outstanding achievements in the field of international cooperation. Furthermore, given the qualitative nature of the study, particular caution should be exercised when attempting to generalise the study's findings to the wider cultural sector.

3. Results

3.1. The importance of international cooperation for theatre institutions in the experts' opinions

In today's reality, international cooperation between theatres is a natural necessity. Experts view theatre as part of a transnational cultural circuit in which artistic, scientific and educational exchange form the basis of development and identity formation. Theatre operates within a global network of relationships and exchange, which continually requires cross-border collaboration:

> *„For several years now, we have been designing a lot of international activities in the fields of art, education, and science, because one conference is behind us and another is just ahead (...). Polish theatre, but also theatre in Europe, is of great importance. We are in a global village, we are connected, we feel it, we cooperate, and we want to continue doing so" [E1].*

> *„From the very beginning, we have also focused on an international audience, which means that our activities and our team have always included representatives of other nations" [E2].*

In some cases, international cooperation is a conscious strategic choice that forms the basis of an institution's existence and is closely linked to the mission and values of a given organisation. However, it is neither an obligation nor a universal model of activity.

„As far as [our] theatre is concerned, since its foundation (...) it has been conceived as an international institution, as an international entity, and this is based on several fundamental pillars. (...) certain universal values to which we refer (...) have been enshrined in our statutes. So this is, let's say, an element of our strategy" [E2].

International cooperation between theatre communities not only serves to convey a specific production, but also contributes to the transfer of approaches to theatre and artistic practices. Furthermore, it brings together transnational theatre cultures for joint thinking and creation.

„You don't travel just to tick a trip off your list. You don't travel with a spectacle. The spectacle is merely a vehicle. You travel with the theatre, with the entire theatre culture" [E3].

The internationalisation of theatre activities contributes to a better understanding of interpersonal relationships and enriches one's identity. The essence of international cooperation is breaking down barriers through the universal languages of theatre, physical presence and music.

„In order not to lose one's identity in international cooperation, but rather to enrich it, it is very important to me not to lose oneself by imitating anyone or anything" [E4].

In relation to the statements of the experts cited, international cooperation between theatres should be considered, in particular, from the perspective of:

- enrichment of the artistic programme – by proposing international productions, there is an opportunity to enrich the repertoire through the exchange of experiences with other institutions, participation in international festivals, and broadening creative horizons;
- presenting their own theatrical productions – this helps to build their own brand and position in the theatre industry, which is an important part of theatre image management. At the same time, theatres fulfill their mission of presenting the cultural achievements of the country they represent;
- integration with the global cultural network – cooperation with theatres in other countries enables the creation of international networks that promote the exchange of ideas and the creation of performances. Globalisation forces theatres to function efficiently and participate in major cultural processes;
- development of theatre staff competence – this should be understood more broadly than just development resulting from theatre co-productions. Theatres can also improve their teams through research and educational activities (e.g., workshops, conferences, seminars);

- axiological dimension – International cooperation can be an effective tool for realising the values to which theatre itself refers, such as intercultural dialogue, invoking folk or even archaic traditions, searching for a supra-local dimension of cultural experience. In this sense, locality is not the opposite of internationalism, but merely a starting point for creating content that can benefit a wider audience.

In the statements of the experts surveyed, international cooperation between theatres is presented as a complex and important element of the functioning of contemporary theatre. Its role goes beyond the ad hoc promotion of institutions or simple artistic mobility. The respondents emphasise the importance of international cooperation as a tool for deepening artistic reflection and perceiving theatre as a space for intercultural encounters that enable the breaking down of linguistic and organisational barriers.

3.2. Key factors determining the effectiveness of international cooperation between theatres in the experts' opinions

Engaging in international cooperation is a multifaceted managerial challenge, especially when it comes to cultural institutions, due to the specific nature of their activities, complexity, and diversity of their missions. A qualitative analysis of the collected empirical material allowed us to identify the key determinants of the effectiveness of international cooperation between theaters, understood as factors determining their ability to initiate, implement, and sustain international projects. The identified factors include external and systemic conditions, as well as internal factors related to the organizational aspects of the theatre and its strategic orientation.

When analysing the factors that determine the effectiveness of international cooperation between theatres, particular attention should be paid to their **internal organisational capabilities**.

„Another one is the organisational preparation of the institution itself. If we have over 100 people in the theater team (...) then the organization itself, the logistics of the work (while maintaining permanent work on site, i.e. at the theatre itself), is also another barrier, which, in a way, may not prevent, but does mean that this cooperation could not be on as many levels as I, or the people from this theatre who work with me, would like to see" [E1].

„(...) and there is nothing wrong with the fact that the international cooperation does not exist in some theatres. There may be a small theater for the local community that works great and fulfills its mission, but it's a matter of (...) what we want to do and why we do it (...) we also focus on an international audience from the very beginning, which means that our activities and our team have always included representatives of other nations" [E2].

„From the very beginning, i.e. from the theatre association, (...) at the institute [Jerzy Grotowski Institute – author's note], it found its (...) entire studio facilities (...), logistical and administrative resources, to put it simply, (...) without the institute, this activity would not have been possible" [E3].

„We are a small theatre. Our team consists of 31 people, which means that everyone has to be very compatible and very flexible when (...) we do host a lot of foreign groups, but welcoming them (...) is easier for us because each of us, whether we are actors, technical staff, or work in audience organisation, is able to take care of them. We don't have to involve other people to take care of these people" [E4].

The study participants point to work logistics, which becomes more important as the size of the managed organisation increases [E1, E3]. The implementation of an efficient work logistics system is crucial to ensure that international projects do not interfere with the theatre's daily activities, and that the team can effectively fulfill its duties and objectives. Respondent E3 links work logistics with the concept of agency, emphasising the role of internal organizational factors as determining the very existence of international activity. In the case of smaller entities, the compatibility and flexibility of the theater team, as well as its readiness to accept visiting teams, becomes more important [E4]. In this context, respondent E2 emphasized the importance of foreigners in theater teams. Theater teams are the basic resource of these organizations. It can therefore be concluded that the key determinant at the level of the internal capabilities of theatre organisations is the competence of the theatre company necessary to conduct international activities, including language skills, cultural competence, and, more broadly, international competence (Bieniek, Steinerowska, 2014; Słaboń, 2019).

At the strategic level, respondents emphasise the importance of proper **planning and an awareness of the mission and goals** set for the theatre.

„(...) exchange at various festivals, (...) ensuring that residents (...) stay with us and create. These are the areas we are currently working on, but when designing such a task, we must first and foremost have a plan, a schedule, and, consequently, a cost estimate" [E1].

„A fundamental question to ask ourselves is: "what do we want to do, and for whom do we want to do it?" (...) and when it comes to [our – author's] theatre (...), since its founding (..), it has been conceived as an international institution. As an international entity, it is based on several pillars. The fundamental one is that certain universal values, to which we refer, which we even have, have been enshrined in our statute. So, this is also an element of, let's say, strategy. It does not necessarily have to be developed as a separate document, but these certain strategic provisions must always be there, and we must be aware of them and of our mission. Hence, our activities include the development of unconventional cultural forms, mainly through theatre, but also through other forms of activity. It also involves linking artistic activities with the natural environment and referring to traditional, archaic cultures. These things are not just local. They are something that connects locality with certain elements of cultures, including folk cultures and archaic cultures" [E2].

„In short, apart from the prospect of presenting one's own artistic achievements abroad, cooperation involving co-productions is certainly very important in the strategy (...), and these are very long processes. Of course, in the sense that it takes time to achieve such cooperation (...)" [E3].

„When going abroad, it is very important for me not to lose my identity (...), but to enrich it, not to lose myself by imitating anyone or anything (...), this internationalism has always been close to our hearts (...) as a way and a desire to reach out to other people" [E4].

As can be seen in the above statements, respondents emphasise the need to ensure conditions for creation (including for visiting theatre companies), which requires an appropriate planning process and scheduling and budgeting, particularly in the case of festival organisation [E1]. A similar situation applies to foreign performances, including co-productions, where the duration of the project determines the need for strategic planning [E3]. Effective international cooperation requires defining the target group to which the theater's offer is directed, which, in the case of foreign activities, requires appropriate profiling of the theater. Respondent E2 directly refers to the statutory provisions in this area. It is worth emphasizing here that the inclusion of international cooperation at the level of theater statutes is a common phenomenon in the theater industry, but this does not always translate into real action. At the same time, respondents point to the need to preserve their identity [E4] (including artistic identity), which requires consistency between the internationalization strategy and the mission and objectives of the theatre, as well as the search for a platform for cooperation, including at the cultural level [E2].

Among the key factors determining the effectiveness of international cooperation, survey participants also mention **financial challenges**.

„(...) if the municipal theatre does not have the funds, (...) if we do not have the funds for our core activities, and our operations and cooperation with the city only provide a basic operating budget, which is 75%, then the remaining 25%, i.e., all core activities, must be based on additional activities. I apologize for the colloquialism – on activities carried out on an ad hoc basis, so to speak. What can I say about our own contributions to EU projects, to projects that we are working on very intensively. We simply do not have these funds, and this is a very important issue" [E1].

„(...) as far as financial problems are concerned, they do exist, of course, but they can be overcome (...). In 2021/22, we implemented a large international project under the 'Culture' programme, financed by the European Economic Area (EEA) Financial Mechanism, worth PLN 2 million, with a Norwegian partner, our long-standing friends (...) the Stella Polaris group" [E2].

„(...) please imagine that most of this (...) was actually possible until 2016 (...). I never received any support from the Ministry. Literally not a single penny, either for my own work, or, even less so, for trips. Now, we can breathe for the first time, because we are actually preparing a very large project, a very large presentation" [E3].

„(...) of course, there are grants. It must be made clear that nothing can be done without them (...)" [E4].

Effective international cooperation in theatre requires stable funding for theatre institutions in terms of their basic statutory activities related to the preparation and presentation of theatre performances. Due to the sector-wide problem of underfunding of cultural institutions and economic paradoxes concerning the cost dimension of artistic activity, in particular Baumol's cost disease (Baumol, Bowen, 1965), there is often a lack of funds for activities outside the country [E1, E2, E3, E4]. Theatres have to undertake additional activities to balance their budgets [E1], rely on foreign partners [E2] and funds from grants and international programs supporting cultural activities [E3, E4].

Limited resources prevent the realisation of ambitious international projects, due to the large financial investments required at the stage of applying for funding. It therefore seems reasonable to single out a particularly important factor among the financial aspects - **the barrier of own contribution in international projects.**

„One very important factor that hinders our international cooperation. We wrote a huge project that was formally approved and received a lot of points. It is the 'Creative Europe' project, which was based on cooperation with over 10 locations, theatres across Europe. The project was worth PLN 2 million. We needed PLN 400,000 of our own contribution and, unfortunately, we failed because such costs are unimaginable in budgets. I think that (...) this is the first (...) barrier in the importance of internationalising an institution such as a theatre" [E1].

„The history of the place, which I have been running for over 20 years now, makes it possible to collaborate with such prominent figures of European theatre as Eugenio Barba or Peter Brook, and it is not entirely about money, in the sense that these budgets are, of course, much, much larger. Our financial contribution may not be symbolic, but it is "complementary". (...) I was unable to collaborate on an international scale, for example by co-producing Krzysztof Warlikowski's play, because the amounts involved were at least five times higher. And this remains the case to this day" [E3].

High thresholds for the required own contribution can be a significant barrier, particularly for small theatres. Even highly rated projects may be rejected due to the inability to make a contribution [E1, E3]. This situation highlights the importance of diversifying funding sources for activities and of direct cooperation between theatres and non-governmental organisations and international institutions.

Legal and organisational barriers should also be mentioned among the determinants of the effectiveness of a theatre's international activities.

„(...) as I said, we are a municipal institution, so there is a legal barrier. The very fact of (...) concluding agreements or any copyrights, the diversity of approaches in different places and countries is perhaps a smaller but equally important factor" [E1].

„Previously, we were simply a municipal cultural institution, categorised as (...) 'other' — neither a library, nor an archive, nor a theatre. Now we are a theatre (...)" [E3].

As the above statements show, the problem lies in legal regulations, particularly those concerning the conclusion of international agreements, as well as the diversity of regulations in other countries, which generates delays in project implementation, and also in the legal status of a given cultural institution [E2] and its related activity profile [E1]. Furthermore, effective international cooperation requires the development of clear and consistent rules on copyright, the conclusion of agreements and data protection [E1], and for this, the theatre's organisational situation must be clear.

In the context of effective international cooperation, **the role of the theatre organiser** (e.g. municipal and provincial authorities) in overcoming barriers to such cooperation is also important. In particular, this concerns the financial involvement of entities organising cultural activities. Financial support from organisers, although not in every case, can be a temporary solution to the previously mentioned problem of own contribution to international projects. Furthermore, cooperation between local governments at the level of organising joint cultural projects is important. This is confirmed by the statements of respondents E1 and E3 below.

„(...) the Silesian Voivodeship in several places – Katowice and the main leader, the city of Sosnowiec. We are applying for the title of "European Capital of Culture" and let us hope that by 2029, all financial barriers, as well as the organisational preparation of all institutions (...), including theatres in this area, will have been cleared and we will have enough money to visit all cities in Europe" [E1].

„Fortunately, as a municipal cultural institution, I have the opportunity to use municipal funds for this kind of collaboration. The amounts are not large — sometimes maybe PLN 100,000 — but this contribution is substantial nonetheless" [E3].

This section presents the respondents' statements, which outline the key factors of international theatre cooperation while also highlighting potential barriers to such activity. It should be noted that these are mainly systemic in nature. They primarily concern insufficient and unstable funding for theatres' fundamental activities, meaning these entities encounter difficulties in securing the required contribution to participate in international projects. Additionally, extensive legal and administrative regulations surrounding contract conclusion, copyright and settlements present challenges. The organisational complexity of international cooperation requires theatre managers to demonstrate strong leadership competence, implement flexible human resource management models and engage in long-term planning, all while maintaining stable local and national operations.

4. Discussion

Experts' statements highlight the multidimensional nature of international cooperation between theatres. In particular, one can identify artistic, image-related, integrative, developmental and axiological contexts. It can therefore be concluded that the significance of international cooperation for contemporary theatres should be considered in terms of these organisations' identity, rather than solely in economic terms. The artistic, image-related and integrative dimensions are a natural consequence of its core activities, the classical social functions of the theatre (Karcz-Ryndak, Zapata-Aguirre, 2025; Wilk, 2015) and its marketing activities (Krawiec, Szymańska, 2016; Wróblewski, 2012). The axiological dimension warrants separate comment. It would seem that this aspect should be particularly important for auteur theatres; however, the results obtained suggest that this phenomenon may be more universal, which presents an interesting avenue for further research. A similar situation applies to the developmental function of international cooperation. This can be considered at the level of individual units (e.g. individual competence development) and at the organisational level (e.g. organisational competence development). Therefore, it is evident that the surveyed experts perceive the international activities of theatres as a field for experimentation aimed at improving the entire organisation.

Furthermore, the findings clearly highlight the identity-related dimension of these international activities. To a lesser extent, theatres perceive economic opportunities in this regard. This situation fits into the narrative found in the literature concerning organisational paradoxes occurring in theatres, such as the manager–artist dichotomy (Szostak, Sułkowski, 2021), where the artistic identity of the theatre manager may conflict with their managerial role.

Regarding the key factors determining the effectiveness of international cooperation, they highlight: the internal organisational capabilities; planning and an awareness of the mission and goals; financial challenges; barrier of own contribution in international projects; legal and organisational barriers; and the role of the theatre organiser.

Therefore, it can be concluded that theatres' participation in international projects is primarily determined by their organisational capacity and the resources at their disposal. It should be noted, however, that whilst theatres are able to compensate for certain shortcomings at the organisational level, at the financial level, they are largely dependent on external factors. The financial aspect of the present study forms part of a broader body of research on approaches to the financial management of cultural institutions (Gałecka, Smolny, 2017; Trzeciak, 2011). At the same time, it is worth noting that artistic aspects were not included among the factors identified as determining the effectiveness of theatres' international cooperation. This can be explained, amongst other things, by the high artistic standard of the organisations represented by the experts. In their case, artistic resources are not critical resources and therefore play a lesser role in determining the effectiveness of activities on the international stage.

Theatres possess production capacities (human resources, technical resources, artistic concepts, etc.), but these are limited by the costs of participating in international projects.

The above narrative reflects the financial paradoxes associated with theatre operations, in particular Baumol's cost disease (Baumol, Bowen, 1966; Last, Wetzel, 2011). At the same time, there are indications in the literature that the globalisation of theatre operations may help mitigate these effects (Sibora, 2014). On the one hand, the theatre faces financial problems associated with undertaking international activities, thereby exacerbating financial paradoxes; on the other hand, the high effectiveness of these activities may lead to their mitigation. This mechanism operates on the principle of a positive feedback loop, although an inhibitory effect may occur in the initial period (e.g., limiting development by committing significant resources whilst failing to yield financial benefits). The dual nature of the internationalisation processes of theatres at the financial level is thus evident. Consequently, activities on the international stage should form part of theatres' strategic analyses.

In practical terms, the findings suggest a need to introduce mechanisms for funding theatres' international activities at both the level of cultural policy and within the theatres themselves. In particular, theatres should diversify their revenue streams further, which will allow for the allocation of a budget for international activities. At the same time, given the dual nature of the processes of internationalisation of theatres at the financial level, these should form part of the theatres' strategic analyses.

When considering the limitations of this study, one must keep in mind the shortcomings of the qualitative method employed. Furthermore, the relatively small number of experts surveyed poses a problem. Consequently, caution should be exercised when attempting to generalise the results to the theatre industry as a whole, and, more broadly, to the entire cultural sector.

These limitations point to potential avenues for research into the internationalisation of theatres. In particular, it is worth considering quantitative research with a larger sample of respondents and international comparative studies. Furthermore, the aforementioned feedback mechanism from the perspective of theatre financial management presents an interesting research topic. It is also worth considering further research into the relationship between the axiological dimension of theatre activity in the context of management processes and its impact on organisational paradoxes.

5. Conclusion

International cooperation is an important element of the theatre's activities. Due to its multidimensional nature, the level of internationalisation influences not only the development of artistic practice, but also the way it is managed. International cooperation can be a tool for long-term development, enabling the exchange of experiences, broadening artistic expression,

and creating relationships that are not affected by language or cultural barriers, while maintaining institutional identity.

From a management perspective, the internationalisation of theatre requires full awareness of strategic planning, a clearly defined mission, high organisational skills and the ability to function within complex financial and legal structures. The research revealed barriers that affect the scope and accessibility of international cooperation opportunities, especially for theatres with limited financial resources. Key limitations identified include insufficient funding for activities and barriers related to securing own contributions to participate in international projects.

When assessing the impact of the research, it is important to emphasise its contribution to both the theory and practice of contemporary theatre management. In terms of theory, new insights have been provided into the importance of international cooperation for the operation and development of theatres. According to the authors, this is particularly valuable due to the direct confrontation of cultural management theory with operational practice, taking into account the realities of the functioning of cultural institutions. In turn, the practical dimension of the research concerns primarily the usefulness of knowledge in the context of planning and implementing international projects, managing a multinational team, overcoming legal and organisational barriers, and securing sources of funding for such activities.

The knowledge provided may be useful for theatre managers, persons performing other managerial functions in theatres, cultural managers, theatre organisers, festivals and other theatre initiatives. It can also serve as a point of reference for researchers addressing the topics of theatre management and cultural management, international cooperation and third sector organisations whose activities are related to the theatre industry.

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THE NETWORK-EMBEDDED PROCESS OF TECHNOLOGICAL KNOWLEDGE ACQUISITION IN STARTUPS: A QUALITATIVE STUDY

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Purpose: The purpose of the paper is to identify and analyze the sources of technological knowledge acquisition that function as central and intermediary nodes in the relational networks of startups. The study seeks to demonstrate the networked character of technological knowledge flows and their role in strengthening startup innovation and competitiveness.
Design/methodology/approach: The study adopts a qualitative research approach. Data were collected through expert interviews with representatives of the startup ecosystem. The empirical material was analyzed using qualitative data analysis software (Atlas.ti), which enabled the identification of key sources of technological knowledge and the reconstruction of relational networks linking these sources.
Findings: The results indicate a diversity of technological knowledge sources available to startups and reveal the existence of complex networks of relationships among them. Some actors perform central roles, while others act as intermediaries facilitating the flow of technological knowledge. The analysis highlights the importance of interactions between various ecosystem actors in supporting startups' access to technological knowledge.
Research limitations/implications: The study is based on qualitative interviews with experts, which may limit the generalizability of the results. Future research could complement these findings by applying quantitative methods, analysing larger samples of startups, or examining differences between industries and national innovation ecosystems.
Practical implications: The findings provide guidance for startups and organizations supporting entrepreneurship by identifying actors that play a key role in technological knowledge exchange. The results may also support incubators, accelerators, and policymakers in strengthening collaboration mechanisms within startup ecosystems.
Originality/value: The study contributes to the literature by presenting a qualitative analysis of technological knowledge acquisition networks from the perspective of actors operating in the startup ecosystem. It addresses a research gap concerning the limited number of qualitative studies exploring the network structure of technological knowledge sources for startups.
Keywords: technological knowledge; startups; knowledge acquisition; innovation networks; startup ecosystem.
Category of the paper: Research Paper.

1. Introduction

The business world is undergoing rapid and extensive transformation on a global scale (Fuentes-Fernández et al., 2024). Contemporary organizations, in their pursuit of development and increased competitiveness, face numerous managerial challenges related to the proper understanding of the business environment. Managers are therefore required to monitor and interpret market trends while demonstrating the ability to anticipate ongoing changes in the market and adapt their strategies accordingly (de Diego Ruiz, Almodóvar, Birkinshaw, 2024).

The pervasive advancement of technology is also generating a range of changes in business operations. Consequently, digital technologies have acquired a strategic dimension, as they can support collaboration and knowledge sharing with business partners and customers (Abuseta, Iyiola, Aljuhmani, 2025). It is therefore important for organizations to effectively leverage the potential embedded in new technologies within their business activities. However, the ability to exploit technological opportunities is often conditioned by the possession of technological knowledge.

Thus, ensuring appropriate sources of technological knowledge acquisition becomes crucial, particularly for startups that frequently rely on new technologies in their business activities. Startup companies have broad opportunities in terms of acquiring technological knowledge. Establishing cooperation with other entities often becomes a necessity for firms competing through innovation (Wściubiak, 2019). Nevertheless, knowledge sources are highly diversified, as each firm pursues its own mission and develops specific interactions with different entities (Pinto, Guerreiro, Fernández-Esquinas, 2023).

It is recognized that companies can acquire knowledge from outside the organization, thereby enriching their expertise, fostering development, and striving for innovative success (Adam, Alofaysan, 2023). At the same time, organizations experience increasing pressure to possess knowledge that is essential for maintaining competitiveness in a knowledge-based economy (Danko, Crhová, 2024). Therefore, ensuring access to sources of technological knowledge remains a strategic issue for startups seeking growth and scalability.

In light of these considerations, it is justified to examine from which external organizations or individuals startups most frequently acquire technological knowledge. Identifying the sources of technological knowledge acquisition may represent an important step toward enhancing the innovativeness and competitiveness of startups. Moreover, the relationship maps between individual knowledge sources proposed in this article deepen the understanding of the analyzed phenomenon and may therefore provide significant practical value for startup managers. At the same time, it is noted that the literature on the subject still lacks in-depth analyses of the sources of technological knowledge acquisition and the relationships between them in the context of startup ecosystems. This paper fills this gap through a qualitative analysis of the network of relationships, identifying the crucial role not only of access to central nodes

but also of intermediary nodes that support the effectiveness of technological knowledge acquisition.

2. The Role and Importance of Technological Knowledge in Contemporary Organizations

Technological knowledge constitutes a critical component of an organization's intangible resources, directly determining the ability to design, produce, and improve products and processes, while indirectly influencing the pace of learning and adaptation to environmental changes (Barney, 1991). In the national literature, it is emphasized that managing a knowledge-based organization involves focusing management functions on knowledge-related resources, the processes associated with them, and the conditions enabling their efficient functioning (Mikuła, 2018). Consequently, the role of technological knowledge is twofold: (1) it represents substantive content enabling the creation of technical solutions, and (2) it is an object of management that requires appropriate mechanisms for identification, transfer, protection, and utilization.

Current diagnoses of innovation policies and trends indicate increasing pressure on the efficiency and speed of implementing new technologies under conditions of accelerated change and growing uncertainty (OECD, 2025). From a macro perspective, innovation indicators such as the European Innovation Scoreboard (EIS) and the Global Innovation Index (GII) consistently emphasize the importance of the capacity to generate, absorb, and utilize knowledge as a foundation of organizational and economic innovativeness (European Commission, 2025; WIPO, 2025).

Technological knowledge can be understood as a resource encompassing information about technologies (e.g., parameters, standards, requirements), operational competencies (know-how), understanding of mechanisms (know-why), and relational knowledge (know-who), indicating where and from whom complementary competencies can be obtained. A crucial distinction is made between explicit and tacit knowledge, as this determines the possibility of knowledge transfer and scaling within an organization (Nonaka, 1994). In the case of technological knowledge, a substantial portion is tacit (e.g., engineering practices, diagnostic intuition, implementation experience), which creates specific requirements for organizational learning and knowledge-sharing mechanisms.

The strategic value of technological knowledge is manifested in its capacity to generate value. It underpins the design, production, integration of systems, cybersecurity, and data analytics. The dynamic capabilities perspective suggests that under conditions of volatility, competitive advantage stems from the ability to sense opportunities, seize them, and reconfigure resources (Teece, 2007). In this context, technological knowledge is both an object of

reconfiguration (e.g., updating technological architectures) and a mechanism enabling such reconfiguration (e.g., integration competencies and implementation capabilities). Polish literature also highlights the strategic dimension of knowledge management, including the development of knowledge strategies, identification of competence gaps, and decisions regarding the development of knowledge resources and relationships within the environment (Mikuła, 2006). Thus, the strategic nature of technological knowledge results not only from its quality but also from its alignment with long-term organizational development directions. At the same time, various technological solutions can support processes involving knowledge (Kędziera, 2025).

Technological knowledge is a direct predictor of innovativeness because it enables organizations to generate solutions and implement and scale them. However, a key condition is absorptive capacity, defined as the ability to recognize the value of external knowledge, assimilate it, and apply it commercially (Cohen, Levinthal, 1990). This capacity depends on the existing competence base, which enables organizations to understand and integrate new knowledge. Depending on the conceptualization, absorption may involve not only assimilation but also transformation and exploitation of knowledge (Zahra, George, 2002).

Comparative reports (EIS, GII) indicate that innovation outcomes are strongly associated with R&D expenditure, the quality of human capital, and the intensity of collaboration within innovation systems. At the organizational level, this translates into the need to simultaneously strengthen technological competencies and network-based collaboration mechanisms (European Commission, 2025; WIPO, 2025). These conclusions are consistent with the assumptions of the open innovation concept, according to which companies increasingly rely on the purposeful use of external knowledge sources and cooperation with diverse actors in their environment (Chesbrough, 2003).

3. Sources of Technological Knowledge Acquisition

In the literature, knowledge acquisition is regarded as one of the key processes of knowledge management. This process includes the identification, acquisition, and introduction into the organization of knowledge originating both from internal resources and from the external environment, determining the possibilities for further transfer, use, and development of knowledge within the organization (Mikuła, 2006). Technological knowledge acquisition therefore has a hybrid character.

On the one hand, organizations acquire knowledge endogenously through research and development activities, learning-by-doing, and implementation experience. On the other hand, they absorb knowledge from the external environment through partnerships, technology transfer, and resources available within innovation ecosystems. The effectiveness of this

process depends both on the alignment of knowledge sources with organizational strategy and on absorptive capacity, understood as the ability to recognize the value of new knowledge, assimilate it, transform it, and use it in practice (Cohen, Levinthal, 1990; Zahra, George, 2002).

Internal sources of technological knowledge include, in particular, R&D activities, development work, experience derived from technology implementation, and learning through solving technical problems. Not only the generation of knowledge within projects is important, but also its preservation and diffusion across the entire organization (Pietruszka-Ortyl, 2020). Approaches structuring knowledge management processes emphasize the need to design the organizational environment, including its structure, culture, and organizational climate, in a way that supports knowledge creation and sharing (Mikuła, 2006). In the context of technological knowledge, this includes, among others, the formalization of project reviews, retrospectives, documentation standards, and mechanisms for transferring competencies between teams and projects. External sources of technological knowledge include cooperation with universities and research institutions, technological alliances, relationships with suppliers and customers, licensing solutions, and the use of open-access components.

According to the concept of open innovation, knowledge flows into and out of organizations can significantly shorten technology development cycles and increase the diversity of generated innovations (Chesbrough, 2003). In this perspective, competitive advantage increasingly depends not on the full internalization of resources but on access to distributed competencies operating within broader ecosystems. The importance of network relationships is also confirmed by innovation reports and indicators, which consistently point to collaboration and science–business relations as key determinants of innovation performance (European Commission, 2025; WIPO, 2025). From the organizational perspective, this implies the need for deliberate management of the portfolio of relationships and the development of capabilities to integrate knowledge originating from heterogeneous sources.

4. The Specificity of Startup Activity in the Context of Technological Knowledge

A startup can be defined as an organization operating under conditions of high uncertainty whose objective is to search for a repeatable and scalable business model (Blank, 2013; Ries, 2011). The literature emphasizes that startups are characterized by a low level of formalization, high operational flexibility, and strong dependence on the competencies of the founding team and key employees. On the one hand, this facilitates rapid decision-making and adaptation to market changes; on the other hand, it increases the risk of excessive personalization of knowledge and its concentration at the individual level (Blank, 2013).

Combined with the pressure of rapid market validation and persistent resource constraints, knowledge management in startups typically takes an agile form, closely linked to iterative product development. Startups primarily learn through market experiments, rapid prototyping, and testing hypotheses concerning value and growth (Ries, 2011). From the perspective of technological knowledge, this implies a high frequency of short cycles of knowledge creation, updating, and obsolescence, while limiting the development of extensive formal structures.

In many startups, technological knowledge forms the core of the value proposition, and competitive advantage results from unique technological competencies (e.g., algorithms, system architectures, data integration) or from the speed of implementing and iterating solutions. Consequently, aligning knowledge management strategies with the nature of the product and technology becomes particularly important. In areas where technology functions as a key strategic resource, it is necessary to simultaneously apply mechanisms for knowledge protection (intellectual property protection, trade secrets) and build capabilities for scaling and diffusing knowledge within the organization (Mikuła, Pietruszka-Ortyl, 2003).

At the same time, financial, temporal, and human resource constraints mean that startups rely more heavily than mature organizations on network-based forms of technological knowledge acquisition. Intensive use of advisors, mentors, investors, technology communities, cloud infrastructure providers, and ecosystem partners makes the ability to operate effectively within relational networks a substitute for missing internal resources. In this perspective, absorptive capacity becomes a critical organizational capability (Cohen, Levinthal, 1990). From a process perspective, this requires at least a minimal but sufficient competence base enabling the assessment of the quality of externally acquired knowledge, its selection, transformation, and application in the context of a specific product or technology (Zahra, George, 2002). Simultaneously, startups may use instruments supporting internal knowledge transfer; research indicates that motivational and project-based solutions, including elements of gamification, can strengthen employee engagement in knowledge-sharing activities (Witoszek-Kubicka, 2023).

5. Methods

The purpose of this article was to identify and analyze the sources of technological knowledge acquisition that function as central and intermediary nodes within the relational networks of startups. Accordingly, the following research question was formulated: Which sources of technological knowledge perform the role of central and intermediary nodes in the relational network identified among startups?

To achieve the objective of the study and answer the research question, a qualitative research approach was applied. Sixteen interviews were conducted with representatives of the business environment supporting startups, using remote online communication. The respondents were experts cooperating with organizations that support the startup ecosystem (e.g., science and technology parks). Their overall professional experience ranged from 6.5 to 35 years, while their experience related specifically to startups ranged from 3 to 16 years. The selection of experts from the external environment was justified by their broader and more cross-sectional perspective on startup-related challenges, as well as a lower risk of bias.

The collected empirical material in the form of interviews was analyzed using computer-assisted qualitative data analysis software. Currently, numerous software tools from the CAQDAS (Computer-Assisted Qualitative Data Analysis Software) family support qualitative data analysis. The development of such software has been strongly influenced by the assumptions of grounded theory, which shaped the design of their analytical functionalities (Bryda, 2014). In this study, Atlas.ti software was used due to its intuitive interface, grounded theory–based architecture, and advanced capabilities for creating relational networks between individual codes (Konopasek, 2008; Niedbalski, 2014).

The interview data were first uploaded into the Atlas.ti environment, after which relevant coding categories were developed. In the next stage of analysis, the interview material was coded until theoretical saturation was reached. As Gibbs (2011) notes, codes can be understood as short labels assigned to fragments of text that relate to a specific issue. In this study, the codes represented sources of technological knowledge acquisition for startups.

The identified sources of technological knowledge acquisition were subsequently presented through generated maps that also illustrated possible relationships between the individual codes. These maps enable a better understanding of the diversity of technological knowledge sources used by startups and the potential relational networks among them. Consequently, they may provide practical value for the managerial staff of startup companies.

6. Results and Discussion

Figure 1 presents a relational map of the sources of technological knowledge acquisition used by startup companies, identified through the analysis of the interview data. The map reflects the structure of codes and the relationships between them. Each node represents a distinct source of technological knowledge acquisition. The symbol “G” indicates the number of occurrences of a given code in the empirical material, reflecting the frequency with which experts referred to a particular source of technological knowledge. The symbol “D” denotes the number of relationships in which a given code is involved with other codes, indicating its degree of connectivity within the analyzed network of knowledge sources.

The relationships between individual sources of technological knowledge are illustrated by arrows of different colors, enabling the distinction of the nature of these connections. Green arrows represent relationships with a positive impact, indicating that a given source of knowledge supports or strengthens the use of another source. Red arrows indicate a negative impact, understood as limiting or weakening the importance of another technological knowledge source. Blue arrows denote neutral relationships, indicating co-occurrence or functional linkage between sources without a clearly defined direction of influence.

The analysis of the relational map indicates that selected sources of technological knowledge function as central nodes. This is reflected both in the number of references by experts (G) and in the number of connections with other codes (D). In particular, technology parks are characterized by a relatively high number of occurrences in the empirical material (G = 5) and a significant number of relationships with other knowledge sources (D = 2), indicating their role as institutional platforms integrating access to technological knowledge. An even more pronounced central node function is performed by experts, who reach one of the highest values in terms of the number of connections in the network (D = 7, with G = 5), confirming their importance as intermediaries and knowledge brokers within the startup ecosystem. Universities also stand out due to a high frequency of references (G = 11) and the presence of connections with other sources (D = 2), confirming their role as significant providers of technological knowledge, particularly of a formal and expert nature. This result is consistent with findings in the literature, which indicate that knowledge institutions and actors possessing specialized competencies serve as integrators of knowledge flows within innovation ecosystems, providing access to expert knowledge and reducing information asymmetry for startups (Nonaka, Takeuchi, 1995; Argote, Ingram, 2000).

It's also worth noting specialized online channels, which were characterized by a high number of references (G = 5) and connections to other sources at a high level (G = 2). This suggests that specialized online channels can also be an important source of technological knowledge for startups. At the same time, a connection between this source and online trends was observed. This may lead to the conclusion that the observed trends may lead to a search for more advanced technological knowledge.

Attention should also be given to sources such as inter-firm collaboration, training, and industry meetings, which perform intermediary node functions within the analyzed network. Inter-firm collaboration is characterized by a moderate number of references (G = 4) and a relatively high number of connections (D = 5), suggesting its role as a mechanism linking different categories of actors and knowledge sources. A similar pattern is observed in the case of training (G = 6; D = 5), which functions as a channel of knowledge transfer, particularly explicit knowledge, while simultaneously facilitating knowledge internalization through interaction. Industry meetings, despite a lower number of references (G = 2; D = 3), demonstrate significant connections with other sources, confirming their role as occasional yet important contact points enabling the flow of tacit knowledge. Such intermediary nodes support the

diffusion of knowledge between diverse groups of actors and enable the recombination of knowledge resources, which the literature associates with increased organizational innovativeness (Burt, 1992; Obstfeld, 2005). The findings of Pittaway et al. (2004) indicate that network relationships with suppliers, customers, and intermediaries such as industry and professional associations are key factors influencing innovation. In the context of our research, we note that an extensive network for acquiring technological knowledge sources within the framework of open innovation can enhance startups' innovativeness.

The obtained results are also consistent with the assumptions of the open innovation concept, according to which startups, due to their limited internal resources are particularly dependent on external sources of technological knowledge. At the same time, the findings emphasize that the effectiveness of knowledge acquisition depends not only on access to central nodes but also on the presence of intermediary nodes, which enable relationship building, learning through interaction, and the transfer of tacit knowledge. In the context of the research question, it can therefore be concluded that the network of technological knowledge acquisition among startups has a functionally differentiated structure in which central nodes provide access to key knowledge resources, while intermediary nodes facilitate their diffusion and practical utilization. The study also highlights that it is the combination of central and intermediary nodes, not just the dominant role of one, that creates multi-channel learning environments. Thus, the diverse flow of technological knowledge creates unique conditions for the growth of innovation and startup development. This study also demonstrates that startups face numerous challenges related to building relationships in the external environment. The multidimensional nature of technological knowledge sources also raises questions regarding the speed of its acquisition, the level of accessibility, and its cost-effectiveness.

This study, however, has certain limitations. The study was based on interviews with representatives of organizations supporting startup development. Adopting this perspective imposes a specific perspective on the sources of technological knowledge, focusing primarily on the experiences and observations of intermediaries rather than the startups themselves. This approach may result in the possibility of partially omitting important startup conditions, internal processes, and adopted strategies for acquiring technological knowledge. Future research could therefore focus on adopting an internal perspective, and thus be conducted among startup founders or representatives. An interesting research direction would also be examining the sources of technological knowledge acquisition and the relationships between them in public administration institutions.

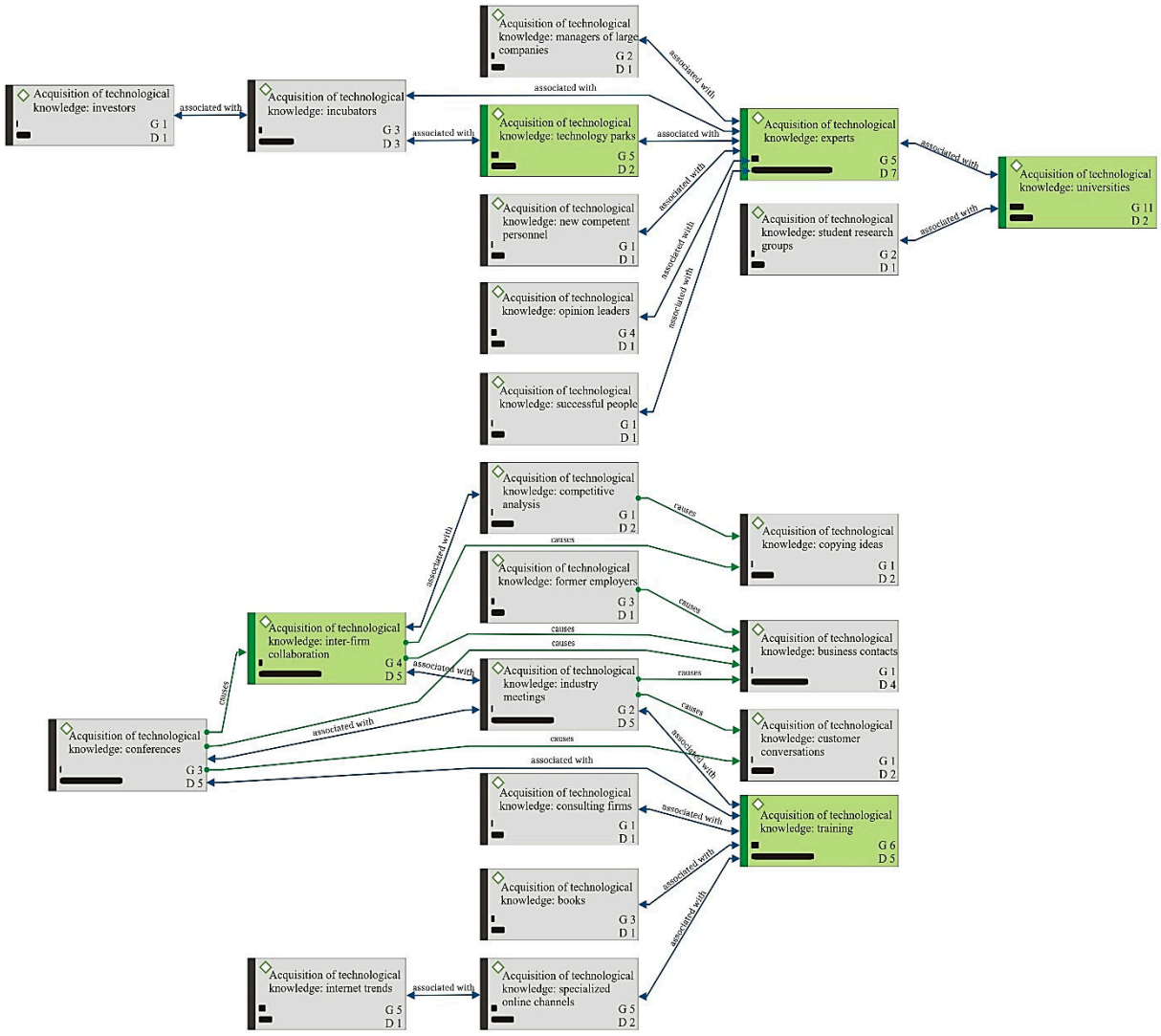

Figure 1. Relational map of technological knowledge acquisition sources among startups.
Source: own elaboration.

7. Summary

Startup companies have access to numerous and diverse sources of technological knowledge acquisition. The conducted study indicates that key sources include technology parks, experts, and universities. An important role is also played by inter-firm collaboration and training activities, which support the acquisition of technological knowledge within startups.

This study presents the networked nature of individual codes (sources of technological knowledge acquisition) in the form of relational maps. These maps may provide practical value for managers responsible for the development of new technologies and the implementation of innovative solutions in organizations. The research also addresses a theoretical gap related to the limited number of qualitative studies presenting networks of technological knowledge

acquisition from the perspective of actors operating in the startup environment. In doing so, the study contributes an alternative perspective to the literature, which often focuses primarily on the viewpoint of startup founders. Such an approach allowed for the identification of technological knowledge sources in a more systemic and cross-sectional manner.

The study also leads to broader theoretical implications, demonstrating the complementary nature of central and intermediary nodes as sources of technological knowledge acquisition for startups. This leads to the conclusion that the effectiveness of technological knowledge acquisition may depend on startups' ability to configure diverse knowledge source connections within their ecosystem. The study therefore indicates that for startups, a strategic approach to building a network of knowledge sources is crucial to their development.

Nevertheless, it is difficult to construct a universal map of technological knowledge sources and the relationships between them that could serve as a universal solution ensuring startups' competitive strength in the market. The selection of technological knowledge sources should also be considered in relation to the financial capabilities of a startup, as some of these sources may involve significant costs. Access to technological knowledge may constitute an important pathway for development and increased innovativeness not only for startups but also for other types of organizations.

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DEVICE FOR TESTING PARTICLE FILTERS, PARTICULARLY REUSABLE PARTICLE FILTERS FOR HALF-MASKS AND MASKS

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Purpose: there are a large number of dust masks and half-masks with replaceable filters available on the market. Dust filters are classified as new and clean breathing filters. There is no method for classifying these filters based on their service life and duration. The device guarantees that this test is performed objectively. To date, masks have been tested in real-world conditions by miners, who subjectively assess comfort.
Design/methodology/approach: a device was constructed to simulate human breathing. This device measures the amount of energy used for breathing. This amount of energy is proportional to the breathing resistance and serves as a substitute for it.
Findings: the device is used to determine the amount of energy used for breathing in used (clogged) filters. The difference in the energy used for breathing in a used filter compared to the energy used for breathing in a new filter indicates increased breathing difficulty.
Practical implications: the device described in this publication allows you to determine the maximum service life of dust filters. Using this device, you can differentiate filters based on their wear time and dust clogging.
Social implications: the device will allow for the identification of dust filter usage times and the differentiation of filters. This will impact the economics of filter purchase costs and the quality of miners' work.
Originality/value: a new device for carrying out a new type of research needed to optimize the use of reusable filters for masks.
Keywords: masks, halfmasks, breathing resistance, dust, mining.
Category of the paper: research paper, technical paper.

1. Introduction

Reusable half-masks and masks are equipped with dedicated filters, including particle filters. Particle filters are designed to filter the air breathed by humans.

The minimum requirements concerning half- and quarter-masks used as respiratory protective equipment, excluding escape and diving apparatus, as well as the laboratory and field tests enabling the conformity assessment of the half- and quarter-masks with the requirements,

are described in standards PN EN 140:2001 Respiratory protective devices – Half masks and quarter masks – Requirements, testing, marking, and PN EN 149:2010 Respiratory protective devices – Filtering half masks to protect against particles – Requirements, testing, marking.

The problem affects tens of thousands of miners, and the cost of purchasing dust filters is enormous. Optimizing the filter purchasing process based on reliable and objective research seems justified. To illustrate the scale of costs, one coal company uses approximately 530,000 filters per year. Knowledge of filter performance parameters is one element of cost management and optimization, as some filters have a lifespan of one day or several days.

Methods for assessing the practical usability of particle filters for reusable half-masks and masks are an established concept in the current state of knowledge, though not all of them guarantee conformity with the requirements of the above standards.

Current control practices concerning the practical usability of particle filters for reusable half-masks and masks are based on breathing resistance tests. The breathing resistance measurement consists in forcing an airflow through a half-mask placed on a head model at a constant volumetric flow rate and determining the pressure drop inside the half-mask relative to atmospheric pressure. The tests are described in standard EN 13274-3:2005 and performed at airflow rates of 30 l/min and 95 l/min, which correspond to minute ventilation during rest and heavy labour. The pressure readings are performed on a digital differential micromanometer.

The use of the device and filter testing will be useful in the decision-making process and in managing the purchasing process of personal protective equipment.

Given its low precision, such a procedure does not make it possible to identify certain faults or the wear level of the filters.

The device was designed to solve the key problem of distinguishing between different dust filters. Miners use respirators with dust filters daily. To date, there is no method or device for distinguishing between filters and identifying their characteristics, including cost. It is necessary to consider whether it is advisable to use cheaper disposable filters or more expensive, longer-lasting filters, and to establish a correlation between these parameters.

2. State of knowledge

Devices for inspecting industrial filters, such as filtering separators, are also an established concept in the current state of knowledge. The description of invention PL188632 (fig. 1) provides a device for testing filters, intended for inspecting filtering separators, particularly with bag-, pouch-, or cartridge-shaped filters, characterised in that it has a hose- or tube-shaped air conveyance section comprising a surface contact fitting at one end, wherein an air conveyor is installed in the air conveyance section for generating an airflow in at least one direction,

and furthermore the air conveyance section comprises a pressure gauge for sensing and displaying the airflow pressure and is further equipped with an airflow meter and/or an air volume meter with a display, wherein the device is designed as a portable unit.

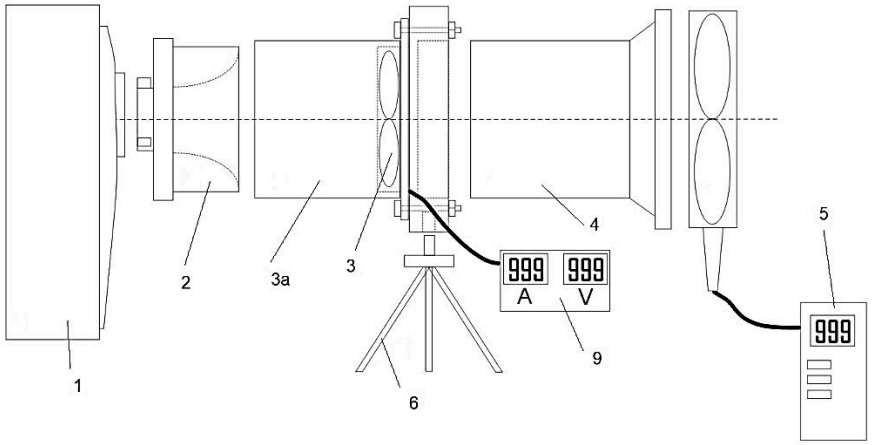

Figure 1. The device for testing power needed to breathing through filters, (1 – testing filter, 2 – original connection from mask, 3 – fan, 3a, 4 – tube, 5 – anemometr, 6 – stand, 9 – power supply of fan).

Source: own elaboration.

The invention PL188632 was made by GIG-PIB.

In this invention preferably is:

- the pressure gauge is installed in the surface contact fitting section,
- the air conveyance section comprises a controller for setting a specific pressure or volumetric flow rate,
- the device comprises multiple pressure gauges,
- the air conveyor is in the form of a fan, alternatively an air ejector,
- the air conveyor is adapted to generate an airflow from the air conveyor to the surface contact fitting,
- the air conveyor is adapted to generate an airflow from the surface contact fitting to the air conveyor,
- the air conveyor is adapted to generate an airflow in both directions,
- a dust detector with a display is installed in the air conveyance section,
- the device comprises a hose- or tube-shaped air conveyance duct, wherein the air conveyance duct comprises a surface contact fitting at one end, and furthermore a valve is installed in the air conveyance duct, wherein the air conveyance duct has a compressed air connection on the side of the valve facing away from the surface contact fitting,
- an auxiliary compressed air tank is installed between the compressed air connection and the valve,
- the auxiliary compressed air tank can be closed from the side of the compressed air connection,

- the auxiliary compressed air tank is surrounded by the air conveyance duct between the valve and the surface contact fitting,
- the valve is a diaphragm valve,
- the valve comprises an electromagnetic controller with a controlled opening time,
- the surface contact fitting is bell-shaped,
- the surface contact fitting comprises sealing elements on the front side,
- the air conveyance duct and the air conveyance section are mutually connected,
- the air conveyance duct and the air conveyance section converge in the area of the surface contact fitting,
- the air conveyance section comprises a closing valve.

Testing particle filters, particularly reusable particle filters for half-masks and masks, which would enable inspecting the filters and their wear level, particularly from the perspective of their flow capacity (degree of clogging), is a technical problem. This led to the need to develop a solution enabling the testing of particle filters, particularly reusable particle filters for half-masks and masks, from the perspective of inspecting their wear level according to standards PN EN 140:2001 and PN EN 149:2010. There was a need to develop a solution that would eliminate or at least minimise the inconveniences of methods established in the current state of knowledge. There was a need to develop a solution that would enable the comprehensive determination of the quantity of energy necessary to obtain a given airflow through the tested filters. There was a need to develop a solution that would enable the simple determination of the level of airflow obstruction in the tested filters (e.g. due to contamination). There was a need to develop a solution that would complement an existing market gap – the demand for a simple method of conducting filter testing in such a manner (currently there are no such methods on the market).

The above goal is fulfilled by the solution according to this invention, in the form of a method for testing particle filters, particularly the wear level testing of reusable particle filters for half-masks and masks, the nature of which is that a tested filter is connected to a sealed measuring system comprising at least a fan and an anemometer, after which an airflow is forced by means of the fan installed in the system, drawing air from outside the measuring system through the filter, and the airflow passing through the tested filter and measuring system is measured by the anemometer, wherein the fan is supplied by a direct current power supply unit with a display and smooth intensity [A] and voltage [V] control, which is used to conduct the testing and measuring procedures, consisting in that the intensity and voltage of the fan power supply unit are set to a value ensuring the adopted airflow in the measuring system, after which the intensity [A] and voltage [V] are measured and the fan power is calculated, whereas the obtained results, i.e. the airflow through the measuring system and the fan power required to obtain the adopted airflow through the measuring system, in measuring series simulating the energy required for standard ventilation during respiration and labour, particularly 30 l/min and

95 l/min, are collected, systematised and analysed by known methods, wherein the described method involves the use of a fan and an anemometer in a sealed installation in a sealed air conveyance section, wherein the testing and measuring procedures are performed in a measuring system with an air conveyance section located on an axis shared with the fan and the anemometer, thereby forming a measuring circuit with the same internal diameter, wherein the above procedures are carried out for new filters and filters of various wear level.

Preferably, in this method the tested filter is connected to the sealed measuring system by a ring with a sealed bayonet coupling, which is located between the tested filter and the measuring system, before the fan.

Preferably, in this method the applied ring is formed from moisture-resistant plastic.

Preferably, in this method the applied fan has an airflow measurement capacity ranging from 30 l/min to 100 l/min, most preferably 30 l/min and 95 l/min.

Preferably, in this method the applied fan has a power rating of 0.8 W to 2 W.

Preferably, in this method the applied fan is supplied by a direct current power supply unit with a display and smooth intensity A and voltage V control enabling the setting and reading of the fan power through intensity A and voltage V readouts.

Preferably, in this method the applied anemometer has an airflow measurement capacity ranging from 20 l/min to 100 l/min.

Preferably, in this method the applied anemometer is a vane anemometer.

Preferably, in this method the applied anemometer is adapted to the measuring circuit diameter in a sealed manner.

Preferably, the method as described above utilises a device comprising a ring with a sealed bayonet coupling for mounting a tested filter, with a fan and a tube installed after it, and an anemometer installed further after them, wherein the ring, the fan and the anemometer are installed in a sealed manner on the sealed air conveyance section, wherein the central points of the air conveyance section, the ring, the fan, the tube and the anemometer are located on a shared axis and form a measuring circuit with the same internal diameter.

Preferably, the method as described above can be applied in an enclosed climatic chamber under controlled climatic conditions corresponding to the ultimate operating conditions of the filters, preferably corresponding to the conditions present in a mining plant, preferably in an enclosed climatic chamber with controlled air temperature and relative air humidity.

The advantage of the solution in the form of the method for testing particle filters, particularly reusable particle filters for half-masks and masks, per this invention is that it enables the determination of the energy necessary to obtain a given airflow through tested filters in a simple manner. The method makes it possible to examine filters and draw conclusions regarding the filter wear level (the more clogged a filter, the higher the fan energy required to obtain the given airflow). The method is simple and inexpensive, and it complements an existing market gap.

The subject of the invention is described in examples of execution below and depicted in drawings, where Fig. 1 presents the device and the tested filter as a block diagram, Fig. 2 displays the individual elements of the device and the tested filter, and Fig. 3 depicts charts with results obtained using the method by means of the device.

3. Design of a new device for testing particle filters

The device for testing particle filters (fig. 2), particularly reusable particle filters for half-masks and masks, comprises: an anemometer 5 with a connecting tube 4, before which is a fan module (stand, connectors, fan power supply) with a fan 3 and a ring 2 with a bayonet coupling dedicated for a specific filter 1, enabling the establishment of a precise and sealed connection of the tested filter 1 with the measuring system.

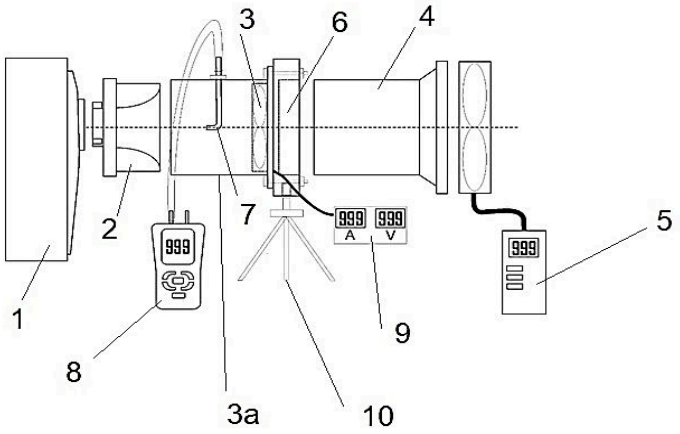

Figure 2. The device for testing power needed to breathing through filters with module of testing breathing resistance, (1 – testing filter, 2 – original connection from mask, 3 – fan, 3a, 4 – tube, 5 – anemometr, 6 – seal, 7 - pressure measurement probe , 9 - pressure instrument, 9 – power supply of fan, 10 – stand).

Source: own elaboration.

As regards the device described above:

- it constitutes an enclosed and sealed (i.e. all the drawn in air passes through the filter 1) isolated system,
- all the elements of the measuring system, together with the fan module with the fan 3, have the same internal diameter, making it possible to avoid air swirls that would disrupt the measurement,
- it is terminated with a ring 2 with a bayonet coupling for mounting filters 1 of various types on one end,

- it comprises a fan 3 that simulates human respiration and is intended to draw in air from the outside through a filter 1 – the efficiency of the fan 3 must be sufficient to obtain an airflow ranging from 30 l/min to 100 l/min, preferably 30 and 95 l/min, according to standards PN EN 140:2001 Respiratory protective devices – Half masks and quarter masks – Requirements, testing, marking, and PN EN 149:2010 Respiratory protective devices – Filtering half masks to protect against particles – Requirements, testing, marking,
- it comprises an anemometer 5, preferably a vane anemometer with a display, which measures the airflow in the measuring system and must enable airflow measurements within a range of 20 l/min to 100 l/min,
- it is contained in a housing ensuring the air-tightness of the entire measuring circuit from the tested filter 1 to the anemometer 5.

Optionally, the housing of the fan 3 can comprise a thread for mounting the device on a stand, so that the tests may be performed on a stably fixed device.

Furthermore:

- anemometer 5 – has an internal diameter as close as possible to the internal diameter of the fan 3 and the entire measuring system,
- fan 3 – has a power rating of 0.8 W to 2 W,
- ring 2 – enables the mounting of the filter 1 on one end, and is tightly adapted to the measuring system on the other end. The ring 2 is formed from moisture-resistant plastic.

The device is characteristic in that all the above elements are installed on a shared axis and have the same internal diameters.

Device correlation was made using appropriate reference standards and instruments, including anemometers and power measuring instruments.

An example advantage of the solution described above is that:

- it constitutes a sealed measuring circuit – therefore the measured airflow corresponds only to the airflow through the tested filter 1,
- the airflow measurement concerns exclusively air drawn in through the filter 1 by means of the fan 3,
- it makes it possible to measure the amount of air flowing through the filter 1,
- it is relatively inexpensive and simple to construct,
- it makes it possible to measure the power of the fan 3 required to provide a sufficient airflow through the tested filter 1.

A number of procedures can be performed using the above system, consisting in:

1. grouping filters 1 according to the time of use / level of wear,
2. measuring the power of the fan 3 required to obtain the adopted airflow through an open measuring system (without the filter 1),

3. measuring the power of the fan 3 required to obtain the adopted airflow through a new / clean filter 1,
4. measuring the power of the fan 3 required to obtain the adopted airflow through filters 1 grouped according to the time of use / level of wear,
5. correlating the above data.

4. Testing procedure with device

The method as described in example execution I, using the device described in example execution I or example execution II, wherein the method is applied in a climatic chamber under controlled climatic conditions, preferably with controlled relative air humidity and temperature, corresponding to the ultimate operating conditions of the filters, preferably corresponding to the conditions present in a mining plant.

Thereby it is possible to conduct measurements of airflows through the filters under controlled atmospheric conditions (relative air humidity and temperature) that are identical to the ultimate operating conditions of the filters (e.g. as found in a mining plant).

This is intended to simulate the conditions in which the filters 1 were used. Additionally, it is possible to investigate whether the climatic conditions (dry or humid) affect the performance of the filters.

During stage I:

The tested filter 1 is classified according to its time of use / level of wear.

Afterwards:

- a new, unused filter 1 (reference filter) is mounted on the ring 2 of the device described above, and the power of the fan 3 required to obtain the adopted airflow through the measuring system is determined (the power of the fan 3 is determined by means of a power supply unit measuring the intensity A and voltage V, characterised by smooth intensity and voltage control, by which the power supplied to the fan 3 can be adapted freely),

afterwards:

- a used filter 1 (tested/evaluated filter) is mounted on the ring 2 of the device described above, and the power of the fan 3 required to obtain the adopted airflow through the measuring system is determined (in the same manner as above),

afterwards:

- the above procedure is repeated for filters 1 with different times of use / levels of wear.

During stage II:

The measurement results from stage I are compiled in the form of a chart (Fig. 3) or table.

The obtained results (fan power) are compared to the filter time of use / level of wear during measuring series involving the adopted airflow (30 and 95 l/min according to standards PN EN 140:2001 Respiratory protective devices – Half masks and quarter masks – Requirements, testing, marking, and PN EN 149:2010 Respiratory protective devices – Filtering half masks to protect against particles – Requirements, testing, marking).

Fig. 3 presents an example chart with a compilation of two measuring series involving airflows of 30 l/min and 95 l/min for filters with three levels of wear (new, used for one day, used for three days).

To sum up, the device for testing particle filters, particularly reusable particle filters for half-masks and masks, comprises a ring 2 with a sealed bayonet coupling for mounting a filter 1, with a fan 3 installed after it, and an anemometer 5 installed further after them, wherein the ring 2, the fan 3 and the anemometer 5 are installed in a sealed manner on a sealed air conveyance section, wherein the central points of the air conveyance section, the ring 2, the fan 3 and the anemometer 5 are located on a shared axis and form a measuring circuit with the same internal diameter.

Furthermore, in the device:

- the air conveyance section is a round section, preferably a tube or hose section,
- the air conveyance section, the ring 2, the fan 3 and the anemometer 5 have the same internal diameters,
- the ring 2 is a ring formed from moisture-resistant plastic,
- the fan 3 is a fan with an airflow measurement capacity ranging from 30 l/min to 100 l/min, preferably at a level of 30 l/min and 95 l/min,
- the fan 3 is a fan with a power rating of 0.8 W to 2 W,
- the anemometer 5 is an anemometer with an airflow measurement capacity ranging from 20 l/min to 100 l/min,
- the anemometer 5 is an anemometer adapted to the diameter of the measuring circuit in a sealed manner,
- the anemometer 5 is a vane anemometer,
- the ring 3 is a ring equipped with a bayonet coupling on one side, enabling the sealed mounting of a tested filter 1, and a sealed coupling with the measuring system on the other side.

It is permissible for the filter testing to be conducted in a climatic chamber under controlled climatic conditions, preferably with controlled relative air humidity and temperature, corresponding to the ultimate operating conditions of the filters, preferably corresponding to the conditions present in a mining plant.

To sum up, the method for testing particle filters, particularly reusable particle filters for half-masks and masks, is applied as follows:

A tested filter 1 is connected to a sealed measuring system, comprising at least a fan 3 and an anemometer 5, after which the fan 3 installed in the system is used to force an airflow by drawing in air from outside the measuring system through the filter 1, and the airflow through the tested filter 1 and measuring system is measured by means of the anemometer 5. The fan 3 is powered by a direct current power supply unit with a display and smooth intensity [A] and voltage [V] control, and it is used to conduct the testing and measuring procedures consisting in setting the intensity and voltage of the fan power supply unit to obtain the adopted airflow in the measuring system, after which the intensity [A] and voltage [V] are measured and the power of the fan 3 is calculated. The obtained results, i.e. the value of the airflow in the measuring system and the power of the fan 3 required to obtain the adopted airflow through the measuring system, from measuring series simulating the amount of energy required for standard ventilation during respiration and heavy labour, particularly 30 l/min and 95 l/min, are collected, systematised and analysed using known methods. The described method involves a fan 3 and an anemometer 5 installed in a sealed manner on a sealed air conveyance section. The testing and measuring procedures are carried out in a measuring system with the air conveyance section located on a shared axis with the fan 3 and the anemometer 5, thereby forming a measuring circuit with the same internal diameter. All the above procedures are performed for both new filters 1 and filters 1 with different levels of wear. The measurement method is intended to simulate the amount of energy required for standard ventilation during respiration, particularly 30 l/min corresponding to rest and 95 l/min corresponding to heavy labour. Respiration will be more difficult through a used filter 1, therefore the power required for respiration will be higher relative to respiration through a clean (unused) filter 1.

Furthermore, in the method:

- the applied air conveyance section is a round section, preferably a tube or hose section,
- the applied air conveyance section, the ring 2, the fan 3 and the anemometer 5 have the same internal diameters,
- the applied ring 2 is a ring formed from moisture-resistant plastic,
- the applied fan 3 has an airflow measurement capacity ranging from 30 l/min to 100 l/min, preferably at a level of 30 l/min and 95 l/min,
- the applied fan 3 has a power rating of 0.8 W to 2 W,
- the applied anemometer 5 has an airflow measurement capacity ranging from 20 l/min to 100 l/min,
- the applied anemometer 5 is a vane anemometer, preferably with a display,
- the applied anemometer 5 is adapted to the diameter of the measuring circuit in a sealed manner,

- the applied ring 3 is equipped with a bayonet coupling on one side, enabling the sealed mounting of the tested filter 1, and a sealed coupling with the measuring system on the other side,
- the results obtained by means of the anemometer 5, i.e. the airflow in the measuring system and the fan power required to obtain the adopted airflow through the measuring system, are subjected to further analysis – the obtained results (fan power) are compared with the time of use / level of wear of the filters 1 during measuring series involving the adopted airflow (30 and 95 l/min according to standards PN EN 140:2001 Respiratory protective devices – Half masks and quarter masks – Requirements, testing, marking, and PN EN 149:2010 Respiratory protective devices – Filtering half masks to protect against particles – Requirements, testing, marking), after which charts and comparisons are made and conclusions are drawn from them.

It is permissible for the measurements to be conducted in a climatic chamber under controlled climatic conditions, preferably with controlled relative air humidity and temperature, corresponding to the ultimate operating conditions of the filters 1, preferably corresponding to the conditions present in a mining plant – see the device described in example execution III.

5. Testing of filters using in mine

A method for testing particle filters, particularly the wear level testing of reusable particle filters for half-masks and masks was used to test filters in one of the silesian mining.

Filters from half-masks used by miners were collected for the study. The filters were identified by their duration of use, as determined by the miners. The fan power required to achieve a given flow rate through each tested filter was tested. This flow rate corresponds to the standard flow rate and the actual airflow through the upper respiratory tract during breathing. For comparison, the same tests were performed for a new filter and without a filter, serving as reference values.

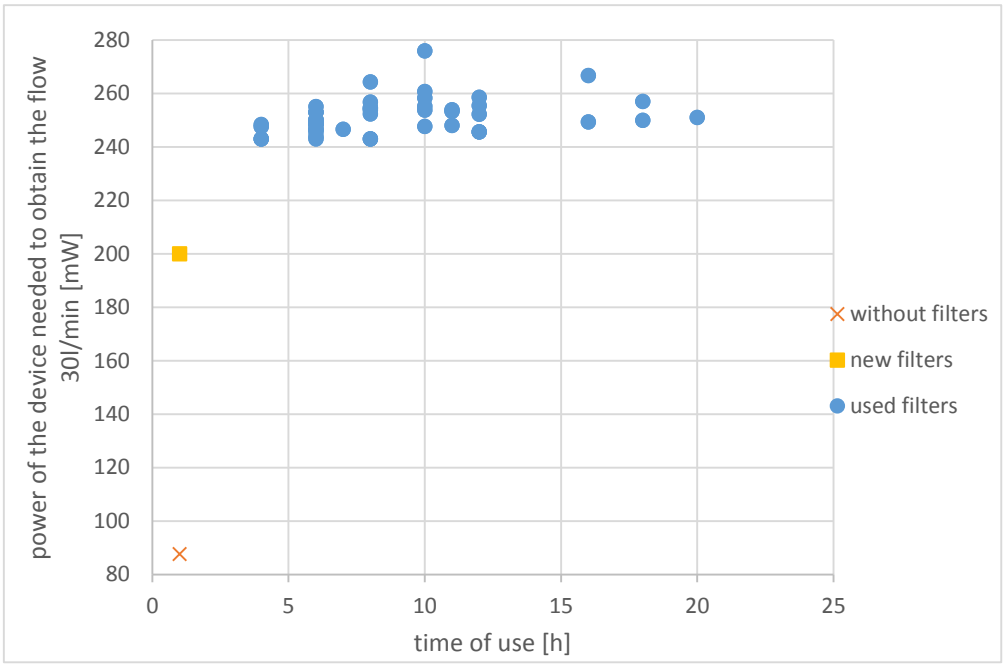

Figure 3. summary of the power of the device simulating breathing through used dust filters.

Source: own elaboration.

The power levels are presented in Figure 3.

The percentage increase in breathing difficulty was determined by the increase in power required to achieve the given flow rate through the tested used filter compared to the new filter. These values are presented in Figure 4.

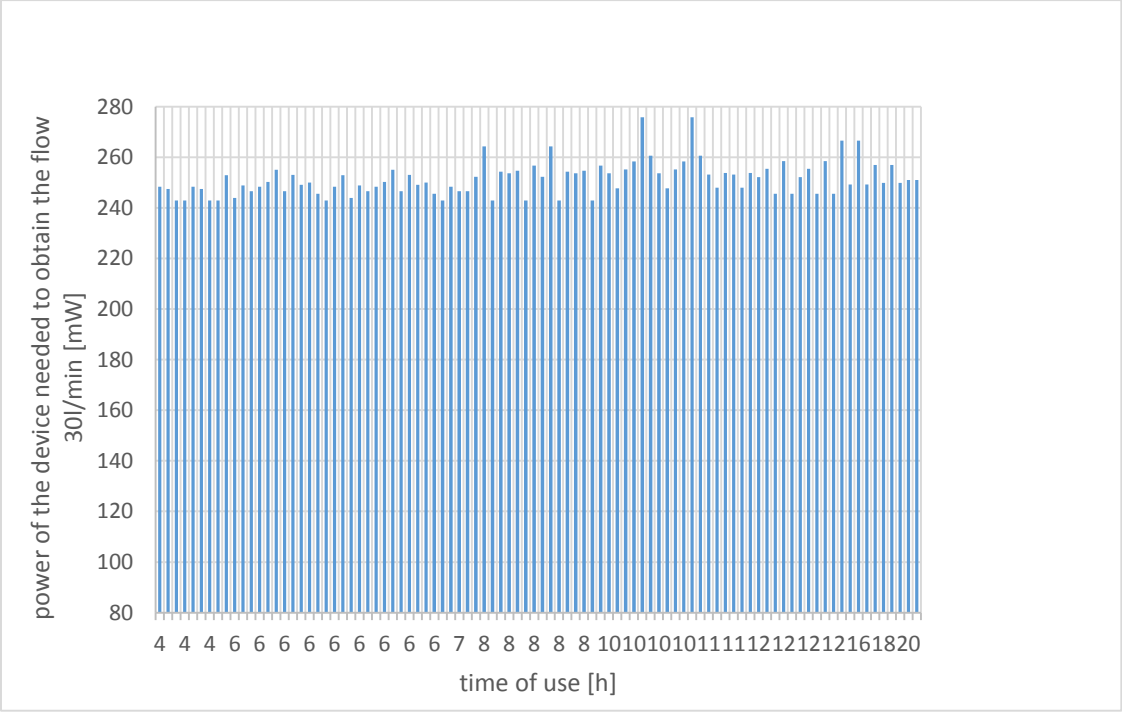

Figure 4. percentage increase in the power of the device simulating breathing through the used dust filters.

Source: own elaboration.

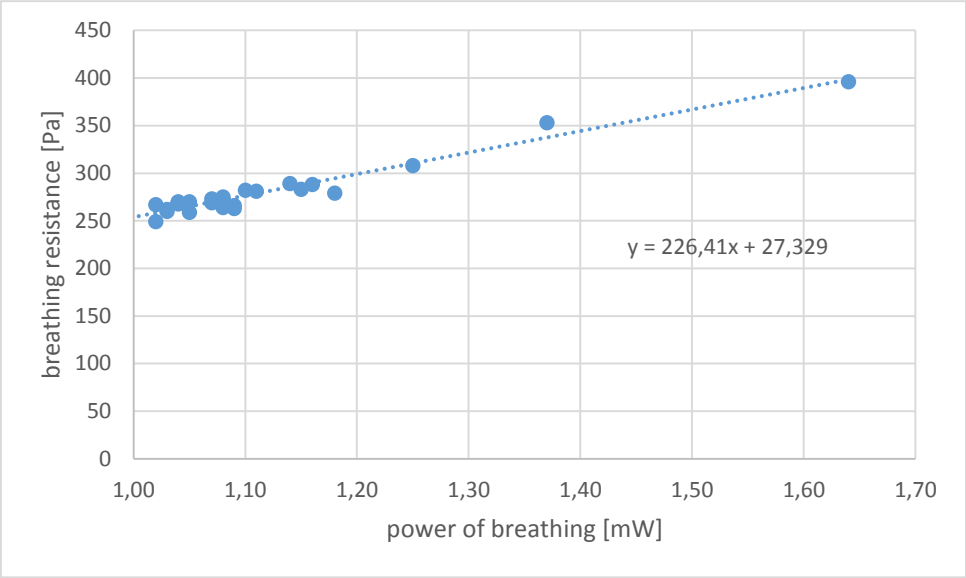

Figure 5. Correlation of breathing resistance and power needed to breathing.
Source: own elaboration.

Using the device in Figure 2 and the breathing resistance measurement functionality, the relationship in Figure 5 was created. Figure 5 shows the correlation between breathing resistance and the increase in power required for breathing. This graph clearly shows that breathing resistance increases in clogged filters.

6. Summary

The device design and measurement method have been registered with the Polish Patent Office. Commercialization plans include demonstrating the device's functionality to both dust filter manufacturers and customers. Implementation of the device assumes its use in filter differentiation, identifying their effectiveness and durability, which is crucial for production costs. Filter life is crucial for customers, who prioritize both economic considerations and disposal.

The costs of type testing for filters are negligible and provide a wealth of important information regarding their performance characteristics. The primary benefit of this test is the differentiation and identification of filter lifespan and usefulness. This testing can complement performance/in-service testing. To date, masks have been tested in real-world conditions by miners, who subjectively assess their comfort. The device guarantees that this test is performed objectively.

The use of the device and filter testing will be useful in the decision-making process and in managing the purchasing process of personal protective equipment.

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ECOSYSTEM SERVICES OF URBAN GREEN SPACES AND THEIR IMPACT ON QUALITY OF LIFE

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Purpose: Natural landscapes have changed fast lately, mostly because urbanization is pushing cities to grow. Resources are consumed faster. Natural areas disappear. Air pollution gets worse. Temperatures rise in dense city zones. In this situation, urban green spaces matter more. In the research, the focus is on urban green infrastructure and ecosystem services, their impact on the environment, and the quality of life.

Design/methodology/approach: The study is based on a review of scientific literature related to ecosystem services and urban green infrastructure. Different academic articles and analytical reports were considered during the analysis. To explore how ecosystem services affect environmental conditions and human well-being in cities, comparative and thematic analyses were used.

Findings: Urban green spaces provide essential ecosystem services across four specific categories. Trees and plants trap dust to improve air quality and reduce temperatures during extreme heat waves, acting as crucial regulating services. These areas sustain rich biodiversity as a supporting service. Parks provide cultural services by offering vital space for relaxation and social interaction. This routine access to nature lowers stress, improves health, and often boosts local property values. Urban greening can also facilitate provisioning services like agriculture right in the city. There are numerous disservices associated with these environments. Issues such as pollen allergies, root damage, pests, and safety concerns require careful management. Balancing these positive and negative realities is exactly what maximizes human well-being and promotes truly sustainable living.

Research limitations/implications: This study relies only on previously published literature, so its conclusions depend on the scope of existing research. Naturally, the results are mirrors of the data and approaches used in previous research. To truly understand the environmental and social reach of green infrastructure, we need to see more empirical research conducted across a wider range of urban environments.

Originality/value: This study synthesizes findings from several scientific sources to highlight the ecological, social, and economic importance of urban green infrastructure. The results make it clear: sustainable urban development and better city life are only possible if ecosystem services become a central part of the planning agenda.

Keywords: urban green spaces; ecosystem services; green infrastructure; urban sustainability; quality of life.

Category of the paper: literature review.

1. Introduction

Urban areas are great places for culture and jobs, but they also use too many global resources. As these zones grow, concrete and asphalt replace natural land. As a result, living spaces become overcrowded, and complex environmental problems begin to emerge. The world is changing fast. More than 50 percent of the global population is currently living in urban areas (Wentworth, 2017). But in Europe, the situation is even more extreme. Today, about 75 percent of the EU population lives in urban areas (Figure 1), which is a huge number considering these environments cover only 24.5 percent of the total land area (Eurostat, 2024). And this number will grow in the next decades.

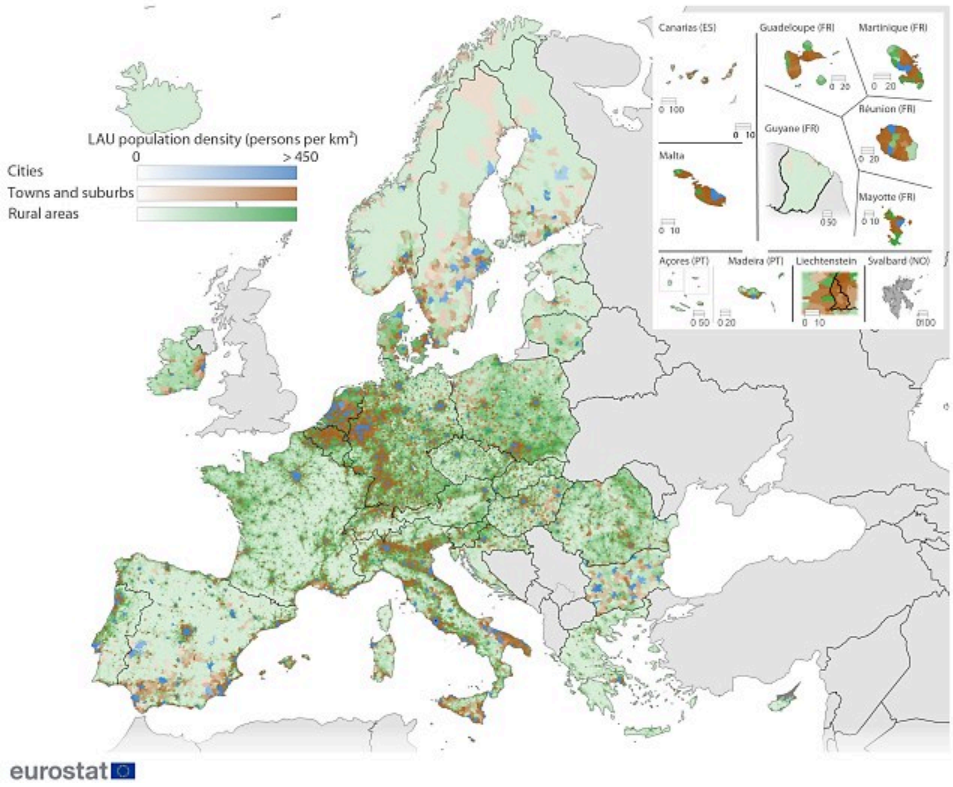


Figure 1. Degree of urbanisation, 2021.

Source: Eurostat (2024).

Life in a big city can be tough on human health because of dirty air, loud noises, and extreme heat during summers. In fact, sickness and mortality rates increase during heatwaves. Chronic stress is another big issue, because it leads to cardiovascular diseases and costs healthcare systems billions of euros every year (Kowarik et al., 2017). However, there are not only physical health problems. Modern urban lifestyles also cause hidden psychological issues, such as depression and social isolation (Bratman et al., 2019; Jennings, Bamkole, 2019). This loss of connection to nature is bad for children, who often experience an "indoor childhood" and do not play outside much (Kowarik et al., 2017).

Fortunately, there is a natural way to fight these urban issues. It is called Urban Green Infrastructure (UGI). Under the term UGI, a network of natural and semi-natural city areas is meant. This includes parks, trees, and gardens. Such locations provide "ecosystem services" to the people. Basically, these are simple benefits that humans obtain from nature, like clean water, climate regulation, or recreation (Breuste et al., 2013). At the local city level, green elements are the main providers of these daily benefits for residents.

How do these services work? Air dust is filtered by trees, and on a hot day, a park can be much cooler than the built-up streets around it. Expensive floods are prevented because natural soils and plants soak up extra rainwater (Kowarik et al., 2017). Furthermore, nature is vital for the social fabric of a city. Green spaces build social cohesion, giving different demographic groups a safe place to meet and interact (Jennings, Bamkole, 2019). Nature is also a strong economic factor. Attractive green areas increase local real estate values and save maintenance costs for governments (Kowarik et al., 2017; Trojanek et al., 2018).

Scientists call certain problems ecosystem disservices. Severe pollen allergies, for example, or tree roots that damage city pavements (Sokolova et al., 2024). There is also the problem of unfair distribution. Fewer parks, more noise, and more pollution are usually found in socially disadvantaged neighborhoods, which creates a clear social problem.

Even with all these good things, cities still destroy green spaces to build new houses or roads. Many city planners only see parks as a maintenance cost. This must change. This research explains why urban green spaces are so important for daily life. It reviews the literature on the different ecosystem services they provide and shows how green infrastructure affects human well-being. Sustainable city development is only possible if ecosystem services become a central part of the urban planning agenda.

2. Theoretical framework and methodology

To better understand how different authors assess urban green spaces, this study uses a qualitative synthesis of existing scientific literature and research reports instead of conducting primary research. Because the selected articles focus on various cities and urban spaces, a wider perspective on the chosen topic is provided.

The principles of transparency and reproducibility were directly taken into account while choosing the literature. The study was mostly based on searches carried out in Google Scholar using the following keywords: "urban green spaces", "ecosystem services", "green infrastructure", and "urban sustainability". Preferably, the studies chosen for review were those published within the last 20 years and available in open-access full-text format. Thus, any reader can easily verify all cited sources without the need for paid subscriptions.

Thematic and comparative methods were applied to analyze the collected data. The first step was to categorize information into specific themes, including climate regulation, health benefits, social impacts, and economic benefits. A comparative method was then used to look at data from different urban spaces after the information was arranged by theme. This helped determine the most significant benefits of green spaces and how they function in various cities.

There are some limitations to this method as well. Because this paper is based entirely on previously published literature, it cannot cover all aspects of a particular topic in specific cities. Moreover, since no primary research was conducted, the findings are limited by the original authors' perspectives. Future primary research methods, such as conducting surveys among local residents, could be used to obtain a wider perspective on the local effects of green spaces.

3. An overview of the literature

Throughout the past few decades, the interest in urban nature has expanded from numerous points of view. The literature indicates significant growth in this area. According to Sokolova et al. (2024), the evolution of this domain has been examined through a bibliometric analysis of scientific articles published since 1995 (Figure 2). Prior to 2010, Green Infrastructure and Ecosystem Services were usually considered as separate and independent concepts. However, later researchers recognized the need to examine both concepts in an integrated manner.

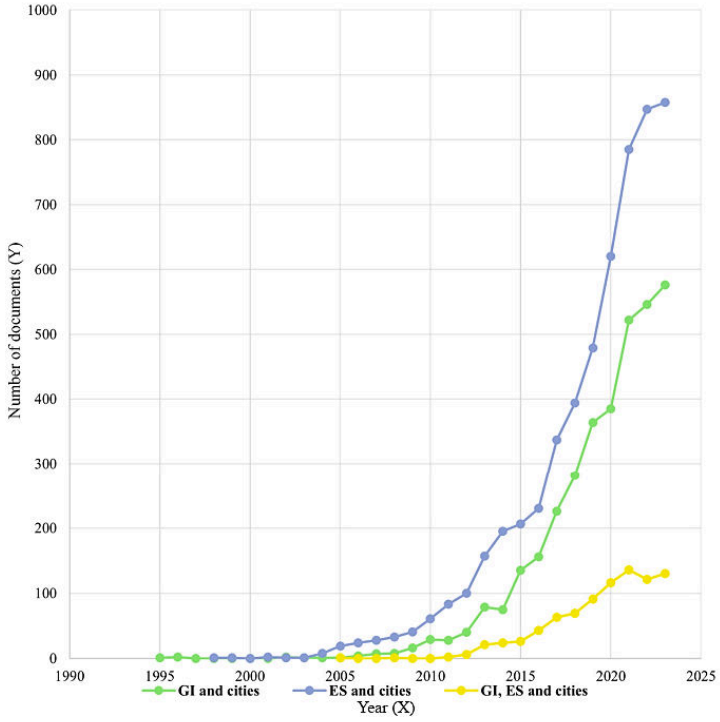


Figure 2. Trend of Green Infrastructure and Ecosystem Services-related publications from 1995 to 2023. Source: Sokolova et al. (2024).

Global research in the contemporary world has focused on human wellbeing, urban resilience, nature based solutions and mitigating climate change (Sokolova et al., 2024). The literature has categorized the services provided by the ecosystem into several types. Four main types of ecosystem services are defined by the TEEB approach: provisioning, regulating, cultural, and supporting services (Breuste et al., 2013; Kowarik et al., 2017; Wentworth, 2017; Coutts, Hahn, 2015). To systematically evaluate the benefits of urban green infrastructure, this study uses these categories as a clear analytical framework linking theoretical concepts to specific empirical indicators. Regulating services include essential environmental controls like temperature reduction, air purification and water absorption (Coutts, Hahn, 2015). Cultural services provide intangible benefits to the population such as psychological restoration, active recreation and social cohesion (Jennings, Bamkole, 2019). Supporting services are necessary to maintain basic ecological functions including soil formation and habitats for urban biodiversity (Hanna et al., 2024). Finally, provisioning services supply direct material goods to city residents, for example fresh food from urban agriculture (Kowarik et al., 2017). Through this structured framework, the numerous empirical studies provided by the literature can be logically organized to show how these services function and directly impact the quality of life in modern cities.

However, the quantification of the benefits provided by these services has proven to be difficult. The measurement of regulating services, such as air cooling and water absorption, is usually done directly using physical measurement tools (Hanna et al., 2024). On the other hand, the evaluation of cultural services has proven to be more difficult, as it relies heavily on human perceptions and subjective surveys (Bratman et al., 2019; Hanna et al., 2024). A bias has also been observed in the literature. For a long time, large urban parks and forests were the main focus of research. Moreover, the literature often ignored small green infrastructure such as green roofs, wetlands, and sports facilities (Sokolova et al., 2024). The contemporary literature is now trying to examine the functioning of green infrastructure as a whole (Stangl et al., 2022).

For example, regulating services are crucial because city environments are often very stressful. They have too much concrete and asphalt. This increases the temperatures in these regions compared to those in the surrounding rural areas. This effect is referred to as the urban heat island effect (World Health Organization, Regional Office for Europe, 2016). For example, Wentworth (2017) shows that temperatures in central London are 5 degrees Celsius higher than in the surrounding rural areas. This high heat increases the risk of heat-related diseases. In fact, Kowarik et al. (2017) indicate that in Berlin, heat stress contributes to 4-5 percent of total deaths. In contrast, trees and green spaces have the advantage of reducing air temperatures (Figure 3). It is notable that a park with a width of 50-100 meters is 3-4 degrees cooler than the streets surrounding it during hot weather (Kowarik et al., 2017; Meili et al., 2021). Air pollution is another major concern in the literature. In the United Kingdom, vehicle emissions form the major cause of air pollution in urban areas (Wentworth, 2017). Green spaces have the advantage

of filtering pollutants in the air. For example, dense tree avenues can reduce air pollution by 15 percent (Kowarik et al., 2017). Ineffective planning of spaces in urban areas can actually increase exposure to air pollution. Specifically, poorly planned street trees can trap dirty air and make pollution worse (Wentworth, 2017). In this case, it is apparent that low hedges are often more effective than tall trees in improving air quality in major roadways.

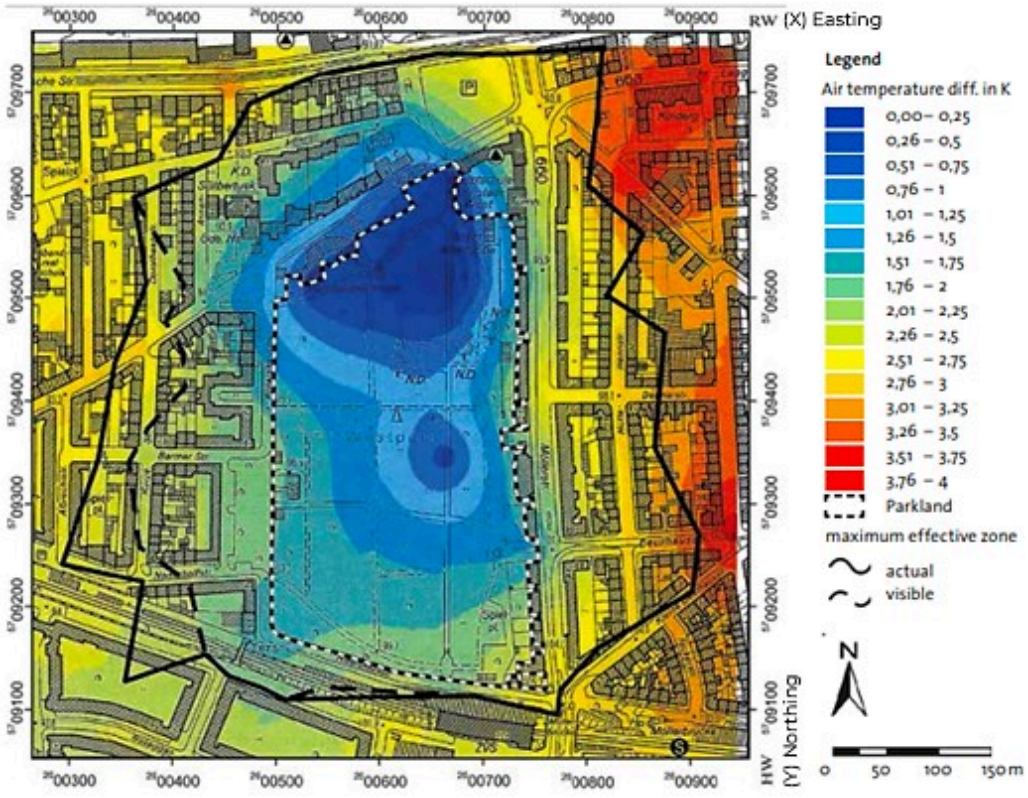


Figure 3. Lower night air temperatures in a Dortmund park and their effects on the environment. The differences refer to the coldest point on the north edge of the park.

Source: Bongardt (2006), as cited in Kowarik et al. (2017).

Another important issue is water management (Coutts, Hahn, 2015). Heavy rain often floods city streets. Hanna et al. (2024) did a big study in Zaragoza, Spain. They evaluated how various green spaces regulate water. They found that "imperviousness", which means hard surfaces like asphalt, is the main reason why water regulation fails in cities. During heavy rain, these hard surfaces block water infiltration and become a major source of runoff pollution (Zhao, Ma, 2019). To overcome this problem, Sustainable Drainage Systems can be implemented, as suggested by Wentworth (2017), Hanna et al. (2024), and Hoffmann et al. (2015). Such natural interventions will not only control flooding but will also reduce the expenses for the government.

Beyond physical conditions, psychological well-being is a major theme in recent studies. In modern cities, mental health problems are growing. A large review by Bratman et al. (2019) explains that contact with nature works as a "psychological ecosystem service". Sleep problems, high anxiety, and depression are significantly reduced when people spend time in green

environments. To measure this practically, scientists often use specific rules. For example, the new 3-30-300 green space rule was recently tested in Barcelona by Nieuwenhuijsen et al. (2022). According to this rule, every person should see three trees from their window, live in a neighbourhood with 30 percent tree cover, and be only 300 meters away from a park. Sadly, only about 4.7 percent of people met all these criteria in the Barcelona study. However, the results were very clear. When the full rule was met, people visited psychologists or psychiatrists much less. Also, they used fewer antidepressant medications. Daily nature contact acts as a strong medicine (Bratman et al., 2019; Chen et al., 2021).

Social networks are significantly affected by urban greenery. By taking simple walks in a park, communities build social capital and trust. Jennings and Bamkole (2019) highlight that green spaces support social cohesion. They provide a secure environment where different people can meet and feel a sense of belonging (Chen et al., 2021). This naturally reduces social isolation. Breuste et al. (2013) offer empirical evidence on how this works in several global cities. In Buenos Aires, people visit parks mostly to relax and relieve stress. Once there, visitors usually spend over two hours sitting or walking. In fact, a large number of residents use these green spaces on a daily basis. For almost half of the respondents, visiting the local park is their most important free-time activity. However, these visitors focus much more on basic cleanliness and security than on the actual trees and plants. The majority of people travel less than 500 meters to access these green spaces (Figure 4). This shows that local neighborhood parks are the most useful. In Shanghai, public parks offer the urban population a rare chance to observe and learn about nature. Without these accessible green zones, building a cohesive and healthy community becomes very difficult. Because daily access is so critical, the physical distance from home plays the biggest role.

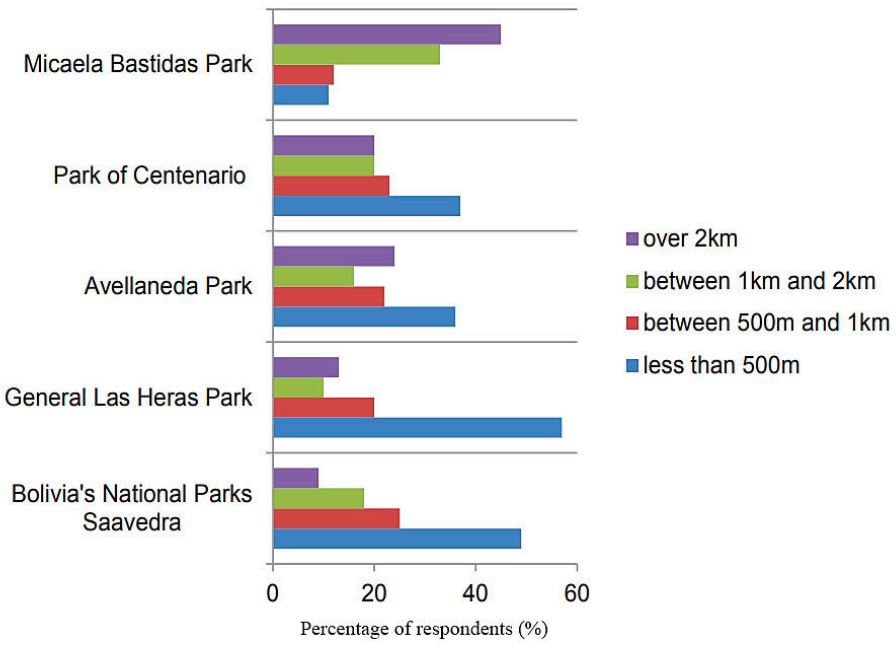


Figure 4. Distance from where the visitors came to the parks in Buenos Aires.
Source: Breuste et al. (2013).

Urban environments offer habitats for many wild animals, and green spaces become vital to ensure high biodiversity. Breuste et al. (2013), for instance, assessed 19 public parks in Linz, Austria by means of breeding bird populations as a measure of environmental quality. As shown in their research findings, the park with mature trees and a wild forest area had 37 bird species, while the smallest one and the most disturbed hosted only one species. Therefore, such factors as park size and level of human disturbance play a significant role in ensuring the diversity of species in these sites. In addition to being a habitat for birds, urban green infrastructure provides an environment for important insect pollinators, such as bees. According to Coutts and Hahn (2015), pollination is a key aspect of ecosystem services. However, an important drawback associated with this issue is the lack of awareness among a vast majority of the population. Breuste et al. (2013) found in their Shanghai case study that park users were primarily motivated by recreation rather than the acquisition of ecological knowledge. At the same time, people have a special emotional relationship towards urban parks, which may be transformed into useful ecological knowledge through effective educational activities.

Provisioning services associated with food production have been discussed in the literature. There is growing interest in urban food production. In London, 21 tonnes of food were produced through urban farming in 2013, as stated in Wentworth (2017). Although this is a small quantity for a big city, community gardens have other benefits. In urban farming, people tend to eat more vegetables and also increase their level of physical activity (Wentworth, 2017). In Germany, 50 percent of fruits and vegetables for households with allotment gardens are provided by their gardens (Kowarik et al., 2017). In addition, gardening programs help children learn about healthy diets. The "Vegetable Academy" in Germany is described in Kowarik et al. (2017), where school children learn to grow and prepare vegetables (Figure 5). Children today do not know much about their food, but by growing and harvesting their own food, they develop a stronger understanding of nature, which may help them fight obesity and develop social skills.



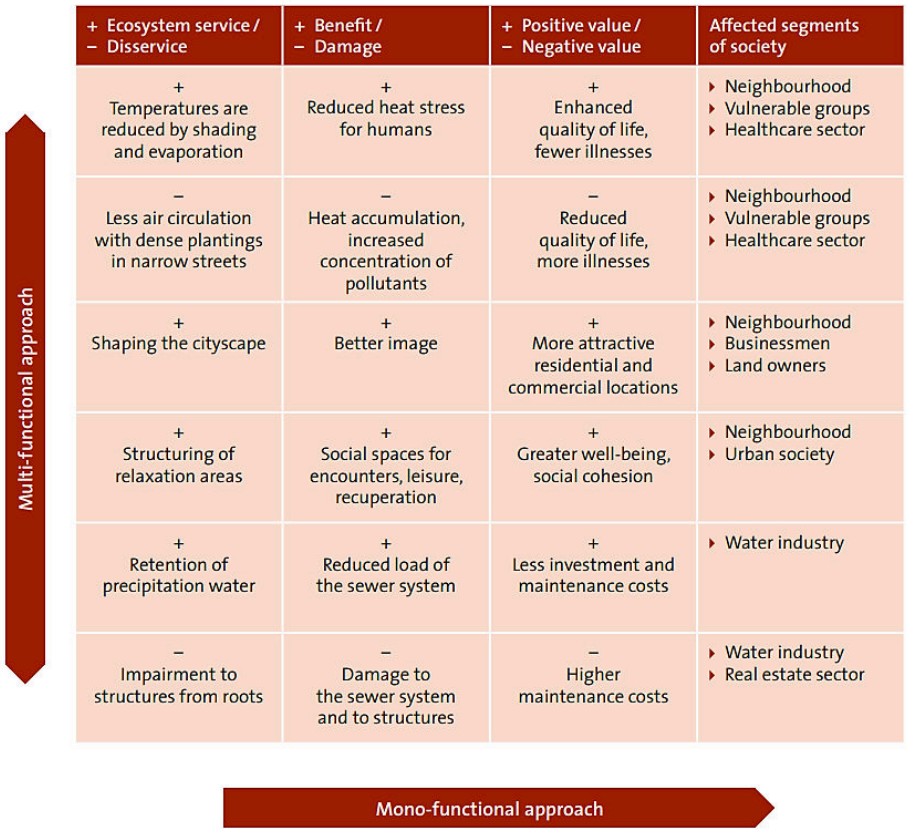
Figure 5. A litter-strewn wasteland at Moritzplatz in Berlin-Kreuzberg (left) was transformed into the "Princess Gardens" (right). (Photographs: Marco Clausen).

Source: Kowarik et al., 2017.

Nature is not always perfect. The scientific literature also looks at ecosystem disservices. These are the negative effects that nature can have on city life. Sokolova et al. (2024) state that researchers must study these negative sides to make smart planning decisions. What are these disservices? Some plants cause severe pollen allergies for residents. Tree roots can break pipes and damage the asphalt on roads. Additionally, new green spaces can accidentally introduce invasive species that displace local plants (Sokolova et al., 2024). Also, Wentworth (2017) notes that urban environments can have dangerous pests or diseases. Sometimes, people are simply afraid of dark, overgrown parks because of crime. Because of this fear, local communities might avoid these areas completely (World Health Organization, Regional Office for Europe, 2016). To fix this, city authorities must hold open discussions with residents to ensure these negative effects remain tolerable (Wentworth, 2017). Planners need to balance these negative things with the positive benefits.

Why do city planners often destroy parks to build new houses? Because they usually see green spaces as a financial cost, not as an asset. But the literature proves that nature has real economic value (Xu, Zhao, 2021). Urban nature is a strong location factor. Companies want to open offices in green, attractive cities. Having natural grounds around an office saves maintenance costs and creates a positive "green address" for the business (Kowarik et al., 2017). This green environment directly improves employee motivation and work performance. Also, green spaces increase the price of local real estate (Chen et al., 2022). A study in Cologne showed that moving 100 meters closer to a park increases an apartment's price by about 600 euros (Kowarik et al., 2017). Furthermore, living near a park makes people happier. Statistically, one extra hectare of green space in a neighborhood gives people a feeling of satisfaction equal to 276 euros of extra annual income (Kowarik et al., 2017).

Other European data also show this economic impact. In Warsaw, Trojanek et al. (2018) analyzed over 43,000 apartment sales. They found that an apartment less than 100 meters from a green area costs about 2.8 to 3.1 percent more. But distance really matters. The price bonus drops significantly after 200 meters. Beyond 400 meters, it completely disappears (Trojanek et al., 2018). Interestingly, this price premium is much higher for modern apartments constructed after 1989. New housing estates usually have too much concrete, so buyers highly value nearby public parks. Some cities adopt new policies to protect these spaces. Stauffer and Chagnon (2025) describe "Warsaw's Green Vision" and Budapest's "pocket parks" as great examples of this. These projects aim to bring nature back into crowded zones. The Hungarian pocket parks cover only about 1400 square meters. Yet, they successfully combine recreation with community food production (Stauffer, Chagnon, 2025). Even with such progress, many local planning authorities still lack ecological experts on their staff. In England, fewer than 35 percent of local councils actually employ an in-house ecologist (Wentworth, 2017). This highlights the need for a more comprehensive approach to managing urban greenery, moving from individual benefits to integrated multifunctional systems (Figure 6).



Source: Kowarik et al., 2017.

Figure 6. Approaches to city tree ecosystem services. Compares monofunctional (individual benefits) and multifunctional (synergies/trade-offs) methods. List of examples is not exhaustive.

The literature review also points out important gaps in current research. Sokolova et al. (2024) highlight a major problem. While large parks and forests are frequently studied, other green components like green roofs, sports facilities, and wetlands are often completely ignored. Because of this, stakeholders cannot fully comprehend the value of these alternative spaces. Hanna et al. (2024) observe that numerous projects currently concentrate heavily on green spaces inside dense urban cores. To overcome this, an increase in studies on peri-urban areas is strongly proposed, since these transition zones between city and country are critical for mitigating climate change. Another big challenge is measuring highly subjective cultural ecosystem services. To get a comprehensive understanding of urban sustainability, physical measurements must be combined with social and economic data (Sokolova et al., 2024).

4. Results of the investigation

A comparison of different scientific studies shows how urban green spaces work in reality. The results indicate that green infrastructure provides various ecosystem services depending on its location, size, and level of naturalness. Several city case studies illustrate these patterns.

Climate and water regulation are highly dependent on the design of the city (Hoffmann et al., 2015; Zhao, Ma, 2019). In Karachi, Pakistan, rapid growth occurred. According to Breuste et al. (2013), the built-up area increased massively between 1986 and 2003. At the same time, green coverage decreased from 111 to 75 sq. km. As a result, temperatures rose by up to 4°C. Small parks could not provide adequate air cooling due to the blocking effect of tall concrete structures (Breuste et al., 2013). The results of research in Zaragoza, Spain, prove this negative effect of concrete construction. By conducting tests on 30 green sites, Hanna et al. (2024) concluded that "imperviousness", or the surface covered with materials such as asphalt, is the core factor causing the ineffectiveness of climate and water regulation. Meanwhile, sites characterized by high naturalness and ecological functions provided more effective water supply and temperature cooling (Hanna et al., 2024). Nowadays, local authorities implement various initiatives to overcome dangerous urban heat islands. The threat is deadly: in Berlin alone, extreme heat causes about 4 to 5 percent of all mortalities (Kowarik et al., 2017). Furthermore, across Europe, up to 43,000 deaths could be prevented simply by meeting standard green space recommendations (Stauffer, Chagnon, 2025). For example, when adapting to heat waves in urban areas, Munich introduced temporary measures involving "walking tree alleys", while Basel adopted mandatory green roofs in new constructions to cut down energy use (Stauffer, Chagnon, 2025; Nasr et al., 2024). These practical solutions perfectly demonstrate the value of alternative green infrastructure that previous studies overlooked. The adoption of such sophisticated solutions, nevertheless, depends on the economic environment in which they are to be implemented. As far as affluent urban centers like Basel are concerned, it is relatively easy to mandate expensive strategies like green roofs. These interventions, however, may often prove beyond the financial reach of urban areas still growing economically (Breuste et al., 2013). In cases where cities lack sufficient resources, it becomes imperative to resort to more accessible options. Solutions which are both simple and highly efficient, like planting street trees and preserving local woodlands, become common practice (Kowarik et al., 2017).

One other equally important feature is whether city parks do indeed support wildlife. And the answer lies totally within the structure of the park itself. As noted by Breuste et al. (2013), in a study conducted across 19 public parks in Linz, Austria, the number of breeding birds was used as an index for biodiversity. The outcome of the research was unambiguous. With a size of 9.5 hectares, old trees, and patches of wild forests, the top park hosted 37 species of birds. But the worst park was very small and highly disturbed by human activity. It had only 1 bird species. This clearly shows that park size and human disturbance directly control urban biodiversity (Breuste et al., 2013). Furthermore the supporting services provided by these habitats yield immense economic value. For example the annual economic value of the pollination service that bees alone provide is estimated at 14.6 to 40 billion dollars in the United States (Coutts, Hahn, 2015).

In addition to physical and ecological factors, some interesting behavioral and mental health trends were uncovered by the findings. High urban density correlates positively with psychological stress. As stated by Bratman et al. (2019), access to nature can be viewed as a certain "psychological ecosystem service". But how much greenery do people actually need to feel better? To solve this problem, Nieuwenhuijsen et al. (2022) tested the new 3-30-300 green space rule on Barcelona residents. Under this guideline, a person should be able to see three trees from their home, have 30 percent tree canopy cover in their neighborhood, and live within 300 meters of a park. In the Barcelona study, only 4.7 percent of people met all these criteria. However, when the full rule was met, residents used less antidepressant medication. Also, their visits to psychiatrists or psychologists dropped significantly (Nieuwenhuijsen et al., 2022).

Social connections also grow stronger in green areas. Jennings and Bamkole (2019) report that urban parks create safe spaces where diverse groups interact. This builds social capital and reduces isolation. Distance is a very important factor for these visits. In Buenos Aires, Argentina, Breuste et al. (2013) interviewed park visitors. They found that most people walked less than 500 meters to get to their local park. Once there, the majority stayed for more than two hours. Many people visited every single day.

To fully understand these behavioral patterns, they must be integrated into a broader conceptual model of interaction between humans and nature proposed by Bratman et al. (2019). According to this framework, the actual psychological benefits depend heavily on the specific experience and the environmental awareness of the user. For instance, perceived safety and upkeep strongly moderate the relationship between natural features and park exposure. This perfectly explains why visitors often care more about cleanliness and security than about natural elements like plants (Breuste et al., 2013). Furthermore, the interaction model suggests that the delivered dose of nature is affected by the individual attitudes and receptivity of the people (Bratman et al., 2019). This theoretical concept is supported by empirical findings from Shanghai, where a study by Breuste et al. (2013) showed that most people visit parks primarily for psychological restoration and to escape the crowded city. Since engaging with biodiversity depends on previous environmental education, the educational potential of these spaces is frequently ignored. As a result, about 37 to 53 percent of visitors admit they never use the park to learn about nature.

Synthesized data shows that environmental and social benefits translate into real economic results. Natural capital directly saves money for local governments (Kowarik et al., 2017; Xu, Zhao, 2021). Natural drainage systems prevent expensive floods (Stangl et al., 2022; Hoffmann et al., 2015; Wentworth, 2017), while billions of euros are saved on healthcare by lowering stress and respiratory diseases (Kowarik et al., 2017; World Health Organization, Regional Office for Europe, 2016; Roe et al., 2013). Furthermore, this economic impact extends directly to the real estate market (Chen et al., 2022). In Warsaw, Trojanek et al. (2018) analyzed over 43,000 apartment sales. An urban green area within 100 meters increases an apartment's price

by 2.8 to 3.1 percent. This price premium is significantly amplified for newer apartments built after 1989. Since modern concrete housing estates lack natural elements, an extra 8.0 to 8.6 percent is willingly paid by buyers for homes near public urban green areas (Trojanek et al., 2018).

Based on the findings presented in the scientific literature concerning various ecosystem disservices, it becomes evident that the negative aspects of urban green infrastructure should not be ignored in favor of positive ones. While green spaces help in mitigating climate change, they are capable of exerting physical pressures on urban infrastructure as well. In this regard, tree roots tend to damage pavement and penetrate into underground sewage systems, causing considerable economic problems for both water utilities and real estate developers (Kowarik et al., 2017). Apart from that, negative health outcomes can arise from the presence of green spaces as well. There is no doubt that certain tree species produce large amounts of pollen that can trigger asthma and allergies. Additionally, natural spaces can serve as hosts for vectors of certain diseases such as ticks and mosquitoes, which results in a higher prevalence of conditions such as Lyme disease within the area (World Health Organization, Regional Office for Europe, 2016). Lastly, the benefits of social interaction in green spaces can be hindered by issues of safety. The overgrowth of plants may cause anxiety due to the fear of crime, hence discouraging the elderly, women, and ethnic minorities from using parks (World Health Organization, Regional Office for Europe, 2016). In this regard, to counteract the undesirable aspects of the ecosystem and improve the positive ones, the following measures should be taken by park management: planning the space to reduce pollen exposure, installing proper lighting systems, and conducting regular maintenance to prevent vegetation overgrowth.

In order to give a complete overview of the available research, the empirical findings and their corresponding indicators from the literature were systematized using the TEEB framework discussed earlier. These results have been provided in Table 1.

Table 1.
Summary of main empirical findings by ecosystem service category

ES Category	Indicator	Main Findings	Reference
Regulating	up to 4 degrees Celsius rise	loss of greenery caused extreme heat islands in Karachi	Breuste et al. (2013)
Regulating	30 green sites analyzed	impervious surfaces reduce climate and water regulation in Zaragoza	Hanna et al. (2024)
Regulating	4 to 5 percent of mortality	extreme heat increases death rates in Berlin	Kowarik et al. (2017)
Regulating	3 to 4 degrees Celsius lower temperatures	parks measuring 50 to 100 meters wide effectively cool surrounding streets during hot weather	Kowarik et al. (2017)
Regulating	up to 15 percent reduction in particulate matter	dense tree avenues effectively filter particulate matter from the air	Kowarik et al. (2017)
Regulating	43 000 prevented deaths	impact of meeting green space recommendations across Europe	Stauffer and Chagnon (2025)
Regulating	11.7 percent mortality reduction	green infrastructure reduces heat related deaths in Sydney	Stauffer, Chagnon (2025)

Cont. table 1.

Cultural	8.0 to 8.6 percent price increase	observed for newer apartments (built after 1989) located within 100 meters of an urban green area in Warsaw	Trojanek et al. (2018)
Cultural	2.8 to 3.1 percent price increase	observed for all apartments located within 100 meters of an urban green area in Warsaw	Trojanek et al. (2018)
Cultural	almost 600 euros price increase	observed for apartments located 100 meters closer to a park in Cologne	Kowarik et al. (2017)
Cultural	276 euros income equivalent	extra hectare of green space increases life satisfaction equivalently	Kowarik et al. (2017)
Cultural	Less than 500 meters distance	crucial threshold for daily park visits in Buenos Aires	Breuste et al. (2013)
Cultural	4.7 percent of residents meet the 3-30-300 rule	meeting the rule significantly reduces visits to psychologists or psychiatrists in Barcelona	Nieuwenhuijsen et al. (2022)
Cultural	37 to 53 percent of visitors	visitors primarily seek rest ignoring educational potential of parks	Breuste et al. (2013)
Supporting	37 versus 1 bird species	larger natural parks boost urban biodiversity in Linz	Breuste et al. (2013)
Supporting	14.6 to 40 billion dollars	annual economic value of pollination services provided by bees in the United States	Coutts, Hahn (2015)
Provisioning	21 tonnes of food	urban farming supplied fresh food in London in 2013	Wentworth (2017)
Provisioning	50 percent self sufficiency in fruit and vegetables	allotment gardens provide half of the required produce for gardening households in Germany	Kowarik et al. (2017)
Provisioning	1400 square meters	pocket parks integrate community food production in Budapest	Stauffer and Chagnon (2025)

Note. ES refers to Ecosystem Service. Indicator refers to the specific empirical metric used to quantify the service's impact as identified in the reviewed studies. Higher property values serve as an indicator of cultural services, reflecting residents' willingness to pay for the aesthetic and recreational amenities that local green spaces provide.

Source: own work based on the literature review.

Urban planning needs real changes. Large forests and regular parks are simply not enough anymore. To actually deliver ecosystem services, smaller components like green roofs, wetlands and sports areas must be incorporated into dense neighborhoods (Sokolova et al., 2024; Nasr et al., 2024). The solution is clear. Cities should reduce impervious areas to protect natural soils. Vital green spaces must be located very close to residential areas. Without this approach, future health problems cannot be avoided.

5. Conclusions

In modern cities, urban green spaces must be viewed as a basic survival tool rather than simple decoration. As the urban population grows, routine nature contact is lost completely. Cities face extreme heat, dirty air, and heavy flooding. Fortunately, these dangerous problems can be fixed by ecosystem services to improve human quality of life significantly. The comparative analysis of the literature allows drawing several overarching conclusions:

1. *The physical quality of green spaces matters*. Planting a tree in a small hole surrounded by asphalt is not enough (Stangl et al., 2022). Too much concrete ruins water regulation, as Hanna et al. (2024) proved. To protect cities from floods and heat, impervious surfaces must be reduced. Also, the "naturalness" of urban soils and plants needs to increase. A mix of different green areas is required. Often, scientists focus only on large forests. However, green roofs, wetlands, and sports areas are just as important for urban sustainability (Sokolova et al., 2024; Nasr et al., 2024). Small spaces work well. Budapest created "pocket parks" to bring nature back into dense city zones (Stauffer, Chagnon, 2025).
2. *Green infrastructure regulates climate and air quality.* Urban environments suffer from the heat island effect. These elevated temperatures pose severe health hazards (Coutts, Hahn, 2015). According to Kowarik et al. (2017), about 4 to 5 percent of all deaths in Berlin are linked to extreme heat. Trees and parks help lower the temperature (Meili et al., 2021; Reis, Lopes, 2019). In the Sydney area, green infrastructure could reduce daily mortality from heat by up to 11.7 percent (Stauffer, Chagnon, 2025). Vegetation also acts as a crucial filter. Particulate matter pollution kills around 47,000 people per year across Germany. Urban trees could reduce these pollution levels by up to 15 percent (Kowarik et al., 2017). Bad planning makes things worse. Pollutants are actually trapped by poorly planned street trees along busy roads (Wentworth, 2017). For air quality next to big roads, low hedges are sometimes a much better choice.
3. *Distance and accessibility control human health*. If a park is too far away, people do not visit it. The World Health Organization recommends that residents should have access to at least 0.5 hectares of green space within 300 meters from home (Stauffer, Chagnon, 2025). Recently, researchers tested the 3-30-300 rule. According to Nieuwenhuijsen et al. (2022), every person should see three trees from home, have 30 percent tree cover in the neighborhood, and live within 300 meters of a park. When this rule is met, mental health gets much better. Also, Bratman et al. (2019) define nature contact as a strong "psychological ecosystem service". Regular nature visits lower stress and reduce the use of antidepressant medication (World Health Organization, Regional Office for Europe, 2016; Roe et al., 2013). Because healthy people cost less, healthcare systems save a huge amount of money every year (Kowarik et al., 2017). Therefore, giving everyone equal access to nature is a matter of social justice.
4. *Size and human disturbance affect urban biodiversity.* Many wild animals can live in urban parks. As seen in Austria, large parks with mature trees hosted 37 different bird species, whereas small, highly disturbed areas supported only one (Breuste et al., 2013). There is, however, a wide gap between this ecological reality and what residents perceive. Given that most people view parks in terms of recreational activities and ignore their ecological features, city governments need to make use of such settings to

impart knowledge of ecological systems to the citizens (Breuste et al., 2013; Kowarik et al., 2017).

5. *Urban nature builds communities and provides food*. Community gardens do much more than agriculture. Different social groups are brought together in these places. By working in a garden, residents build social capital and strong place attachment (Jennings, Bamkole, 2019; Chen et al., 2021). This naturally reduces social isolation. Growing food in the city also teaches people about healthy diets. Gardening projects fight obesity and help children escape an "indoor childhood", as Kowarik et al. (2017) highlight.
6. *City planners must be realistic about ecosystem disservices.* Nature has a negative side too. Tree roots can penetrate underground sewage systems and cause structural damage. This directly leads to higher maintenance costs for local authorities and the real estate sector (Kowarik et al., 2017). As the World Health Organization, Regional Office for Europe (2016) noted, unmanaged vegetation can increase anxiety due to fear of crime among vulnerable populations like older people, women and ethnic minorities. They also highlighted the real risk of vector-borne conditions such as Lyme disease spreading through ticks and mosquitoes in these areas. Furthermore, pests can live in urban environments, and severe allergies and asthma can be triggered by some plants (Wentworth, 2017; World Health Organization, Regional Office for Europe, 2016). Poorly planned street trees can even trap vehicle emissions and worsen local air quality (Wentworth, 2017). New green spaces might also accidentally introduce invasive species that displace local plants (Sokolova et al., 2024). These negative effects must be considered by planners. Ignoring these environmental and social issues can potentially lead to community resistance against new green projects (World Health Organization, Regional Office for Europe, 2016). Balancing both the benefits and the negative effects is necessary to make safe decisions, as Sokolova et al. (2024) noted.
7. *Nature is a basic public service, not a financial burden.* Urban green spaces are a highly valuable part of natural capital (Chen et al., 2022). In Cologne, reducing the distance to a park by 100 meters increases an apartment price by almost 600 euros (Kowarik et al., 2017). According to Trojanek et al. (2018), an urban green at a distance of less than 100 meters increases the price of an apartment in Warsaw by 2.8 to 3.1 percent. This financial premium steadily declines as the distance increases and completely disappears beyond 400 meters. Furthermore, this value is significantly amplified for newer housing. Buyers willingly pay an extra 8.0 to 8.6 percent for modern homes built after 1989 and located less than 100 meters from an urban green. However, many local authorities still lack ecological experts on their staff (Wentworth, 2017). This critical gap must be closed. The true economic value of nature should be calculated directly in city budgets (Xu, Zhao, 2021). Because green infrastructure is not considered a luxury, ecosystem services belong at the heart of all future urban planning (Kowarik et al., 2017).

The study demonstrates that urban greening contributes significantly to all four categories of ecosystem services, with regulating and cultural benefits being the most frequently reported in the reviewed literature. The worldwide relevance of green infrastructure in the context of urbanization cannot be questioned. However, the techniques applied to it cannot be identical everywhere. Modern urban development must consider urban morphology and different stages of economic development. Advanced and expensive technologies like green roofs and complex living walls will have the maximum efficiency in developed cities like Basel (Nasr et al., 2024; Stauffer, Chagnon, 2025). They also play an integral part in sustainable urban drainage systems. These installations retain rainwater and significantly reduce the load on traditional municipal sewers (Hoffmann et al., 2015). On the other hand, rapidly growing cities and less economically developed regions need to focus on cost effective nature-based strategies. The protection of existing local forests and the planting of street trees will be among the most efficient actions for these locations (Breuste et al., 2013). Urban ecosystem initiatives also require customization to specific local conditions. High-density historical centers and modern concrete residential areas will benefit greatly from compact green infrastructure like pocket parks (Stauffer, Chagnon, 2025). At the same time, peri-urban areas will need extensive green infrastructure systems for mitigating climate change effects (Hanna et al., 2024). In order to achieve sustainable urban development, experts may incorporate regional geographic location, climatic conditions, and socio-economic factors in urban planning. Such an intentional approach is, according to Kowarik et al. (2017), a key determinant of high residential quality of life.

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SAFETY MANAGEMENT OF MARITIME TRAFFIC EFFECTS ON BALTIC NUCLEAR INFRASTRUCTURE

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Purpose: The aim of this article is to assess the impact of maritime traffic on the safety of a planned nuclear power plant located in the coastal zone of the Baltic Sea and to develop the principles of an integrated safety management system supporting decision-making processes in the field of critical infrastructure. The starting point is the assumption that the safety of a nuclear power plant in a coastal location should be considered not only in technical terms, but also as a management issue requiring data integration, risk assessment and the coordination of actions by multiple stakeholders.
Design/methodology/approach: The study utilised AIS data to reconstruct vessel trajectories, identify main traffic corridors and assess the fleet structure in the Lubiatowo–Kopalino area. Measurement sections LEG 1–LEG 7 and probabilistic modelling using the IALA IWRAP Mk2 software were applied. The results obtained were interpreted from a safety management perspective, with particular emphasis on the organisation of monitoring, the identification of high-risk zones and emergency response procedures.
Findings: The study showed that maritime traffic in the analysed area is highly spatially varied and concentrated in corridors running parallel to the coastline. The highest traffic intensity was recorded in the LEG 2 area, dominated by general cargo vessels and oil product tankers. IWRAP modelling confirmed that overtaking scenarios are the dominant hazard scenario, whilst the risk of head-on collisions remains relatively low. The results indicate that despite the power plant not being located directly on the main shipping route, its safety remains dependent on the indirect impacts of transit traffic.
Research limitations/implications: A limitation of the study is the use of AIS data and a probabilistic model that does not account for a full analysis of event consequences. Further research should cover the consequence component, extreme scenarios and the impact of variable hydrometeorological conditions on the level of risk.
Practical implications: The article outlines directions for the development of an integrated safety management system, encompassing AIS, radar and VTS monitoring, risk analysis and

response procedures. The results may assist maritime authorities, infrastructure operators and safety stakeholders in designing safety zones and organising traffic around strategic facilities.
Social implications: The study contributes to the debate on the safety of the energy transition and the social acceptance of nuclear investments. It demonstrates that effective security management of critical infrastructure requires a systemic, transparent and data-driven approach.
Originality/value: The originality of the article lies in combining maritime traffic analysis, probabilistic risk assessment and perspectives from management and quality sciences in relation to a planned nuclear power plant in Poland. The value of the work lies in demonstrating how analytical tools can support security management in organisations responsible for the operation of critical infrastructure.
Keywords: safety management; critical infrastructure; nuclear power plant; AIS; navigational risk.
Category of the paper: Research paper.

1. Introduction and Literature Review

The nuclear energy used in nuclear power stations is based on the process of nuclear fission, in which a neutron triggers the breakdown of a heavy element's nucleus, leading to the release of significant amounts of thermal energy. This process is a chain reaction, as it results in the emission of further neutrons capable of triggering subsequent reactions (Brennen, 2005; Todreas, Kazimi, 2011). The stability of reactor operation depends on maintaining a controlled chain reaction, described by the neutron multiplication factor k, which in a critical state takes the value of one (IAEA, 2016). In power generation, enriched uranium containing the U-235 isotope is used; its natural abundance in uranium ore is low, which necessitates enrichment processes, most commonly using gas centrifuges (World Nuclear Association, 2023). To increase the efficiency of the reaction, moderators such as water or graphite are used, which slow down the neutrons and increase the probability of fission (Duderstadt, Hamilton, 1976). The energy released in a nuclear reactor is mainly in the form of heat, which is absorbed by the coolant and transferred to the secondary system, where steam is generated to drive the turbines. Despite the advanced nature of nuclear technology, the final stage of electricity production is based on a classic thermodynamic cycle, analogous to that of conventional power stations (Brennen, 2005).

One of the key elements in the operation of nuclear power plants is the cooling system, which is responsible both for removing heat from the reactor and for maintaining safe operating conditions at the plant. Nuclear power plants are facilities with very high water requirements, and their location is heavily dependent on the availability of a stable cooling source (IAEA, 2016; World Nuclear Association, 2023; Macknick et al., 2012). In particular, for coastal power stations, a significant operational risk is posed by phenomena involving the blockage of cooling water inlets by biological material or suspended solids, which can lead to a reduction in the efficiency of cooling systems and pose a real risk to plant safety (Lin et al., 2023).

The importance of water resources in nuclear energy is also emphasised in the context of sustainable development. Nuclear power plants are among the most water-intensive facilities in terms of water usage, which requires the implementation of modern technological solutions to enhance water management efficiency and minimise environmental impact (Jayabal, 2025). In this context, locating power stations near large bodies of water, such as seas and oceans, enables efficient heat dissipation and stabilisation of the cooling system's operation. At the same time, the operation of nuclear power stations in a marine environment is associated with thermal impacts on coastal ecosystems. Long-term studies indicate that the discharge of heated water may affect local hydrological conditions and the biological structure of the marine environment, which should be taken into account in site selection and environmental assessments (Zhang et al., 2022).

An example of a nuclear power plant utilising the advantages of a coastal location is the plant in Greifswald (Lubmin), which operated using VVER-440 reactors (GRS, 1992). This system employed a multi-circuit cooling system in which seawater was used to remove heat from the condensers and to support auxiliary systems. The primary circuit was responsible for directly cooling the reactor core, whilst the secondary circuit enabled steam production and turbine drive. In addition, there were component cooling systems and emergency systems, such as the ECCS, ensuring safety in the event of a coolant loss (GRS, 1992).

For nuclear power plants located in coastal areas, maritime traffic is also a significant external factor, as it may pose a risk of collision, vessel drift or accidents in the vicinity of critical infrastructure. The literature emphasises that the analysis of vessel traffic based on AIS data is an effective tool for assessing navigational safety and identifying potential hazards (Goerlandt, Kujala, 2014; Montewka et al., 2012). The highest risk of collision occurs in areas with high traffic density and during overtaking manoeuvres resulting from speed differences between vessels (Goerlandt, Kujala, 2014).

A review of the literature indicates that the location of nuclear power plants in coastal zones is primarily determined by access to water resources, which are essential for the efficiency and safety of cooling systems. At the same time, the presence of maritime traffic in such areas constitutes a significant risk factor, requiring the use of advanced analytical methods and safety management systems. The integration of AIS data with probabilistic models is currently one of the key approaches in assessing navigational risk in areas of critical infrastructure.

2. Study Aea and Context

2.1. Planned location of a nuclear power plant in the vicinity of the Baltic Sea

The study area covers the site of the planned first nuclear power plant in Poland, situated in the Lubiatowo–Kopalino region, in the municipality of Choczewo (Pomeranian Voivodeship), in the immediate vicinity of the Baltic Sea. This site was officially designated under the Polish Nuclear Power Programme (PPEJ) as the construction site for the country's first facility of this type (Ministry of Climate and Environment, 2023).

The choice of this location was not accidental – it resulted from a comprehensive analysis that took into account environmental, technical and social factors. As research indicates, the siting of a nuclear power plant is based on a multi-criteria analysis, covering, among other things, environmental, infrastructural and socio-economic aspects (Susiati et al., 2025). Furthermore, this process may involve anywhere from a few to as many as several dozen detailed criteria, which are divided into biophysical, social and regulatory groups (Dede et al., 2024).

One of the most important factors determining the choice of location was the availability of water for cooling the reactors. Nuclear power plants are facilities with very high water requirements – consumption can reach tens of millions of litres per day, making access to large water reservoirs a key element in planning such investments (Jayabal et al., 2025). For this reason, a location in the immediate vicinity of the Baltic Sea provides a stable and efficient cooling source, which directly translates into the operational safety of the power plant.

It is also significant that a large proportion of the world's nuclear power plants are built precisely near large bodies of water, such as seas or major rivers (Kumar, Singh, 2023). Access to a stable cooling system is one of the fundamental conditions for their safe operation – its absence or disruption can lead to serious operational problems (Zhang et al., 2023).

Another key criterion was the low population density of the analysed area. The literature emphasises that when selecting sites for nuclear power plants, efforts should be made to minimise potential risks to the population, which translates into a preference for areas with scattered development (Ahmed et al., 2023). The municipality of Choczewo meets these conditions, characterised by a relatively small number of inhabitants and a limited degree of urbanisation.

Geological and environmental conditions also played a significant role. The most important site selection criteria include geotechnical stability of the ground, low seismic activity and a limited risk of natural hazards (Ahmed et al., 2023). Analyses carried out for the Lubiatowo–Kopalino region indicate that this area meets these requirements, making it suitable for the siting of nuclear infrastructure (PGE EJ1, 2022).

From an environmental perspective, the impact of the project on coastal ecosystems is also of particular importance. The location on the Baltic Sea requires consideration of the impact on the marine environment and protected areas; however, as available analyses indicate, it is possible to limit the negative effects of the investment by applying appropriate mitigation measures (General Directorate for Environmental Protection, 2023).

In terms of infrastructure, this location also offers the opportunity for effective integration with the national electricity system and the development of transmission networks, which is crucial for the operation of the power plant on a national scale (Ministry of Climate and Environment, 2023).

More broadly, this investment forms part of Poland's energy transition, which aims to reduce dependence on fossil fuels and limit greenhouse gas emissions. Given the dominance of coal in the national energy mix, the development of nuclear energy is one of the key tools for enhancing energy security and implementing the European Union's climate policy (European Commission, 2020; Ministry of Climate, 2021).

2.2. Navigational conditions at the site of the planned nuclear power plant (Lubiatowo–Kopalino)

The analysed area of the planned nuclear power plant site in the Lubiatowo–Kopalino region is situated in the coastal zone of the Baltic Sea, characterised by a relatively straight coastline and a shallow continental shelf. From a navigational point of view, this is a body of water of moderate difficulty, but one requiring consideration of a number of significant bathymetric and hydrographic conditions. The navigational conditions of the analysed area are presented on a navigational chart (Fig. 1), showing depth distribution, isobaths and navigational markings in the coastal zone.

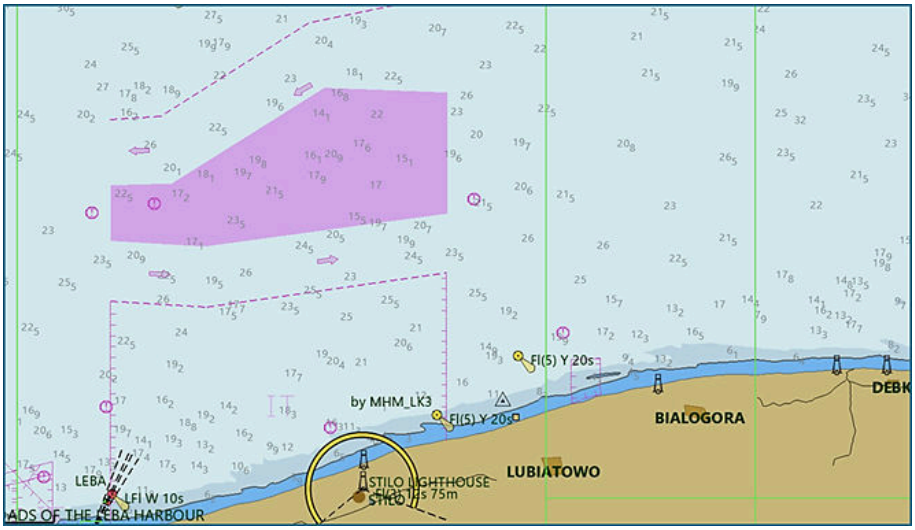

Figure 1. An extract from a navigational chart of the Lubiatowo–Kopalino area showing bathymetric conditions, navigational markings and the coastal zone of the Baltic Sea in the vicinity of the planned site of the nuclear power plant.

Source: own compilation based on navigational charts.

In the immediate vicinity of the shore lies a shallow water zone, where depths gradually increase from around 1-2 m at the shoreline to around 10-20 m a few kilometres offshore. This bathymetric profile is typical of the southern Baltic Sea and necessitates precise navigation, particularly for vessels with greater draught and those transporting large-scale cargo. The charts show numerous point depth marks and isobaths, indicating a relatively uniform, sandy seabed, occasionally interspersed with local shallows. The presence of these seabed features may constitute a significant restriction to navigation and require the designation of approach channels or dredging works. An important element of the navigation system in this area are navigation marks and light buoys, including Fl(5) Y 20s marks, which designate safe approaches from the sea. The system is supplemented by coastal marks, including the Stilo lighthouse, which serves as a distinctive landmark for coastal navigation. From the perspective of maritime traffic management, the analysed water area lies outside the main shipping routes of the Baltic Sea, which results in relatively low vessel traffic. Nevertheless, local shipping routes and approaches to the port of Łeba run in its vicinity, which means the presence of fishing vessels and smaller commercial ships. The map also highlights areas of special purpose (marked in purple), which may include restricted zones, naval training grounds or other areas of limited use. Their presence is of significant importance for the planning of maritime infrastructure and the organisation of future traffic of vessels serving the power plant. Furthermore, the hydrometeorological conditions of the Baltic Sea, including wave action, sea level variability and ice conditions during the winter, constitute a significant factor affecting navigational safety. These factors must be taken into account, particularly when designing hydrotechnical infrastructure and cooling water intake and discharge systems.

2.3. Characteristics of maritime traffic in the Southern Baltic

Maritime traffic in the Southern Baltic region, particularly in the coastal zone of the Pomeranian Voivodeship, is characterised by varying intensity and directionality, depending on the course of the main shipping routes and local coastal routes. The analysed area covers the waters in the Lubiatowo–Kopalino region and the vicinity of the port in Łeba. Based on the data presented in the (Fig. 2), it is possible to identify the dominant directions of vessel movement and areas with a higher concentration of ship trajectories. The measurement points (transects) used allow for the analysis of vessel flow in specific spatial cross-sections, which enables an assessment of traffic intensity and its directional structure.

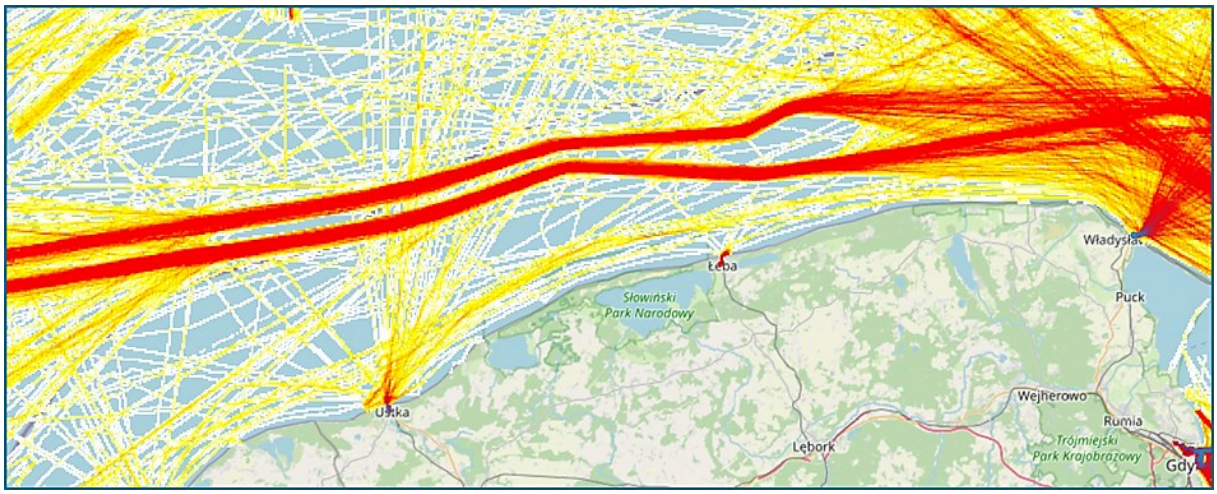

Figure 2. Characteristics of maritime traffic in the southern Baltic Sea in the Lubiatowo–Kopalino area, based on measurement points, showing vessel trajectories and the predominant directions of ship movement.

Source: own compilation based on AIS data in the IWRAP programme.

An analysis of the distribution of vessel tracks indicates that the main shipping lanes run parallel to the coastline, at a distance of several to over a dozen nautical miles from the shore. The highest concentration of vessel tracks is observed in this zone, indicating heavy transit traffic along the coast. In the immediate coastal zone, traffic intensity is significantly lower and is of a local nature. Fishing vessels, recreational craft and small ships operating in connection with local ports, including the port of Łeba, predominate here. This traffic is characterised by greater variability in direction and less regularity compared to deep-sea shipping.

The measurement sections used enable the identification of the dominant directions of vessel traffic. In the analysed area, east–west traffic predominates, which corresponds to the main shipping routes of the Baltic Sea. At the same time, local deviations in traffic routes are noticeable, linked to hydrometeorological conditions and the need to avoid restricted areas. Furthermore, the analysis of movement vectors indicates variations in vessel speeds depending on their type and function. Vessels moving within the main transport corridors exhibit greater stability in course and speed, whereas greater variability in movement parameters is observed in the coastal zone.

From the perspective of the planned location of the nuclear power plant, it is significant that this area is not situated directly on a main shipping route, which reduces the potential risk of collisions and spatial conflicts with heavy maritime traffic. Nevertheless, the presence of local shipping routes and fishing activity must be taken into account in the planning of maritime infrastructure and the organisation of future traffic of vessels serving the project.

3. Materials and Methods

3.1. Data sources

The primary data source used in this study was data from the AIS (Automatic Identification System), which is currently one of the most important tools in the analysis of maritime traffic and the assessment of navigational safety. This system enables the recording of both dynamic vessel parameters, such as position, course or speed, as well as static data, including the vessel type, its dimensions and MMSI identifier. Thanks to their high temporal and spatial resolution, AIS data enable a detailed reconstruction of vessel trajectories and an analysis of their behaviour in the maritime environment (Lei, 2020).

The literature emphasises that AIS data form the basis of modern maritime traffic analysis, enabling the identification of navigation patterns, the determination of transport routes and the assessment of interactions between vessels (Chen et al., 2022). The use of this data enables the identification of major shipping routes and the analysis of interactions between vessels.

This system also allows for the recording of vessels' dynamic parameters, such as position, course and speed, enabling the accurate reconstruction of vessel trajectories and the analysis of their behaviour in maritime space.

Furthermore, the integration of AIS data with analytical methods allows for a quantitative assessment of traffic safety and the identification of areas with an elevated risk level (Ma et al., 2024). Ship trajectory analysis also forms the basis for traffic modelling and the prediction of vessel behaviour in complex navigational conditions (Li et al., 2023).

3.2. Methods of ship traffic analysis

The analysis of ship traffic was carried out based on the reconstruction of vessel trajectories using AIS data and their analysis in a spatio-temporal context. This approach is commonly used in maritime traffic studies as it enables the identification of main navigation routes, areas of traffic concentration and changes in vessel behaviour (Ding, Weng, 2024).

In the first stage of the analysis, the distribution of vessel trajectories was visualised and assessed, which enabled the identification of the main transport corridors in the analysed area of the southern Baltic Sea. Based on the density of AIS tracks, zones of intensive traffic and areas of a local nature, mainly associated with coastal activities, were identified. This analysis was supplemented by the use of measurement sections designated as LEG 1-LEG 7, positioned in such a way as to capture both transit and coastal traffic (Fig. 3). Each section served as a reference line for which the flow of vessels crossing the given cross-section was analysed.

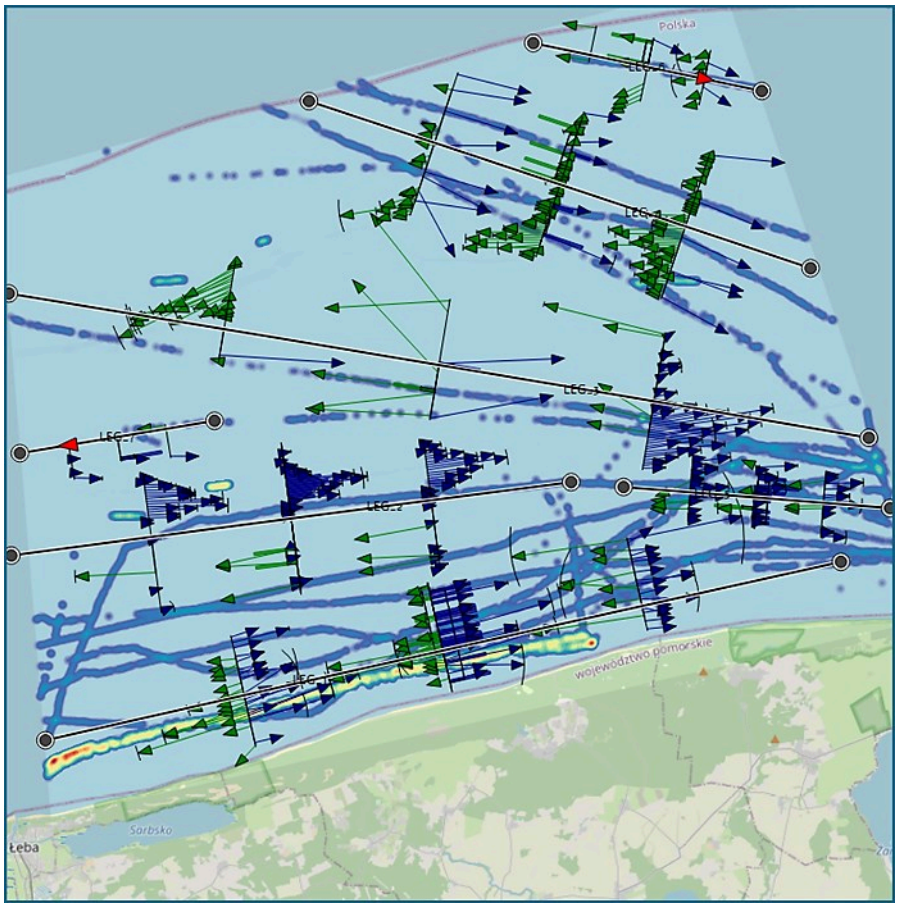

Figure 3. Distribution of ship trajectories with designated measurement sections (LEG 1-LEG7) in the southern Baltic Sea region.

Source: own compilation based on AIS data.

The use of LEG sections enabled a quantitative assessment of traffic by determining the number of vessels travelling in both directions (east–west and west–east), as well as an analysis of the fleet structure. Additional parameters were also determined for individual cross-sections, such as the maximum draught of vessels, the width of the traffic corridor and the proportion of different vessel types.

The analysis revealed a clear variation in traffic intensity between the individual sections. Section LEG 1, located closest to the coastal zone, mainly reflects local traffic, including recreational and auxiliary vessels. Section LEG 2 covers a transitional area between coastal traffic and more organised transit traffic. Sections LEG 3 and LEG 4 intersect the main shipping corridors, characterised by the highest concentration of vessel trajectories and the dominance of commercial vessel traffic. Section LEG 5 covers an area with a more diverse traffic structure, where both commercial and specialised vessels are observed. Sections LEG 6 and LEG 7, situated closer to the shore, primarily represent local traffic with lower intensity and greater variability in directions.

Additionally, vessels were classified by type, enabling an assessment of the contribution of individual vessel categories to maritime traffic. Distinguishing between commercial, fishing and specialised vessels is of significant importance from the perspective of navigational safety, as different vessel types are characterised by distinct traffic parameters and manoeuvrability.

The method employed, combining AIS trajectory analysis with the use of measurement cross-sections, allowed for a comprehensive assessment of the structure of maritime traffic and the identification of areas potentially significant from the perspective of navigational risk.

3.3. Risk identification and assessment

The identification and assessment of navigational risks was carried out on the basis of an analysis of actual vessel movements, reconstructed from AIS data. The AIS dataset used in this study covers the period from 1 January 2024 to 31 December 2024. The data were collected continuously during this time frame, which allows them to be considered representative of the area under analysis. The initial focus was on the spatial relationships between vessels and the course of their trajectories, which made it possible to identify the locations where potentially dangerous situations occur most frequently. The analysis took into account typical scenarios of vessel encounters, such as crossing courses, overtaking and head-on encounters. For each of these situations, basic movement parameters were analysed, including course, speed and their variation over time. Particular attention was paid to the distances between vessels, including the CPA (Closest Point of Approach) parameter, which allows one to determine how close vessels can come to each other whilst maintaining their current movement parameters. This analysis enabled the identification of areas with increased interaction between vessels, which can be treated as zones of heightened navigational risk. These areas are of particular significance in the context of maritime infrastructure planning, as they potentially increase the likelihood of hazardous incidents occurring.

In the next stage, modelling was carried out using the IALA IWRAP Mk2 software, which enables a quantitative risk assessment. Unlike trajectory analysis alone, IWRAP not only identifies potential conflict points but also converts them into probabilistic values. This means that, based on traffic density, route geometry and fleet structure, the programme determines the probability of a collision occurring.

The model takes into account so-called causal factors, which reflect the probability that a vessel will fail to perform an effective evasive manoeuvre. This makes it possible to move from a qualitative assessment of hazardous situations to a quantitative determination of the risk level. The results obtained in IWRAP made it possible to identify the most vulnerable areas of the water body and to determine the risk level on an annual basis. It should be emphasised, however, that this analysis concerns only the probability of events occurring, whilst the assessment of their consequences requires a separate approach.

3.4. Analytical tools and modelling (IALA IWRAP Mk2)

In this study, the IALA IWRAP Mk2 (IALA Waterway Risk Assessment Program) software was used to assess navigational risk; this software belongs to a group of tools used in the quantitative analysis of maritime safety. This programme enables the determination of the probability of adverse events occurring, in particular collisions between vessels and vessels running aground. IWRAP is part of the broader IALA Risk Management Toolbox, in accordance with the recommendations contained in the IALA G1018 guidelines on risk management. This tool does not function as a standalone solution, but serves as a supporting element for a comprehensive safety analysis, which should be supplemented by impact assessment and other analytical methods. The programme operates by creating a model of the analysed waterway that replicates actual navigational conditions. This model includes the geometry of fairways, vessel routes, traffic intensity, fleet structure and bathymetric conditions. In the study conducted, the model was developed on the basis of AIS data, which enabled the reconstruction of actual vessel trajectories and the nature of traffic in the analysed area. Based on the model prepared in this way, the programme performs statistical calculations, the result of which is an estimate of the average annual number of dangerous incidents. The calculations take into account so-called causal factors, interpreted as the probability that a vessel will fail to take effective manoeuvring actions to avoid a collision or running aground. It is worth noting that the scope of the analysis carried out in IWRAP is limited to determining the probability of events occurring, without taking their consequences into account. The assessment of potential consequences, such as environmental damage or threats to infrastructure, requires the use of additional methods and constitutes a separate stage of risk analysis.

The results of the modelling provide values describing the level of risk, including the predicted annual number of incidents and summaries enabling the identification of areas particularly vulnerable to hazardous situations. These results form an important basis for further interpretation and the formulation of conclusions regarding navigational safety, particularly in the context of the planned location of the nuclear power plant.

4. Results

4.1. Structure and intensity of maritime traffic

Analysis of AIS data revealed clear variations in both the intensity of maritime traffic and its structure across the individual measurement sections (LEG 1-LEG 7). Vessel traffic in the analysed area is asymmetrical, with one direction dominating in selected sections and a varied proportion of vessel types depending on the direction of travel. The summary of results is

presented in the graph (Fig. 4), which illustrates both the total traffic volume and the proportion of individual vessel types in the analysed measurement sections. There is a clear dominance of section LEG 2, which stands out with by far the highest number of vessels and the largest proportion of commercial vessels.

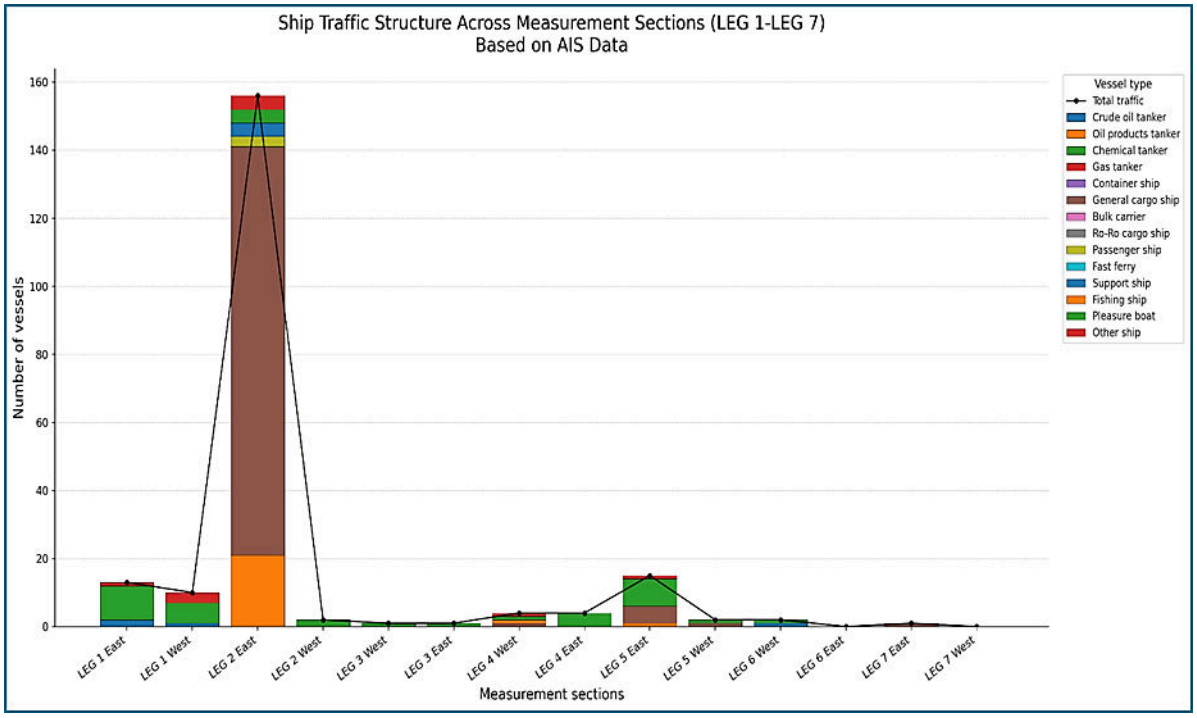

Figure 4. Ship Traffic Structure diagram.

Source: own compilation based on AIS data.

The heaviest traffic was recorded on the LEG 2 section, where 156 vessels were recorded heading east and only 2 heading west. As shown in the graph, the dominant group consists of general cargo ships, accompanied by oil product tankers. Passenger ships, as well as auxiliary and recreational vessels, are present to a lesser extent. Such a clear concentration of traffic and its one-way nature indicate the existence of a major transport corridor of regional significance. On the LEG 1 section, traffic volume is significantly lower and more balanced (13 vessels eastbound, 10 westbound). The graph shows that recreational and auxiliary vessels dominate here, which clearly indicates the local nature of the traffic.

Sections LEG 3 and LEG 4 are characterised by very low activity. The graph shows a marginal share of all vessel types, confirming their negligible significance in the traffic structure. Only isolated vessels are present here, mainly recreational and occasionally commercial.

Moderate traffic intensity is observed on section LEG 5 (15 vessels heading east and 2 heading west). As is also clearly visible in the chart, the fleet structure is dominated by recreational vessels and general cargo ships, indicating the mixed nature of the traffic – partly local, partly transit. Section LEG 6 shows very low activity, limited to isolated vessels heading west, mainly of an auxiliary and recreational nature. The chart shows an almost complete

reduction in traffic in this area. The lowest traffic intensity was recorded on section LEG 7, where only a single vessel appears. Graphically, this section plays virtually no significant role in the maritime traffic system.

This spatial distribution is of significant importance from the point of view of navigational safety, as areas with the highest traffic density and a high proportion of merchant ships and tankers may constitute potential zones of increased collision risk, which will be analysed in detail in the next stage of the work.

4.2. Hazard scenarios – results of IALA IWRAP Mk2 modelling

The navigational risk analysis carried out using the IALA IWRAP Mk2 programme enabled a quantitative assessment of the probability of hazardous events occurring in the analysed area. The study considered two basic collision scenarios: overtaking and head-on encounters. The results for the overtaking scenario are presented in the graph (Fig. 5 and Fig. 6).

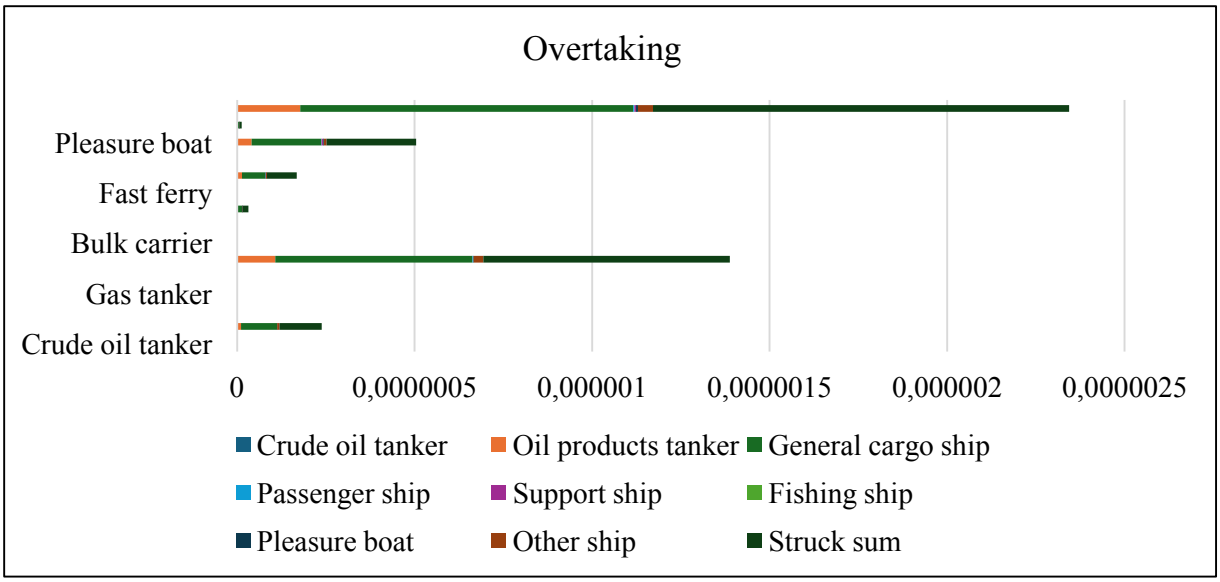

Figure 5. Summary of AIS data regarding overtaking situations.

Source: own compilation based on AIS data.

In the overtaking scenario, interactions involving commercial vessels are clearly predominant, particularly general cargo ships, which account for the largest share of the total risk. Product tankers also make a significant contribution, whilst the share of other vessel types, such as passenger ships or auxiliary vessels, remains relatively small. The total risk value for this scenario is the highest among the cases analysed, indicating that overtaking is the main mechanism for potential collisions in the area under study.

In turn, the results for the head-on encounter scenario are presented in the graph (Fig. 6).

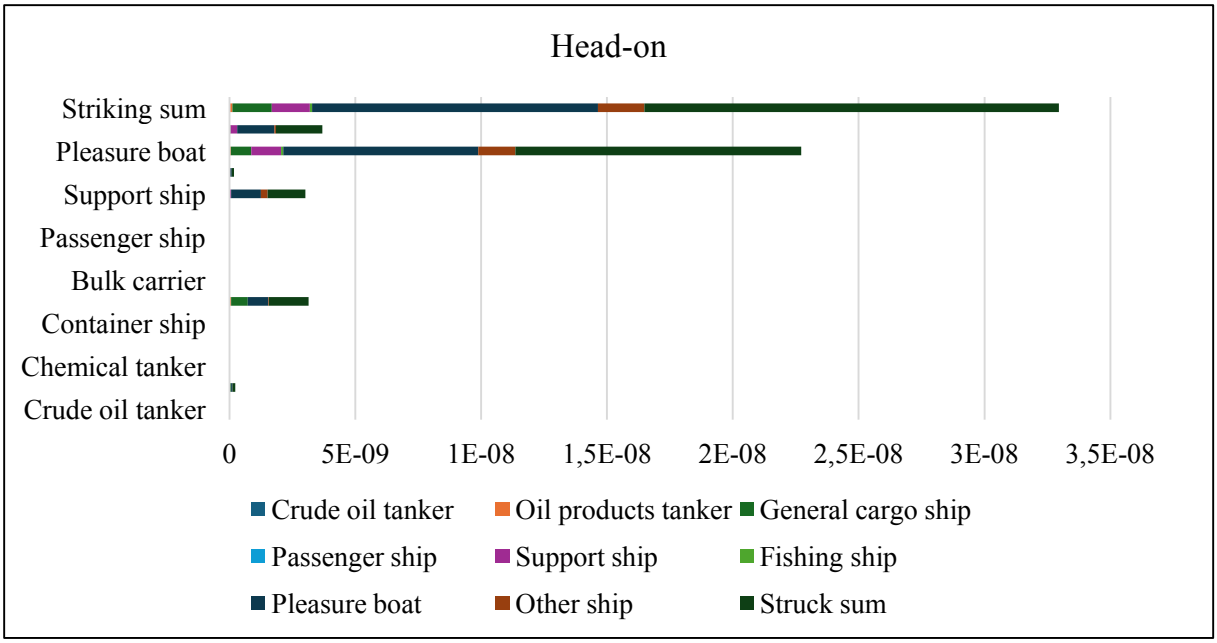

Figure 6. Summary of AIS data regarding head-on situations. Source: own compilation based on AIS data.

In the head-on scenario, the risk values are significantly lower and are marginal in comparison to overtaking. The largest contribution in this scenario comes from commercial vessels as well, and to some extent auxiliary and recreational craft; however, their impact on the overall risk remains limited. The low figures are primarily due to the orderly nature of vessel traffic, which takes place along parallel shipping lanes, significantly reducing the number of direct head-on encounters. A comparison of the two scenarios clearly indicates that the dominant source of risk in the analysed area is overtaking manoeuvres, associated mainly with the high volume of commercial vessel traffic in the main transport corridors. The head-on encounter scenario, however, is of secondary importance and does not constitute a significant risk factor in the studied area. From the point of view of navigational safety and the planned location of the nuclear power plant, this means that particular attention should be paid to areas of intensive transit traffic, where the highest number of interactions between vessels occurs.

4.3. Identification of high-risk zones based on AIS data and IWRAP Mk2 modelling

The identification of high-risk navigation zones was carried out based on the integration of AIS data and modelling results obtained using the IALA IWRAP Mk2 programme. This approach allows the actual distribution of vessel traffic to be linked to a quantitative assessment of the probability of hazardous incidents, such as collisions or groundings.

In the first stage of the analysis, AIS data were used to identify areas of traffic concentration, referred to as ‘hotspots’. An analysis of vessel trajectory density revealed that maritime traffic in the analysed region of the southern Baltic Sea is highly organised and concentrated in several clearly defined shipping corridors running parallel to the coastline. Of particular significance is

the area corresponding to the LEG 2 cross-section, where the highest traffic density and a predominance of large commercial vessels were recorded.

In the next stage, the results of the trajectory analysis were combined with the results of IWRAP Mk2 modelling, which enabled the identification of the spatial distribution of collision risk. The values obtained indicate that the highest probability of hazardous incidents occurs in areas with the highest traffic intensity and where the trajectories of vessels travelling at different speeds overlap.

The most significant high-risk zones were identified:

- along the main transport corridors (particularly in the area corresponding to LEG 2),
- in areas where local and transit routes intersect,
- in the coastal zone, where commercial, recreational and auxiliary vessels mix.

The analysis showed that the dominant mechanism generating risk is overtaking, which results from the large number of vessels travelling in the same direction but at different speeds. In contrast, the risk associated with head-on collisions is marginal and occurs mainly locally. The fleet structure is also a significant factor influencing the level of risk. General cargo ships and tankers contribute most to the generation of risks; due to their size, limited manoeuvrability and economic importance, they constitute a key element of the transport system, but at the same time increase the potential consequences of incidents. From the perspective of the planned location of the nuclear power plant in the Lubiatowo–Kopalino area, the high-traffic zones running parallel to the coast are of particular significance. Although the site itself lies outside the main shipping route, its proximity to areas of increased traffic volume necessitates the consideration of potential collision scenarios in the maritime infrastructure planning process.

It should be emphasised that the identification of high-risk areas in this study is qualitative in nature and is based on an analysis of vessel traffic density and the results of IWRAP probabilistic modelling. This programme provides probability values for events, but does not define clear-cut thresholds for classifying risk levels. Consequently, the identification of high-risk areas was based on a relative comparison of traffic intensity and the risk values obtained within the analysed water body. Due to the methodology adopted, detailed risk maps were not produced; however, the results allow for the identification of zones with an elevated level of risk.

4.4. Impact of maritime traffic on plant safety

An analysis of maritime traffic and the results of navigational risk modelling indicates that the presence of heavy ship traffic in the southern Baltic Sea region is a significant factor that must be taken into account in the context of the safety of the planned nuclear power plant at the Lubiatowo–Kopalino site. The results obtained clearly show that maritime traffic in the analysed area is highly concentrated and takes place along clearly defined transport corridors, dominated by commercial vessels, in particular general cargo ships and oil product tankers. Due to their operational parameters, such as deep draught, limited manoeuvrability and longer

reaction times, these vessels constitute a potential source of risk in the event of an emergency. Although the power plant is located directly outside the main shipping route, its proximity to areas of increased traffic, particularly in the region corresponding to the LEG 2 cross-section, means that the impact of maritime traffic on the safety of the investment cannot be ruled out. This applies in particular to extreme situations, such as loss of vessel control, navigational errors or adverse hydrometeorological conditions.

The results of IWRAP Mk2 modelling indicate that the dominant scenario for potential hazardous events is overtaking, which stems from the one-way nature of the traffic and speed differences between vessels. Such situations increase the likelihood of collisions within the main transport corridors and, consequently, may lead to secondary hazards, such as a damaged vessel drifting towards the coastal zone.

From the point of view of power plant safety, the following potential scenarios are particularly significant:

- ship collisions near the coast, which may lead to loss of control of the vessel,
- vessels drifting towards coastal infrastructure, including cooling installations,
- accidents involving vessels transporting hazardous substances, in particular tankers,
- the impact of increased traffic on the organisation of maritime space, including the need to designate safety zones.

Additionally, account must be taken of the fact that the coastal area is characterised by mixed traffic, where large commercial vessels coexist with recreational and auxiliary vessels. This diversity may lead to an increase in the number of interactions between vessels with different manoeuvring capabilities, which further affects the level of risk.

In the context of the planning and operation of a nuclear power plant, it is therefore essential to implement appropriate risk-mitigation measures, such as:

- the designation of restricted traffic zones (safety/exclusion zones) around the infrastructure,
- adjusting the organisation of maritime traffic in the project area,
- the use of vessel traffic monitoring systems (VTS/AIS),
- the development of emergency response procedures.

Maritime traffic in the analysed area does not pose a direct threat to the power plant site; however, its nature and intensity mean that it is a significant indirect risk factor. This applies in particular to emergency situations and secondary impacts that may affect the safety of coastal infrastructure. Taking these conditions into account in the design and safety management of the power plant is crucial to ensuring its safe operation.

5. Discussion

5.1. Interpretation of results

The analysis of maritime traffic and navigation risk modelling indicates a clear correlation between the intensity of vessel traffic and the level of risk generated. The results clearly show that areas of traffic concentration are of key importance, particularly the main transport corridors running parallel to the coast. In these zones, the highest density of AIS tracks and a predominance of large commercial vessels are observed, which directly translates into an increased likelihood of interaction between ships. A significant finding is the predominance of the overtaking scenario as the main mechanism generating collision risk. This stems from the nature of traffic in the analysed area, which is largely unidirectional but varies in terms of vessel speed. Under such conditions, even minor differences in traffic parameters can lead to potentially dangerous situations. At the same time, the relatively low values for the head-on encounter scenario confirm that vessel traffic is well organised spatially and proceeds in an orderly manner. The role of the fleet structure deserves particular attention. General cargo ships and oil product tankers contribute most to the generation of risk, which is directly linked to their numbers and transport function in the region. Due to their manoeuvrability and operational characteristics, these vessels constitute a key element of the shipping system, but at the same time increase the potential consequences of incidents.

5.2. Comparison with other nuclear power plant locations (case studies)

The results obtained are consistent with observations regarding other coastal nuclear power plant locations, where access to water resources is one of the main location factors, but at the same time necessitates the consideration of maritime traffic as a significant element of the operational environment. In many cases, nuclear power plants are located near areas with moderate or controlled traffic volumes, and the main shipping routes run at some distance from critical infrastructure. Analyses conducted for power plants in Western Europe and Asia indicate that the greatest risk to coastal facilities does not stem from daily ship traffic, but from rare yet potentially serious incidents, such as a vessel losing steering control or collisions leading to drifting towards the shore. In this context, the results obtained for the Lubiatowo–Kopalino area fit the typical operational model of coastal sites, where the main risks are of an indirect nature and relate to the interaction between heavy transit traffic and the coastal zone.

5.3. Implications for safety management

The results of the analyses carried out are of significant importance for the planning and safety management of the planned nuclear power plant. In particular, they highlight the need to consider maritime traffic as a systemic element that may affect the safety of the infrastructure, especially in emergency situations. From a practical perspective, this means there is a need to

implement solutions that mitigate the risk of interaction between vessels and coastal infrastructure. Proper management of the maritime space is of key importance, including the designation of safety zones around the power plant and the adaptation of traffic organisation in its vicinity. Monitoring of vessel traffic using AIS and VTS systems also plays a significant role, as these enable real-time monitoring of the navigational situation and a rapid response in the event of a threat. The results also indicate the need to incorporate emergency scenarios into the infrastructure design process, including the potential impact of drifting vessels and incidents involving the transport of hazardous substances. The integration of navigational analyses with power plant safety planning is therefore a key element of a systems-based approach.

5.4. Limitations of the study

Despite yielding consistent and unambiguous results, the analysis conducted has certain limitations that must be taken into account when interpreting the findings. First and foremost, the analysis is based on AIS data, which, although one of the most important sources of information on maritime traffic, may not cover all vessels, particularly smaller vessels not registered in the system. Additionally, the IWRAP Mk2 model allows for the assessment of the probability of events, but does not account for their consequences, such as environmental or infrastructural impacts. This means that the presented results relate solely to the level of risk in probabilistic terms, and a full risk assessment would require extending the analysis to include a consequence component. Another significant limitation is the use of a static traffic model, which does not fully account for the variability of hydrometeorological conditions, seasonal traffic patterns or extreme situations. In practice, these factors can significantly influence the level of risk and should be the subject of further research. Despite these limitations, the results obtained provide a reliable basis for assessing navigational safety and can be utilised in the planning and management of critical infrastructure in the coastal zone. A significant limitation of the analysis is that it does not take into account hydrometeorological factors, such as wind conditions, wave action or ocean currents, which can have a significant impact on vessel traffic and the level of navigational risk. The model used is based on a statistical analysis of vessel traffic and does not account for variations in environmental conditions over time. Consequently, the results obtained should be interpreted as an average picture of risk, not taking into account the impact of extreme conditions. Taking these factors into account represents an important direction for further research.

5.5. Safety Management System Concept

Based on the analyses conducted, an integrated safety management system has been proposed, the aim of which is to minimise navigational risk in the vicinity of the planned nuclear power plant. This system is based on a multi-layered approach, combining maritime traffic monitoring, risk analysis and operational procedures. A key principle is treating safety as a continuous process, encompassing both the planning and operational phases of the facility.

In the proposed model, the ongoing analysis of vessel traffic data and its integration with risk assessment tools plays a key role, enabling a dynamic response to changing navigational conditions. Figure 7 below illustrates the architecture of the proposed safety management system, incorporating multi-source data integration, vessel traffic analysis and risk modelling.

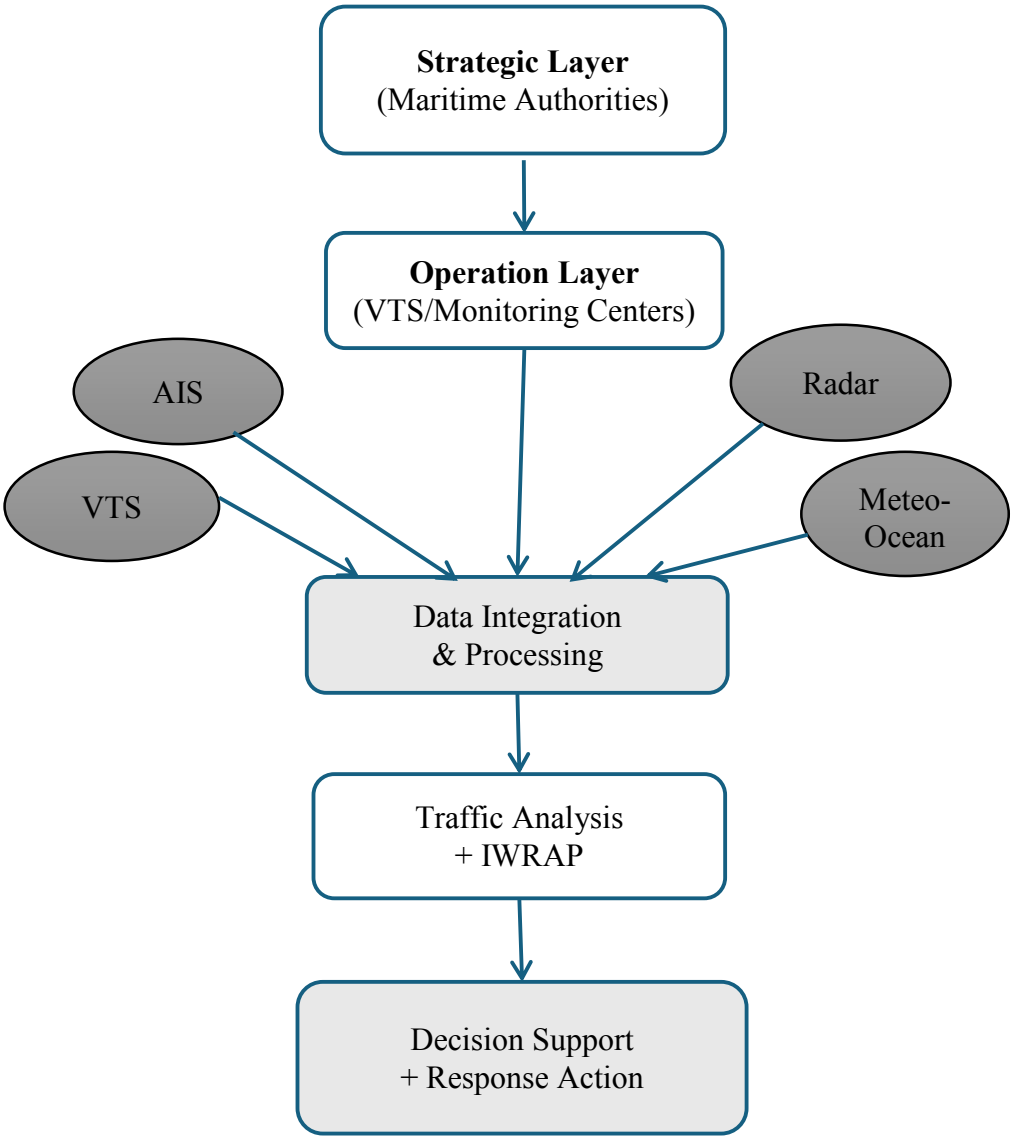

Figure 7. Architecture of an integrated maritime safety management system, combining AIS, radar, VTS and meteorological-oceanographic data with vessel traffic analysis and probabilistic risk modelling (IWRAP) to support decision-making.

Source: own compilation based on AIS data.

The proposed system is conceptual in nature, but its structure is based on the logical interconnection of three fundamental elements: input data, decision-making mechanisms and operational actions. Input data primarily comprises information from AIS, radar and VTS systems, as well as hydrometeorological data, which form the basis for the ongoing assessment of the navigational situation. Based on this, the analytical stage is carried out, involving the identification of potential hazards and risk assessment using tools such as IWRAP.

The results of this analysis form the basis for the decision-making process, within which appropriate operational actions are determined, such as warning vessels, modifying traffic organisation or activating emergency response procedures. This approach allows input data to be linked to specific management actions, creating a coherent framework for the operation of the safety system.

The system also provides for a clear separation of management levels: strategic (maritime administration), operational (VTS, monitoring services) and technical (power plant operator), whilst ensuring their mutual interoperability. The basis for the operation of the safety system is the integration of various sources of navigational data. AIS data enables the identification of vessels and the analysis of their trajectories; however, its effectiveness is limited in the case of vessels not equipped with transponders or in conditions of signal interference. It is therefore necessary to supplement AIS with radar data and vessel traffic surveillance systems (VTS), which provide a more complete picture of the navigational situation. The integration of these systems allows for:

- real-time tracking of vessel movements in the vicinity of the power plant,
- identification of potentially dangerous situations (e.g. vessel approaches),
- forecasting of trajectories and possible conflicts,
- rapid transmission of information to operators and services responsible for safety.

The integrated monitoring system forms the basis for implementing so-called situational awareness, which is crucial in the management of critical infrastructure security.

5.6. Emergency response procedures

A key element of the proposed safety management system is the development of coherent and multi-layered crisis response procedures, taking into account the specific nature of maritime traffic in the coastal zone and the nature of critical infrastructure. These procedures should cover both events with a high probability of occurrence and rare scenarios with potentially catastrophic consequences.

Analysis of vessel traffic and the results of risk modelling indicate that incidents involving loss of control of a vessel, interactions between vessels, and uncontrolled drifting towards coastal infrastructure are of key importance. Particular attention should be paid to vessels carrying dangerous cargoes, whose share – though limited – generates a disproportionately high risk in the event of an accident.

The basis for an effective response is the rapid identification of a threat, based on continuous monitoring of AIS data, radar data and information from VTS systems. The effective flow of information between traffic control services, the maritime administration and the power plant operator is also of key importance, enabling decisions to be made in near real time. In practice, this means that operational procedures based on clearly defined incident scenarios must be implemented, and responsibilities must be assigned to specific entities. Figure 8 presents a diagram of emergency response procedures, taking into account various incident scenarios as well as the decision-making process and operational actions.

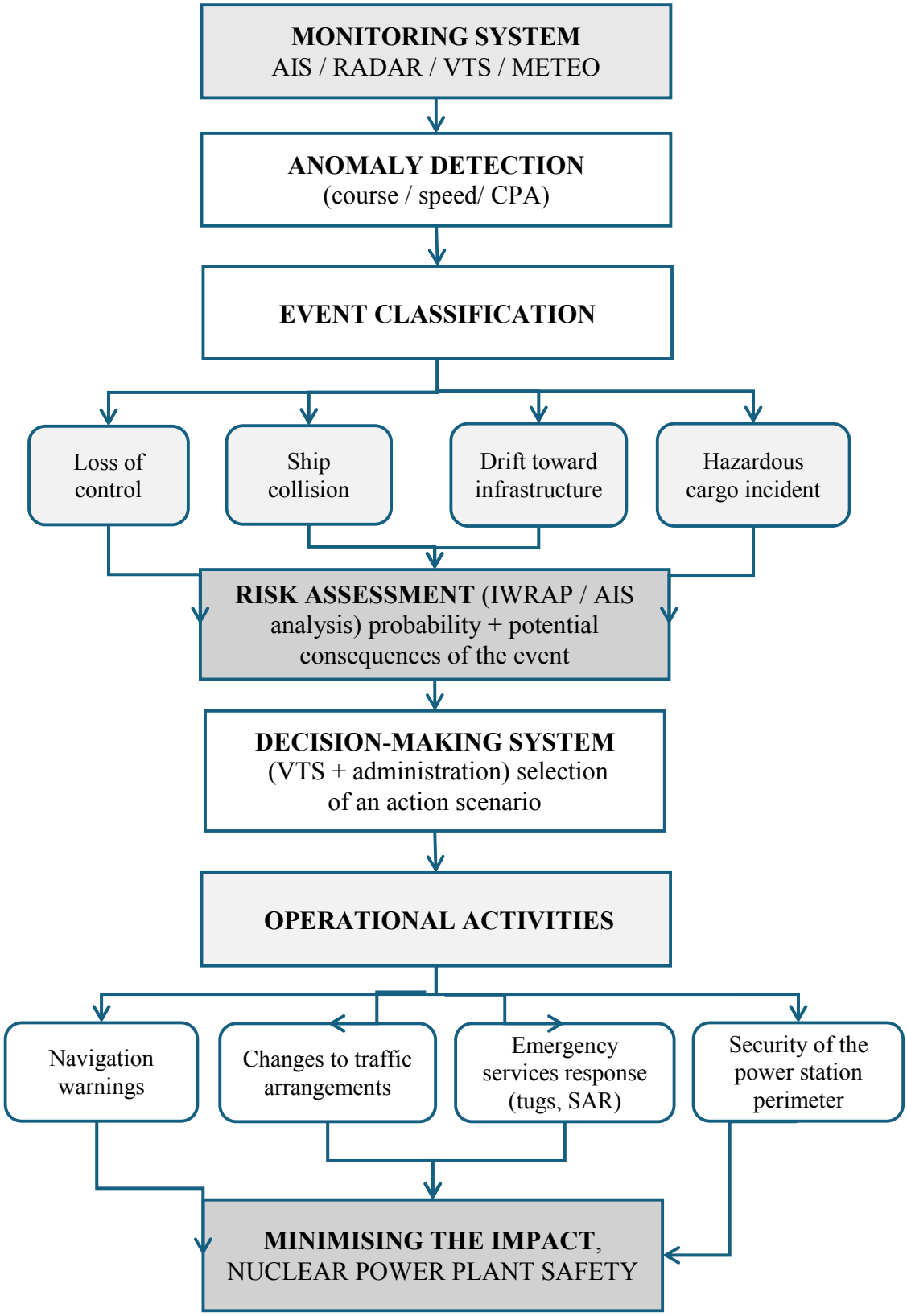

Figure 8. Diagram of emergency response procedures within an integrated safety management system, covering the identification and classification of incidents, as well as operational measures for various hazard scenarios.

Source: own compilation based on AIS data.

In the context of the planned nuclear power plant, it is particularly important to implement preventive and organisational measures, such as the designation of safety zones around the infrastructure, the adaptation of maritime traffic management and the development of monitoring systems.

The integration of AIS data with analytical tools, including probabilistic models (e.g. IWRAP), enables real-time risk assessment and the identification of potential hazardous situations. These measures should be complemented by regular updates to risk analyses and training for operational staff, thereby enhancing readiness to respond to emergencies.

The implementation of a comprehensive emergency response system not only reduces the likelihood of hazardous incidents occurring but also minimises their consequences, thereby enhancing the resilience of the entire safety system in the project area.

6. Conclusions

The analysis of maritime traffic in the southern Baltic Sea region, supplemented by navigation risk modelling using the IALA IWRAP Mk2 tool, enabled a comprehensive assessment of safety conditions in the context of the planned location of a nuclear power plant in the Lubiatowo–Kopalino area. The results obtained clearly indicate that vessel traffic in the analysed area is highly organised and concentrated in clearly defined transport corridors running parallel to the coastline. The most significant sections are those corresponding to the main transit routes, where commercial vessels dominate, in particular general cargo ships and oil product tankers.

Analysis of AIS data revealed significant variation in both traffic intensity and its spatial structure. Areas with the highest traffic intensity coincide with zones of increased risk, as confirmed by the results of probabilistic modelling. The dominant scenario for hazardous incidents was overtaking, resulting from the one-way nature of the traffic and the variation in vessel speeds. Conversely, the risk of head-on collisions remains limited, which indicates a relatively orderly shipping pattern in the analysed area.

From the perspective of the safety of the planned nuclear power plant, it is of key importance that, although the site of the project lies outside the direct route of the main shipping lanes, its proximity to areas of intense maritime traffic necessitates consideration of indirect risks. This applies primarily to emergency situations, such as loss of vessel control, collisions in the vicinity of shipping lanes, or ships drifting towards the coast. Of particular significance here are large vessels with limited manoeuvrability, whose potential impact may extend beyond the immediate traffic area. The results obtained have significant implications for the development of security policy regarding critical infrastructure located in the coastal zone. They highlight the need to integrate maritime traffic monitoring systems, such as AIS, radar and VTS,

with risk analysis tools, enabling the ongoing assessment of the navigational situation and real-time decision-making. The implementation of a systemic approach, involving cooperation between maritime authorities, traffic monitoring services and power plant operators, is also of key importance. The security management model proposed in this study, based on data integration, risk analysis and operational procedures, provides the foundation for building an effective risk mitigation system.

The research findings also highlight the need for further development of risk assessment methods in the maritime environment. In particular, it is appropriate to extend the analyses to include a consequence component, covering the effects of potential incidents on the environment and infrastructure. It is also important to take into account the variability of hydrometeorological conditions and the seasonality of vessel traffic, which may influence the level of risk. In future research, it is also worth considering the use of advanced modelling methods, including dynamic simulations and artificial intelligence-based tools, which will allow for more precise hazard forecasting and support decision-making processes.

In summary, the analysis provides a coherent picture of the relationship between maritime traffic patterns and the level of navigational risk, and highlights the crucial importance of integrating data and analytical tools into the safety management process. These findings can provide significant support for both infrastructure investment planning and the development of modern safety management systems in the coastal zone.

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THE IMPACT OF THE SPLIT PAYMENT MECHANISM ON FINANCIAL LIQUIDITY IN THE CONSTRUCTION INDUSTRY – IMPLICATIONS FOR RATIO ANALYSIS

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Purpose: The aim of this study is to assess the impact of the split payment mechanism on the financial liquidity of construction companies in Poland and to verify the need to adjust traditional liquidity ratios to account for funds accumulated in VAT accounts. The study seeks to identify the mechanisms through which the split payment mechanism constrains cash availability and affects companies' ability to meet their current liabilities.
Design/methodology/approach: The analysis was conducted on a sample of 72 construction companies. Financial data were obtained from the EMIS database for the period 2023-2024. The study employs ratio analysis, including both conventional and adjusted measures of financial liquidity. The adjusted ratios incorporate proprietary metrics that account for funds held in VAT accounts, enabling an assessment of the impact of the split payment mechanism on cash availability and liquidity levels of the examined entities.
Findings: The results indicate that the split payment mechanism reduces the effective financial liquidity of construction companies, particularly in entities with a higher share of funds accumulated in VAT accounts. Adjustments to traditional liquidity ratios reveal that standard measures may not fully reflect the actual ability of companies to settle current liabilities on time, as they do not consider restrictions on the use of funds held in VAT accounts.
Practical implications: The findings suggest the necessity of applying liquidity ratios adjusted for VAT account balances in financial analyses, monitoring companies with a high proportion of funds in VAT sub-accounts and adapting working capital management to constraints resulting from the split payment mechanism.
Originality/value: This study contributes novel empirical evidence by demonstrating the actual impact of the split payment mechanism on the liquidity of construction companies and justifies the need to apply adjusted liquidity ratios under conditions of restricted cash availability resulting from this mechanism.
Keywords: VAT, split payment mechanism, financial liquidity, cash management, construction industry.
Category of the paper: Research paper.

1. Introduction

The introduction of the split payment mechanism (hereinafter: SPM) into the Polish value added tax system constituted a significant component of measures aimed at tightening the tax system and preventing VAT fraud (Kowal-Pawul, Przekota, 2021; Tratkiewicz, 2017). At the same time, this solution aligns with a broader trend of VAT system reforms implemented across European Union Member States, which are designed to reduce the VAT gap, enhance the transparency of settlements and strengthen control over VAT flows (European Commission, 2017; Tarhova, 2021; Caraus et al., 2017; Herbain, 2018).

Although this mechanism has proven effective from a fiscal perspective (Conrado, 2025), it has generated considerable controversy among businesses, primarily due to its potential adverse impact on corporate financial liquidity (Kowal, 2019). The construction industry is particularly sensitive to such regulatory interventions, as it is characterized by high capital intensity, long contract execution cycles, deferred payment terms and frequent payment bottlenecks (European Commission, 2020).

The construction industry has long been regarded as one of the most high-risk sectors of the economy in terms of financial stability (European Commission, 2021; Semenova, Vitkova, 2019). Statistical data and market analyses indicate that it is precisely within this sector that relatively high levels of corporate insolvency and bankruptcy are observed (Statistics Poland [GUS], 2025; Okereke et al., 2021; Coggins et al., 2016).

The specific nature of construction activity is further associated with the execution of long-term contracts, often extending over several months. During their implementation, companies incur substantial financial outlays related to the purchase of materials, engagement of subcontractors and wage payments, while cash inflows are distributed over time. Invoicing is frequently milestone-based and occurs less regularly than in other sectors, leading to periodic mismatches between cash inflows and outflows (Śnieżek, Kaputa, 2013).

An additional challenge in the construction sector is payment bottlenecks. Delays in settling receivables create a domino effect, exacerbating liquidity problems for subsequent participants in the supply chain. Under such conditions, access to liquid cash resources and the ability to manage working capital flexibly are crucial for the survival of construction companies (Antonowicz, 2013).

The introduction of the mandatory split payment mechanism for construction services further intensifies these challenges by effectively freezing a portion of cash funds in VAT accounts (Kowal & Lichota, 2020). The restricted availability of these funds may deepen liquidity constraints, particularly in situations involving delayed payments from counterparties.

In the existing body of literature, research is predominantly focused on the impact of the split payment mechanism on the VAT gap, entrepreneurs' opinions derived from survey-based studies and regulatory impact assessments prepared by public institutions. There is a notable

lack of empirical studies based on actual financial data of companies, particularly those examining the impact of the SPM on traditional measures of financial liquidity. This research gap is especially pronounced in the construction sector (Section F, PKD), which is both subject to the mandatory split payment mechanism and particularly vulnerable to payment backlogs.

The objectives of the article are as follows:

C1: To present the essence of the split payment mechanism and to identify the channels through which it may potentially affect the financial liquidity of construction companies.

C2: To assess the validity of modifying classical liquidity ratios under the conditions of a mandatory split payment mechanism.

The following research hypotheses are formulated in the study:

H1: *The split payment mechanism negatively affects the financial liquidity of construction companies.*

H2: *Classical liquidity ratios require adjustment for funds accumulated in the VAT account in order to provide a reliable assessment of the financial condition of companies.*

The formulated hypotheses aim to verify the impact of the SPM on financial liquidity and the adequacy of traditional liquidity ratios under conditions of restricted access to VAT-related funds. Their verification contributes to addressing the identified research gap by providing empirical evidence based on data from financial statements.

The first hypothesis is based on the premise that liquidity is a function of cash availability rather than merely its book value. Restricted freedom in managing funds leads to a decline in financial flexibility, allowing the SPM to be interpreted as a form of cash resource segmentation. Consequently, companies may incur additional costs—both related to securing external financing and resulting from lost investment opportunities or disruptions in relationships with counterparties. This issue is particularly significant in sectors with long and irregular cash conversion cycles, such as construction.

The second hypothesis concerns the adequacy of analytical tools used to assess financial liquidity. Traditional ratios are based on the assumption of full availability of current assets, which is no longer valid under the constraints imposed by the SPM. Consequently, these ratios may distort the assessment of actual liquidity risk, potentially justifying the need for their modification to account for funds with restricted availability.

Both hypotheses address complementary aspects of the problem—the actual impact of the regulation and the method of its measurement. Considering them together allows for capturing both the economic and methodological consequences of the SPM.

2. Literature review

2.1. The split payment mechanism in the EU VAT system

The split payment mechanism has been introduced in various European Union countries; however, its specific design has taken diverse forms, adapted to national legal and economic conditions. It should be emphasized that the split payment mechanism is not provided for in Directive 2006/112/EC (Council Directive 2006/112/EC). Therefore, its implementation by Member States is optional and requires the consent of EU institutions, which is primarily contingent upon compliance with the principle of proportionality, understood as the adequacy of the measure to its intended objective while simultaneously limiting excessive administrative and financial burdens on taxpayers (Beshi, Susuri, 2023).

The experiences of individual countries with SPM vary. After a short period of voluntary application, Romania introduced a mandatory SPM model without prior approval from the Council of the European Union (Nicolae, 2017; Lucia, 2017). This solution was met with a negative assessment by the European Commission, which pointed to a lack of proportionality, excessive administrative burdens and the risk of violating the principles underlying the functioning of the VAT system. As a consequence, SPM was ultimately abolished in 2020 (Tarhova, 2021).

In the Czech Republic, a voluntary and manual SPM model is in operation, primarily used as a tool to limit the joint liability of the purchaser. However, due to its non-mandatory nature, it does not play a significant role in systematically combating VAT fraud (Zídková, Šťastná, 2019).

A different approach was adopted in Italy, where SPM was introduced as a mandatory mechanism in transactions with public sector entities and later extended to state-controlled companies (La Grutta, 2015). The Italian model, based on the manual separation of payments and the transfer of the VAT amount directly to the tax administration's account, received the approval of EU institutions and has been repeatedly extended through derogation decisions (Council Implementing Decision (EU) 2023/1552 of 25 July 2023).

In the Netherlands, a system resembling SPM has been introduced, aimed at limiting tax abuses in the provision of personnel leasing services by temporary work agencies and similar entities. For services other than construction or shipbuilding-related activities, the principle of joint liability for the supplier's VAT obligations applies. This liability is exempted if the purchaser deposits the VAT amount into the supplier's designated account, references the invoice details in the payment title and discloses the invoices in the VAT register, declaring no knowledge of the improper use of funds. The funds held in the designated account may be used to pay taxes and social security contributions, while also being available for other purposes, with expenditures subject to auditor oversight. Alternatively, regulations allow

avoiding joint liability by paying the VAT directly to the tax authority's account, without the obligation to maintain a designated account (Fornalik, Jaworska, 2020).

Bulgaria provides an example of negative experience, where SPM, implemented as a tool to combat carousel fraud, was withdrawn after several years due to the lack of expected fiscal effects and a significant deterioration in financial liquidity, particularly in the small and medium-sized enterprise sector. It is emphasized that Bulgaria implemented an isolated SPM system without complementary digitalization tools (as in the cases of Poland or Italy) (Tarhova, 2021).

The experiences of EU countries indicate that the effectiveness and impact of SPM on the economy and business operations largely depend on the adopted design, mandatory nature, coverage, automation and adaptation to the realities of the given market (Mitran, 2017; Caraus, 2017; Ecobici, Bușan, 2017).

In Poland, SPM was introduced into the legal framework through the Act of 15 December 2017 amending the Value Added Tax Act and certain other acts (Act of 15 December 2017, hereinafter referred to as the VAT Act) and has been in force since 1 July 2018. Initially, it was voluntary, but from 1 November 2019 it became mandatory for selected goods and services listed in Annex 15 to the VAT Act, including construction services (Annex 15 to the VAT Act).

The essence of SPM lies in the separation of an invoice payment into two parts: the net amount, which is transferred to the supplier's standard settlement account and the VAT amount, which is credited to a designated VAT account (VAT sub-account). Funds held in the VAT account have limited availability – they can primarily be used to settle public-law obligations, such as VAT, income tax, or social security contributions. A transfer of funds back to the main account requires the approval of the head of the tax office, who has up to 60 days to issue a decision (Lipniewicz, 2022). The tax office may refuse to release funds from the VAT account if there is a risk that such a transfer could impede the settlement of the taxpayer's public-law obligations.

Compared to solutions in other EU countries, the Polish SPM model is characterized by a high degree of automation, broad coverage and substantial mandatory application, encompassing B2B and B2G transactions in selected groups of goods and services, including the construction sector (Harding, 2026). At the same time, the stringent restrictions on the use of funds held in the VAT account mean that the Polish SPM may affect corporate liquidity to a greater extent than solutions operating in other EU countries. For this reason, Poland constitutes a valuable empirical case study from an EU perspective, providing insights relevant for further work on VAT system reform and the assessment of alternative tax collection methods.

SPM is part of the ongoing digitalization of VAT (especially in Poland due to automation); however, among the available tools for tightening the tax system, it is the mechanism that most significantly affects corporate finances (Kowal-Pawul, 2023; Stoicea, Iorga, 2018).

2.2. VAT neutrality and the split payment mechanism

From the perspective of economic theory, VAT is considered a neutral tax for businesses, as it should not influence their economic decisions (Schneider et al., 2022; Acosta-Ormaechea, 2021). This neutrality is achieved through the input tax deduction mechanism, whereby the tax burden is ultimately borne by the final consumer rather than by the entities involved at successive stages of economic turnover (Kogels, 2012; Picos-Sánchez, Thomas, 2015).

From a legal perspective, SPM does not violate the principle of VAT neutrality, as it neither restricts the taxpayer's right to deduct input VAT nor changes the amount of the tax liability. However, the mechanism may affect the economic neutrality of VAT. The requirement to transfer the VAT amount to a designated VAT account (VAT sub-account), the use of which is subject to significant restrictions, leads to a temporary freezing of part of a company's cash. Consequently, this reduces the financial flexibility of business entities and their ability to freely manage cash resources (Stolarski, 2019).

This phenomenon is particularly significant in the construction sector, which is characterized by low profit margins, long contract execution cycles and high working capital requirements. Construction companies often incur substantial expenditures during the project implementation phase before actual payment is received from the client. Under such conditions, limited access to funds held in the VAT account may lead to a deterioration of current financial liquidity, increased reliance on external financing and higher capital servicing costs.

In practice, this means that, despite the formal preservation of VAT neutrality, SPM can produce real economic effects that are reflected in the levels of basic financial ratios of companies. In particular, liquidity ratios and working capital turnover may deteriorate under SPM. For this reason, an analysis of the impact of the split payment mechanism on the financial condition of construction companies must take into account not only tax aspects but also their consequences for liquidity management and the financing structure of business operations.

2.3. The split payment mechanism and financial reporting and analysis

One of the key areas in assessing a company's financial condition is the analysis of its financial liquidity, understood as the ability to meet current obligations on time (Noor et al., 2012; Breuer et al., 2012). In practice, this assessment is primarily based on balance sheet data and classical liquidity ratios, constructed using cash positions and short-term liabilities (Seretidou et al., 2025).

According to the provisions of the Polish Accounting Act (Accounting Act of 1994), funds held in the VAT account do not need to be presented in the balance sheet as a separate item; instead, they are included together with the entity's other cash assets. Information regarding the amount of funds held in the VAT account may be disclosed in the notes to the financial statements; however, such disclosures are neither mandatory nor standardized. As a result, the financial statements, while formally correct, do not always fully reflect the economic

substance of the data presented in terms of cash availability and may not accurately represent the actual financial condition of the enterprise (Zeszyty Metodyczne Rachunkowości, 2025).

This method of presentation may lead to a distorted view of a company's financial liquidity, particularly in analyses based on classical liquidity ratios. These ratios treat all cash as homogeneous and fully available, whereas funds held in the VAT account are subject to significant restrictions on their use. As a rule, such funds can only be utilized to settle specific public-law obligations, which means they cannot be freely used to meet commercial liabilities or to finance ongoing operational activities (e.g., payroll).

As a result, the financial statements may provide a picture of financial liquidity that is formally correct but, from an economic analysis perspective, partially misleading. This particularly applies to entities subject to mandatory SPM, where the proportion of funds held in the VAT account may be significant. In such cases, classical liquidity ratios may be overstated, leading to an inaccurate assessment of the company's ability to meet current obligations.

These circumstances suggest that, under the conditions of SPM, a critical approach to the analysis of financial statement data may be necessary, along with the use of liquidity ratios that reflect the actual availability of cash. This means that financial statements remain a reliable source of information; however, in the context of SPM, their interpretation may require additional analytical adjustments, which could potentially provide a more accurate representation of a company's true liquidity position.

Despite the growing body of literature on the split payment mechanism, existing studies focus primarily on its impact on the VAT gap, regulatory aspects, or entrepreneurs' perceptions. There is a lack of empirical research based on financial statement data that examines how the split payment mechanism affects financial liquidity and the reliability of traditional liquidity ratios. In particular, limited attention has been given to sectors highly exposed to liquidity constraints, such as the construction industry. This gap justifies the need for empirical verification of the impact of restricted VAT funds on liquidity measurement.

3. Methods

The empirical study was conducted on a sample of 72 construction companies classified under Section F of the PKD – Construction. Companies eligible for the study were those whose primary activity falls into the following groups (according to PKD 2007):

- 42.11.Z – Construction of roads and motorways.
- 42.12.Z – Construction of railways and underground railways.
- 42.13.Z – Construction of bridges and tunnels.

These entities publish financial statements in accordance with the Accounting Act (Accounting Act of 1994), including information on funds held in VAT accounts in the notes to the financial statements. The activities carried out are subject to mandatory SPM under Annex 15 to the VAT Act (Annex 15 to the VAT Act).

Table 1.
Information on the sampled construction companies

Company Size	Number of companies	Percentage share
Small	30	41.57%
Medium	27	37.50%
Large	15	20.83%

The classification of companies as small, medium, or large was made in accordance with the criteria specified in Annex I to Commission Regulation (EU) No 651/2014, taking into account the number of employees and either annual turnover or total assets.

Source: Own elaboration based on EMIS data.

Financial data were obtained from the EMIS database and covered the most recent available reporting periods (2023-2024). The study employed ratio analysis, focusing on both classical liquidity measures and ratios adjusted for funds held in the VAT account. Some ratios were developed specifically for this study based on the financial statements of the examined companies, taking into account the restrictions arising from the operation of SPM. Differences between the values of classical and adjusted ratios were used to assess the extent of SPM's impact on the financial liquidity of the entities under study.

In particular, the study included:

- Analysis of the share of funds in the VAT sub-account in total cash holdings (*Share of VAT Account Funds – SVAF*):

$$SVAF = \frac{Funds\ in\ VAT\ sub-account}{Cash\ and\ bank\ balances}$$

A lower *SVAF* is desirable, as the smaller the share of funds in the VAT sub-account, the more flexible the management of cash resources.

- Calculation of the VAT Coverage Ratio for Public Liabilities (*VCR-PL*):

$$VCR - PL = \frac{Funds\ in\ VAT\ sub-account}{Public-law\ liabilities}$$

A value below 1 indicates that all funds can be used to settle liabilities and no freezing of cash occurs, whereas a *VCR-PL* value > 1 indicates that some cash is effectively blocked.

- Assessment of the classical and adjusted cash liquidity ratios (*CR* and *CR'*):

$$CR = \frac{Short-term\ investments}{Current\ liabilities}$$

$$CR' = \frac{Short-term\ investments - Funds\ in\ VAT\ sub-account}{Current\ liabilities - Public-law\ liabilities}$$

- Assessment of trade payables coverage by cash before and after adjustment for funds in the VAT sub-account (*TPCR* and *TPCR'*):

$$TPCR = \frac{Cash\ and\ bank\ balances}{Trade\ payables}$$

$$TPCR' = \frac{Cash\ and\ bank\ balances - Funds\ in\ VAT\ sub-account}{Trade\ payables}$$

The applied research approach enabled a comprehensive assessment of the impact of SPM on the financial liquidity of construction companies, both in the traditional sense and after taking into account the limited availability of a portion of cash resources. The adopted methodology allowed for the identification of differences between classical and adjusted liquidity ratios, as well as an evaluation of the potential distortion in the portrayal of financial liquidity under the operation of this tax mechanism.

The results of the analyses, presented in the following chapter, provide a basis for testing the formulated research hypotheses and for drawing conclusions regarding the significance of SPM for the financial situation of companies in the construction sector.

4. Research results

In this part of the study, a detailed analysis of the collected empirical data was conducted, allowing for the identification of relationships between the operation of SPM and the financial condition of the examined entities. The analysis was structured in a way that enabled a comparison between the traditional approach and the approach taking into account the limitations in the availability of cash resources.

Table 2 presents the share of funds in the VAT sub-account in total cash and bank balances. The values of this ratio are highly statistically significant ($p<0.001$) for each group of companies.

Table 2.
Share of VAT Account Funds in Cash and Bank Balances (SVAF)

	Small (n=30)	Medium (n=27)	Large (n=15)	Total
Mean	0.21	0.38	0.41	0.31
Std.dev.	0.24	0.31	0.37	0.31
Min	0.01	0.05	0.01	0.01
Q25	0.06	0.11	0.07	0.09
Median	0.14	0.29	0.29	0.17
Q75	0.23	0.70	0.83	0.51
Max	0.96	0.99	0.95	0.99

Source: Own elaboration.

In this ratio, the median is reported due to the wide range of values observed in each group – from companies with an almost negligible share of funds in the VAT sub-account to those where the share exceeds 90%. In the small companies group, 50% of entities have a VAT account share equal to or greater than 14%. Similarly, in medium and large companies, the median is equal to or greater than 29%.

Differences are also observed in the third quartile (Q75), where 25% of companies in each group have a share of funds in the VAT sub-account in total cash of at least 23% for small companies, 70% for medium and 83% for large companies.

The mean values amount to 21% for small, 38% for medium and 41% for large companies.

The differences in mean values are statistically significant ($p = 0.0413$). At the same time, the values for small companies significantly differ from those observed in medium and large companies. The median test, however, does not indicate statistically significant differences ($p = 0.1343$).

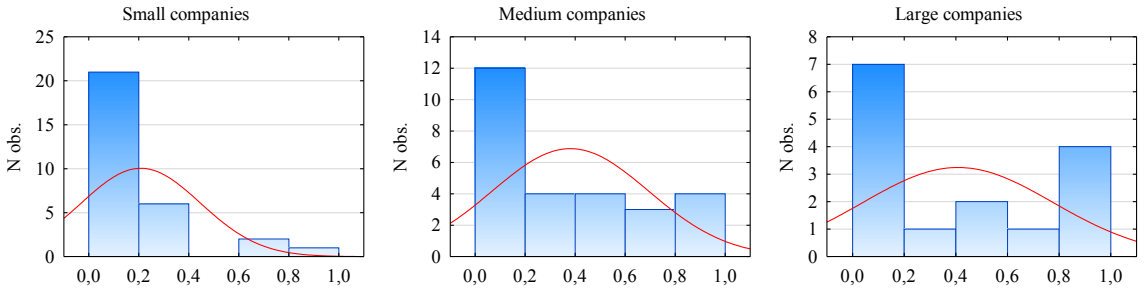

Figure 1. Distribution of the *SVAF* ratio by company size.

Source: Own elaboration.

Companies with an *SVAF* ratio below 20% constitute the largest group in each category. Companies with an *SVAF* ratio above 80% are also observed, particularly among medium-sized and large companies.

The next ratio is the *VCR-PL* (Table 3). The values of this ratio exhibit a very wide range, especially for small and medium-sized companies. Due to this dispersion, significance testing of mean values was not performed.

Table 3.
VAT Coverage Ratio for Public Liabilities (VCR-PL)

	Small (n=30)	Medium (n=27)	Large (n=15)	Total
Mean	342.50	10.78	0.55	146.87
Std.dev.	1194.15	49.60	0.50	781.72
Min	0.01	0.04	0.03	0.01
Q25	0.15	0.46	0.24	0.24
Median	0.49	0.91	0.48	0.62
Q75	4.43	2.08	0.66	2.00
Max	5000.00	258.90	2.09	5000.00
VCR-PL >1	40.0%	44.4%	6.7%	34.7%

Source: Own elaboration.

For small companies, the median value of the *VCR-PL* ratio was 0.49. For medium-sized companies, the median ratio was 0.91. In large companies, the median reached 0.48.

An analysis of the third quartile and maximum values revealed the presence of extreme cases, in which the ratio reached very high levels, clearly exceeding 1 (small companies – Q75 = 4.43 and max = 5000; medium-sized companies – Q75 = 2.08 and max = 258.90; large companies – max = 2.09).

The proportion of companies with *VCR-PL* > 1 is 40.0% for small companies, 44.4% for medium-sized companies and 6.7% for large companies. For small and medium-sized companies, these proportions do not differ significantly from 50% ($p > 0.05$). In large companies, the proportion is significantly lower ($p < 0.05$).

Excluding the funds held in the VAT sub-account from the numerator and public-law liabilities from the denominator of the cash liquidity ratio may result in either an increase or decrease in its value. In Figure 2, the values of the ratio before and after the adjustment are shown along with a 45° line, which represents no change. In general, the ratios align along this line; however, for some companies, they deviate noticeably from the 45° line, sometimes upward and sometimes downward. Consequently, the following section discusses the issue of the differences between the cash liquidity ratios before and after the adjustment.

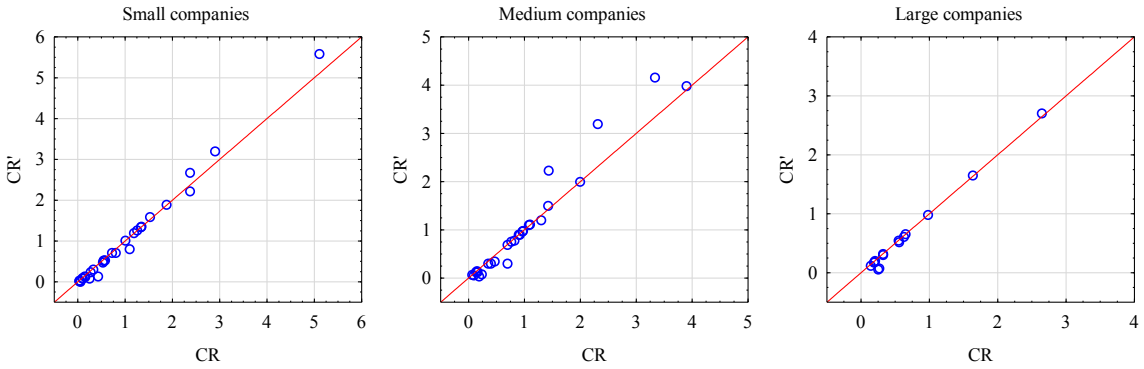

Figure 2. Relationship between the adjusted cash liquidity ratio and the cash liquidity ratio before adjustment.

Source: Own elaboration.

The results regarding the adjustment of the classical cash liquidity ratio are presented in Table 4.

Table 4.
Adjustment of the cash liquidity ratio (difference = CR – CR')

	Small (n=30)	Medium (n=27)	Large (n=15)	Total
Mean	0.0088	-0.0511	0.0320	-0.0088
Std.dev.	0.1515	0.2962	0.0741	0.2092
Min	-0.4800	-0.8765	-0.0635	-0.8765
Q25	-0.0012	-0.0116	0.0012	-0.0001
Median	0.0124	0.0067	0.0148	0.0114
Q75	0.0457	0.0503	0.0242	0.0407
Max	0.3000	0.4000	0.2154	0.4000

If *CR > CR'*, the difference is positive, if *CR < CR'*, the difference is negative.

Source: Own elaboration.

Depending on the values of the numerator and denominator, the adjusted ratio could take either positive or negative values. Across all groups, mean values do not differ significantly from zero ($p>0.05$). For small and large companies, the mean values are positive, whereas for medium-sized companies, the mean value is negative. However, this difference is not statistically significant, as the mean values do not differ significantly from each other ($p = 0.3952$).

Comparison of the distributions using positional statistics also does not reveal any substantial differences. The median test indicates statistical insignificance ($p = 0.7659$). The lack of meaningful differences is also visible in the distributions shown in Figure 3, where values slightly above 0 clearly dominate in each company group.

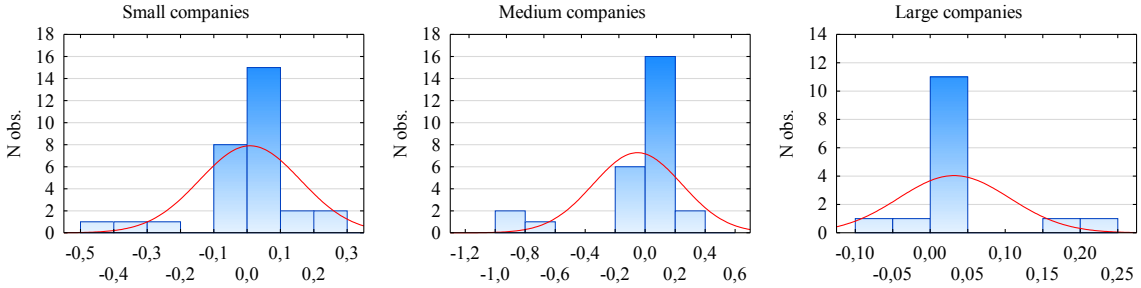

Figure 3. Distribution of the differences between *CR* and *CR'* by company size.
Source: Own elaboration.

Since the mean and median values deviate only slightly from 0, it is worthwhile to examine the values of the ratio that stand out from the typical range (Fig. 4).

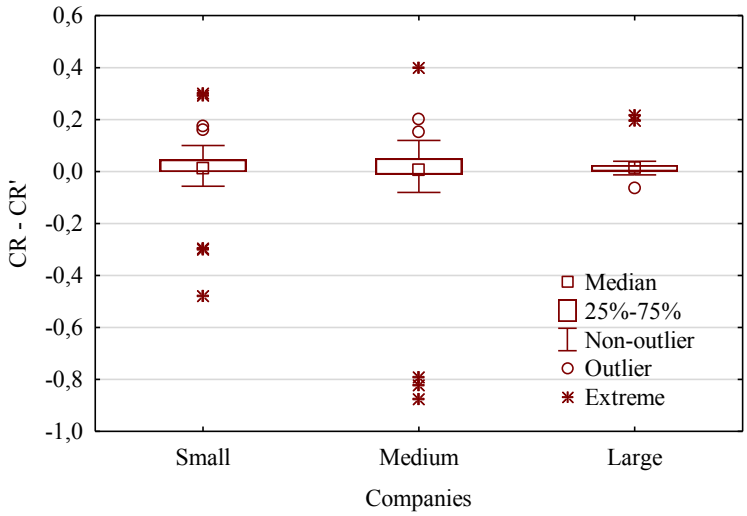

Figure 4. Typical and outlier values of the differences between *CR* and *CR'* by company size.
Source: Own elaboration.

In each company group, there are cases of differences between *CR* and *CR'* that deviate markedly from typical values and in some instances even extreme cases.

It should be emphasized that the classical *CR* ratio does not account for the restrictions on using funds from the VAT sub-account, nor does it distinguish liabilities based on their urgency. From an operational perspective, funds "frozen" in the VAT sub-account cannot be freely allocated to settle other, more pressing obligations, such as payments to suppliers. As a result, the adjusted *CR'* ratio may mathematically indicate improved liquidity (negative difference), which does not reflect the company's actual ability to timely meet its most urgent obligations. Therefore, in companies subject to the split payment mechanism, the classical *CR* ratio – even after adjustment – may not accurately represent the real liquidity situation. This justifies the use of an alternative measure – the *TPCR* – which does not suffer from this limitation (Fig. 5).

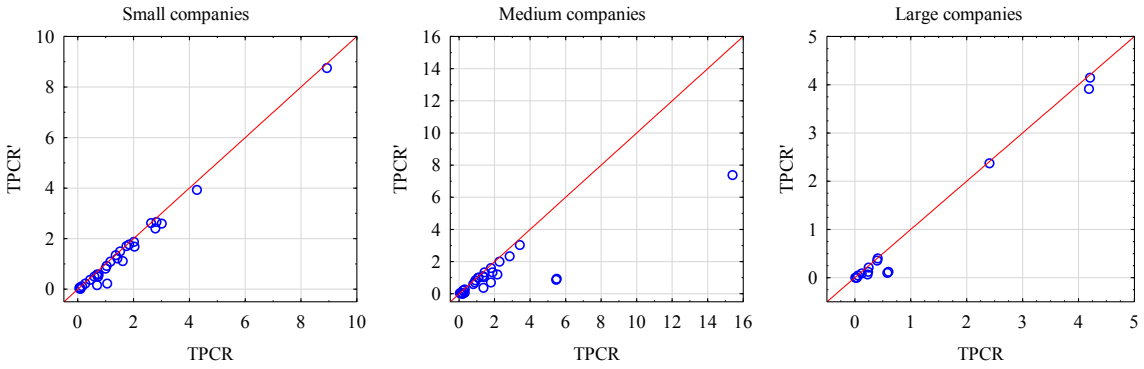

Figure 5. Relationship between the *TPCR* and the *TPCR.*

Source: Own elaboration.

Since the adjustment of the *TPCR* affects only the numerator, the values of the ratio after adjustment are lower than those before adjustment. This is visible in Figure 5, where the points are positioned below the 45° line. It is worth noting, however, that for some companies the deviation from the 45° line is quite pronounced. A detailed description of the differences between the *TPCR* before and after adjustment is presented in Table 5.

Table 5.

Adjustment of the Trade Payables Coverage Ratio (difference = TPCR – TPCR')

	Small (n=30)	Medium (n=27)	Large (n=15)	Total
Mean	0.1814	0.9045	0.1212	0.4400
Std.dev.	0.1927	1.8496	0.1669	1.1854
Min	0.0100	0.0054	0.0024	0.0024
Q25	0.0404	0.1000	0.0279	0.0391
Median	0.1156	0.2047	0.0339	0.1217
Q75	0.2394	0.5535	0.1651	0.3430
Max	0.8380	8.0125	0.5002	8.0125

Source: Own elaboration.

The adjustment of the *TPCR* is statistically significant for each company group ($p < 0.05$). The group of medium-sized companies, however, stands out, showing significantly greater differences between the original and adjusted ratios compared to small and large companies (mean test $p = 0.0335$, median test $p = 0.0408$).

The analysis of the adjusted Trade Payables Coverage Ratio (*TPCR'*) indicates the extent to which funds frozen in the VAT sub-account affect the actual operational liquidity of the surveyed companies. The median differences between the ratio before and after adjustment are 0.1156 for small companies, 0.2047 for medium-sized companies, and 0.0339 for large companies.

The minimum and maximum values reveal the presence of extreme cases – in some companies the adjustment is practically zero, while in others it is substantial (up to 0.8380 in small, 8.0125 in medium-sized, and 0.5002 in large companies).

Compared to the adjustment of the classical cash liquidity ratio (*CR – CR'*), the differences in *TPCR'* are clearly larger and more significant. This is because *TPCR* directly relates to trade payables, while funds held in the VAT sub-account remain unavailable for their settlement.

5. Discussion

The results obtained allow for an in-depth interpretation of the impact of the SPM on the financial liquidity of construction companies and their reference to the existing body of literature. The conducted research confirms that restricting the availability of cash accumulated in VAT accounts can have a negative impact on the financial liquidity of companies. This finding is consistent with studies available in the literature (Kowal, 2019; Szerszeniewska, 2019; Madurski, 2021).

At the same time, it should be emphasized that previous research in this area relied primarily on qualitative methods, such as interviews or survey research, as well as on legal and regulatory analyses.

The results concerning the *SVAF* indicate a clear differentiation between companies and an upward trend along with the scale of operations. This is demonstrated by both the average values and the results in individual quartiles. Simultaneously, it should be noted that in the case of entities with a very high share of funds in the VAT account (above 80%), almost all cash resources remain deposited in this account, which implies a significant restriction of operational liquidity. This phenomenon is particularly evident in the group of medium and large companies. On the other hand, entities with a relatively low share of funds in the VAT account also dominate in each of the analyzed groups, which indicates a significant diversification of the liquidity situation of companies and their experience with SPM.

An interesting fact is that a high level of "frozen" funds is also observed in medium and large companies. Although the literature indicates that larger entities – due to greater diversification of financing sources – are potentially less exposed to liquidity constraints (Ainsworth, 2019), the obtained results suggest that the scale of funds maintained in VAT

accounts in these entities may lead to significant restrictions on cash availability. It should be emphasized that, according to earlier studies, tax regulations regarding VAT, such as the split payment mechanism or reverse charge, can significantly affect the financial liquidity of companies, particularly in the construction sector (Kútna et al., 2018; Szerszeniewska, 2019). The literature also highlights that this industry and the SME sector are characterized by high demand for working capital and relatively long settlement cycles, which increases their sensitivity to liquidity constraints.

For most of the surveyed companies, the *VCR-PL* takes values below 1, which indicates the possibility of using funds accumulated in the VAT account to settle public law liabilities and a limited scale of liquidity blockage. At the same time, in some companies, there is a surplus of funds, which generates the risk of them being "frozen" – this phenomenon affects a significant part of the entities, especially in the group of small and medium-sized companies, where its scale is noticeable and may cover a significant percentage of the surveyed units. This phenomenon was previously identified in survey research, in which entrepreneurs pointed to the problem of surplus funds "frozen" in VAT accounts (Kowal, 2019). However, the results of this study allow for its quantitative identification and determination of the scale of this phenomenon.

Of particular importance are the results concerning the classic *CR* and its modification. The conducted analyses indicate that taking into account the limited availability of funds accumulated in the VAT account does not lead to statistically significant changes in the value of this ratio. Simultaneously, in individual cases, significant deviations are observed, which may lead to a different assessment of the company's liquidity situation. This means that classic liquidity ratios may not fully reflect the actual ability of companies to settle liabilities, which is consistent with previous observations regarding the limitations of ratio analysis based solely on balance sheet data (Zimon et al., 2022).

This mechanism is further corroborated by the literature, which indicates that prior to the implementation of the SPM, companies utilized funds equivalent to the VAT amount to finance their day-to-day operating activities (Szerszeniewska, 2019; Madurski, 2021). Restricting access to these resources, therefore, necessitates the search for alternative sources of financing and increases the significance of working capital management.

In this context, the results regarding the *TPCR* are of particular importance. In contrast to the classic liquidity ratio, its modification leads to statistically significant changes, indicating its greater sensitivity to the constraints arising from the functioning of VAT accounts. This finding confirms that the structure of liabilities and the actual availability of cash resources are of key importance for the assessment of financial liquidity, which is reflected in studies on working capital management (Deloof, 2003; García-Teruel, Martínez-Solano, 2007).

A particularly interesting result is the stronger effect of the *TPCR* adjustment in medium-sized enterprises. This phenomenon may result from their specific position between small and large entities. On the one hand, these enterprises are characterized by a relatively high demand

for working capital resulting from the scale of operations, but on the other hand – they do not have as wide access to external sources of financing as large entities. As a result, restricting the availability of funds in VAT accounts may to a greater extent affect their ability to settle trade payables. Simultaneously, compared to small enterprises, their structure of liabilities is more complex, which further increases sensitivity to liquidity disruptions.

Small companies are often characterized by a high degree of flexibility. They can adjust their activities more quickly to changing market conditions, and their organizational structures are simpler, which favors faster decision-making. In practice, this means that they are able to partially mitigate the impact of the SPM mechanism on their financial liquidity, for example through a selective approach to contracts; moreover, they generally manage cash flows on a smaller scale. In turn, large enterprises have resources that allow them to neutralize the negative effects of this type of regulation. They have access to a wider range of financing sources, and most importantly, their strong market position enables them to negotiate more favorable payment terms with counterparties. Thanks to this, they are able to better cope with constraints resulting from the temporary "freezing" of funds in VAT accounts.

Against this background, medium-sized companies may fare worse, as on the one hand they have already lost the flexibility typical of small entities, and on the other hand, they have not yet achieved the scale and resources characteristic of large entities. As a result, medium enterprises find themselves in a situation where various types of constraints accumulate: relatively high exposure to regulations and limited adaptive capabilities compared to small enterprises, as well as a weaker negotiating position in relation to large enterprises. It is this combination of factors that makes the effects of introducing the split payment mechanism potentially more severe for them than for other groups of enterprises, placing them in a relatively least favorable position compared to the other groups.

Conducted empirical analyses confirm that the classic cash ratio (*CR*), even after its modification (*CR'*), does not fully reflect the actual impact of the SPM on the ability of enterprises to settle current liabilities, because it does not take into account the structure or urgency of these liabilities. In contrast, the *TPCR* ratio allows for a better capture of the actual availability of financial resources, especially in enterprises with a high share of funds accumulated in VAT accounts.

The results obtained confirm hypothesis *H1* regarding the negative impact of the split payment mechanism on the financial liquidity of construction companies, as well as hypothesis *H2*, indicating the need to adjust classic liquidity ratios under SPM conditions.

The conclusions drawn from the study have important both theoretical and practical implications. From a theoretical perspective, they indicate the need for further development of financial liquidity measurement methods that take into account institutional (legal, tax) restrictions on access to cash. From a practical perspective, they emphasize the need to increase the transparency of financial information by separating funds accumulated in VAT accounts in financial reporting or their mandatory disclosure in the notes to the financial statements.

The conducted study not only confirms previous findings regarding the negative impact of SPM on corporate liquidity but also brings new value through the application of classic and modified liquidity ratios based on enterprises' financial data. The introduction of ratios such as *SVAF* and *VCR-PL* enables a more precise capture of the "frozen" cash phenomenon and reduces the risk of misinterpretation of the liquidity situation of enterprises in ratio analysis.

The conducted research makes an important contribution to the analysis of the impact of the split payment mechanism on the financial liquidity of construction enterprises, yet it has certain limitations. The primary research limitation is the analysis of 72 enterprises from the construction sector, which limits the possibility of generalizing the results to other industries. The specificity of the construction sector – in particular long settlement cycles and high sensitivity to payment bottlenecks – may affect the scale of the observed effects. However, even if the presented effects are overestimated, the very process of the split payment mechanism's impact on other enterprises will be fundamentally analogous, with its significance being at most weaker. This, however, does not exempt from the need to adjust ratios, since it is assumed that they are intended to show a true picture of the enterprise's financial condition. Another limitation is the time of the study, namely relying on financial data for the period 2023-2024, which means that the study is short-term in nature and does not take into account long-term changes or the adaptive effects of enterprises to functioning under the split payment mechanism. Looking at the very construction of the mechanism, it can be assumed that the timing of the study does not have a great significance for the results obtained, but it is always worth having a long-term perspective as well. Another limitation may be the problem of information constraints, in particular the presentation of data in financial statements. Sometimes this may affect the accuracy of measuring actual cash availability.

At the same time, directions for further research should be indicated. In particular, it seems justified to extend the analysis to other sectors of the economy and to include additional variables, such as the cash conversion cycle, credit policy of companies, or access to external financing. An important direction for future research would be the analysis of the relationship between the level of frozen funds in VAT accounts and the actual frequency of payment delays or insolvency incidents in the studied sector.

Thus, the study creates a basis for further analysis, in particular in the scope of:

- inter-sectoral comparisons,
- analysis of the long-term effects of using SPM,
- inclusion of additional factors affecting the financial liquidity of companies.

Generally, the research allows for recognizing the issue of the split payment mechanism's impact as important; therefore, it is worth conducting a re-evaluation in the future, perhaps after a longer period since its introduction, taking into account a larger number of economic sectors and a larger number of companies. Perhaps successively implemented solutions in the field of digitalization will make it possible to conduct ongoing verification of enterprise liquidity issues and rapid corrective reactions at the institution-enterprise interface.

6. Conclusion

The conducted study has allowed for a comprehensive assessment of the impact of the split payment mechanism on the financial liquidity of construction companies using empirical data. The results indicate that accounting for the restricted availability of funds accumulated in VAT accounts leads to a different assessment of the liquidity position than when classical measures are applied. This implies that the traditional approach to liquidity analysis may lead to overly optimistic conclusions regarding the ability of companies to settle their current liabilities.

A significant contribution of this research is the proposal and empirical verification of ratios that distinguish between operationally available funds and funds with limited utility. In particular, the use of ratios such as *SVAF* and *VCR-PL*, along with modified versions of classic liquidity ratios, allows for a more precise capture of the actual financial situation of enterprises operating under a mandatory SPM. This approach contributes to the development of financial analysis methods by incorporating institutional (tax) constraints on access to cash resources.

The study's findings also carry substantial practical significance. They highlight the necessity for a cautious interpretation of classical liquidity ratios in companies subject to SPM and the need to consider the structure and availability of cash. From a financial reporting perspective, it seems justified to increase the transparency of information regarding funds held in VAT accounts, which could reduce the risk of stakeholders misjudging the financial health of companies. More broadly, the results contribute to the development of research on the impact of fiscal policy instruments on business activity, pointing to the need to consider their consequences not only for state budget revenues but also for the financial stability of economic entities, upon which, after all, state budget revenues depend.

The conclusions drawn from observing the situation of medium-sized companies compared to small and large ones – which emerged alongside the tested hypotheses – are of significant importance for a broader reflection on the design of economic regulations. They demonstrate that the impact of fiscal policy instruments is not distributed evenly across all companies, and that entities positioned "in between" require special attention – being too developed to benefit from the flexibility of the smallest companies, yet not yet strong enough to fully exploit economies of scale.

Despite the findings obtained, it must be emphasized that the proposed approach requires further analysis. In particular, it is justified to extend the research to other sectors of the economy and to analyze the relationship between the level of "frozen" funds and actual liquidity problems, such as payment delays or insolvency cases. These directions may contribute to the further refinement of financial liquidity assessment tools under institutional (tax) constraints.

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DATA-DRIVEN DECISION-MAKING IN HUMAN RESOURCES MANAGEMENT: OPPORTUNITIES AND CHALLENGES

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Purpose: This paper examines the opportunities, challenges, and employee perceptions of data-driven decision-making (DDDM) in Human Resource Management (HRM), focusing on its impact on organizational efficiency, productivity, and engagement.
Design/methodology/approach: A mixed-method approach combines a literature review with a quantitative survey of employees in organizations using AI-enabled HR practices. Data were analyzed to assess perceptions, benefits, and implementation challenges based on established HRM and DDDM theories.
Findings: DDDM enhances decision objectivity, organizational outcomes, and employee engagement. However, adoption is limited by HR skill gaps, risks of dehumanization, and concerns about data transparency.
Research limitations/implications: The study uses a cross-sectional design with limited demographic variables. Future research should adopt longitudinal approaches and include broader factors such as industry and job roles.
Social implications: Ethical concerns—especially fairness, transparency, privacy, and dehumanization—may shape public attitudes toward workplace data use as DDDM adoption grows.
Originality/value: The study shows that employee acceptance of DDDM is driven more by ethical considerations than technological factors across all age groups, emphasizing the need for human-centered and responsible HR practices.
Keywords: Data-Driven Decision-Making, Human Resources Management.
Category of the paper: Research paper.

1. Introduction

1.1. Overview of Human Resources Management

Human Resources Management (HRM) is a strategic approach to managing employees to achieve better organisational performance (Van Vulpen, Verlinden, 2025). Bratton and Gold (2017) added that it is the strategic approach to managing employment relations which emphasizes that leveraging people's capabilities and commitment is critical for achieving competitive advantage. This means, that HRM focuses on attracting, managing, and retaining employees who actively contribute to the company's success, while ensuring they stay aligned with its strategic objectives and organizational culture (Van Vulpen, Verlinden, 2025). Contemporary literature points out that HRM brings together key basic elements: recruitment and selection, performance management, learning and development, succession planning, compensation and benefits, Human Resources Information Systems (HRIS), and also HR data and analytics (Van Vulpen, Verlinden, 2025). HRIS and HR analytics are not practices in itself but important tools of support and over the past decade, HRM has made a clear shift toward a more data-driven approach to improve outcomes and support management to make more objective decisions (Bratton, Gold, 2017). However, the adoption of digitalisation and analytics in HRM was preceded by a substantial period of transformation and gradual evolution. HRM was traditionally concerned with functional scope of managing people – it was primarily reactive and not necessarily always aligned with business goals. The function used to also be hands-on, with a focus on paper records and in-person meetings (Ankita Manekar, 2024). This often resulted in processes that could feel disjointed, especially when lacking any strategic involvement. The biggest drawback of the traditional HRM was that the teams are not always aware of what they could be doing before the organization or their employees need assistance (Jotform, 2025).

The emergence of the Fourth Industrial Revolution, known as Industry 4.0, created a need to redefine HRM in response to the demands of the new era and the term of HRM 4.0 was coined (World Economic Forum, 2019). HRM became strategic and this changed how HR departments operate, and the technology has become a major force in HRM (Prasad, 2024). Digital and social technologies advance organizational processes and the nature and meaning of works evolve. HR professionals operate in a technology-driven environment, and these technologies have replaced paper-based processes and enabled more efficient, data-informed decision-making (Cohen, 2025). Effective communication has also become central to the HR role, with clarity, empathy, and transparency emerging as core competencies (Cohen, 2025). Such change in traditional HR practices may be useful in determining how HR management systems and practices can respond to the potential opportunities and challenges associated with these changes (Connelly et al., 2021). The advancement in AI and digitization makes the process of evolution of technologies in HRM faster than ever changing

the relationship between employers, employees, and AI. Technology is being used in modern businesses, whether it is in learning and development, or management of skills by providing an innovative microlearning systems, all the way to exit interviews, employee engagement, and compensation and benefits (Tay, 2025). Therefore, HRM just like the technology is fast evolving and the academics and industry specialists speculate what it might look like. As reported by McKinsey, because of technology many roles are becoming fluid or disaggregated, and the prediction is that there will be a need for a flexible workforce defined in terms of skills with 66% of executives saying that those skills will be related to automation/digitalization (Komm et al., 2025). Among key imperatives that can help HR leaders to ready their organizations for the future identified such key components as purpose, value, culture, talent and agility, but also ecosystem which should answer question "How we grow?" (Komm et al., 2025). That ecosystem is closely linked with getting ahead by outlearning others, reaping value from data, and collaborating with HR-tech players and others in the wider HR ecosystem. Looking ahead, industry professionals hope that the future of HR will be increasingly people-centric, positioned as a strategic business partner able to help with the optimal decision-making aided by the modern technology (Cohen, 2025).

1.2. Defining Data-Driven Decision-Making

Data-driven decision-making (DDDM) constitutes a structured approach to organizational decision processes - simply saying DDDM involves utilizing data, facts, metrics and analytics to solve business problems with the key components being (Ghosh, 2023):

- data collection, which means the systematic gathering of information,
- interpretation, which is the organising and structuring of the information in a way that will be meaningful; and finally,
- analysis where data are extracted through various techniques.

DDDM is an approach that "emphasizes using data and analysis instead of intuition to inform business decisions" (Mucci, 2024). DDDM can assist in validating a course of action before the business commits to it, and the form and how it can be incorporated into decision-making process depends on individual business goals and the quality and number of data (Stobierski, 2019).

The origins of data-informed decision-making can be traced back to the early 20th century when one of earliest documented applications includes the statistical visualizations prepared by the American sociologist and civil rights activist, William Du Bois for the 1900 Paris Exposition (Bland, 2025). With his work he intended to illustrate socio-economic conditions of Black Americans and while the immediate impact of this initiative was limited, it nevertheless underscored the potential of data representation in shaping public discourse and informing policy (Bland, 2025). In the decades that followed, the development of digital technologies has facilitated widespread access to large volumes of data across sectors. Current projections suggest that global data produced by humans equals over 402.74 million terabytes daily (Mucci,

2024). This is only expected to grow, and as a result most likely influence data-processing and decision-making practices in the future.

DDDM leverages the various types of data analysis, systems and overall cognitive technologies - a term which describes "a field of computer science that mimics human brain function through a variety of means, including natural language processing, data mining and pattern recognition" (Kuzior, Kwiliński, 2022). Those technologies play a key role in DDDM because acting as tools that help extract valuable insights by analyzing data using advanced algorithms. Properly designed cognitive systems allow for the effective organization and management of vast amounts of information. These systems respond directly to the ever-growing volume of data generated. By analyzing data from various sources and reports, they increasingly support decision-making in management and streamline process management through well-designed workflows. It is being argued that every organization can benefit from integrating data into their decision-making processes by following simple steps and stages in the DDDM model (Gulia, Rastogi, 2024).

The future of DDDM is linked with what advancements occur such as the integration of AI and Internet of Things (IoT) is expected to generate powerful synergies, leading to more comprehensive and actionable insights (Sarioguz, Miser, 2024). As AI technologies continue to advance, DDDM will too increasingly involve the automation of complex decision-making tasks. Machine learning models will be capable of handling sophisticated processes, allowing businesses to automate routine decisions and allocate human resources to more strategic, high-level responsibilities. This shift promises faster and more accurate decision-making, particularly in environments that require real-time responses to large-scale data (Sarioguz, Miser, 2024).

DDDM is becoming a crucial component of contemporary business practice – this is because the strength of DDDM lies in its ability to optimize organizational efficiency and improve strategic decision-making thanks to the use of factual information (Loscher, Bader, 2023). From an operational standpoint, data use supports forecasting, inventory control, and cost optimization, enabling more precise planning in areas such as procurement and staffing (Mucci, 2024). Recent studies and academic reviews confirmed that integrating data analytics into HR processes can enhance decision accuracy, reduce biases and provide insights about workforce trends (Odionu et al., 2024). The need for organizations to use data for accurate and evidence-based decision also founds its use in HRM and the DDDM has integrated into this function.

1.3. Integration of data-driven decision-making in HRM

Data-driven solutions are increasingly recognized as potentially value-generating interventions within Human Resource Management processes (Sohani et al., 2025). However, existing analyses in an available literature review point out a discrepancy between the perceived strategic value of AI applications and their actual operational effectiveness. This is because not

many organizations feel they are ready to adopt technologies, and the actual utilization of HR analytics remains limited. The lack of readiness includes such common barriers as inadequate data infrastructure, internal resistance, and the absence of data-centric organizational cultures (Ghosh, 2025). However, at the same time the field of HRM has been a subject to transformation over the last few years and the technological advancements changed the dynamics of contemporary workplaces, putting an emphasis on need to challenge the status quo in order to remain competitive (Odionu et al., 2024). The conflict between the readiness to adopt the technological changes and the need to evolve revealed the drawbacks of the traditional HR further advertising for the need to adopt data-driven solutions.

The exact beginning of adoption of the DDDM in HRM can be difficult to pinpoint, although some research points out to the technological transformation in HR which began with the use of IT systems in the late 20th century. Initially the aim was to organize routine payroll tasks and employee record-keeping – so to automate the highly time-consuming administrative activities. As time went on when the capabilities of the systems evolved, developers began to include and expand the features such as reporting, analytics and streamlining of tasks (Gulia, Rastogi, 2024). By using those systems HR could contribute to organizational value primarily by enhancing operational efficiency, particularly through the automation of repetitive or routine tasks. It begun to empower organizations to make more informed decisions and save time in the process (Gulia, Rastogi, 2024). In this period of transformation DDDM has allowed to reshape the HRM function into strategic partner – its goal is to create a culture that uses data to make informed decisions, at the same time allowing HR processionals to align HR objectives to those of the organization (Gulia, Rastogi, 2024). Data-driven HRM, sometimes called HR analytics or people analytics, involved leveraging employee and organizational data and analytics to retain talent, drive employee engagement and improve productivity (Gartner, 2021). Data-driven HRM is enabled by various systems and platforms such as HR administrative, Learning management, and various data analytics systems systems (Gulia, Rastogi, 2024):

Further digitalization enabled through cloud-based solutions, is not only allowing automation of tasks but thanks to the integration of many functions allowed for even higher efficiency, accuracy, and instant data backups allowing HR teams to focus on core business activities and more strategic work (Purnomo, 2023). HR functions are adopting not only data analytics solutions, but also other technological advances: chatbots, AI, mobile applications, automation are the most commonly used. Chatbots for instance can be utilized to answer some routine questions regarding company policies and procedures; automation allows to delegate the previously manual tasks, like contracts drafting or scheduling of interviews, mobile applications mean real-time access to employee data, pay and leave details, benefits overviews, timekeeping recording or even learning and development. Data analytics assists with trends and patterns identification thus further assisting Business Partners and leadership to focus on strategic directions (Purnomo, 2023). Further evolution of DDDM solutions into HRM allowed

HR to utilize even more sophisticated systems and solutions such and dashboard, data visualization, predictive analytics and employee surveys adopting sentiment analysis (Purnomo, 2023).

Although, in the field of Human Resource Management, data-driven decision-making and adoption of technology can still be perceived as a disruption (Purnomo, 2023) nonetheless integration of those two fields does bring many strategic advantages to HRM. Empirical studies indicate a positive relationship between the application of analytics in HRM and organizational performance, particularly where HR strategies are closely aligned with broader institutional objectives (Odionu et al., 2024) and CIPD in their global study have found that organizations with a robust people analytics function perform better than other organizations and there is a correlation of strong business performance with strong culture (CIPD, 2018). The key to integrating DDDM with HRM from the organizational standpoint is therefore the strategic focus – development of comprehensive plans for understanding and using the data and the vast amount of it can be used to guide better decision-making (Schmidt, Olson, 2024).

1.4. Ethical considerations

In an organizational context ethics, and more precisely - business ethics, is a field which is devoted to moral issues that arise in economic activity (Orbik, 2023). As modern technology increasingly shapes what people are capable of doing, many argue that a distinct ethical framework is needed to guide its development and use, especially when assessing its broader consequences. Therefore, a concept of ethics of technology has been created to help to answer some of the questions. Technology can be used to achieve both positive and negative outcomes, depending on how its impact is being interpreted so from this perspective, hence the ethical issues linked to technology are not different from those found in other areas of human activity (Braunak-Mayer et al., 2012).

Although the use of technology has often been perceived as a more objective and impartial decision-making agent, there is growing research that challenges this assumption highlighting potential of technology to repeat or even increase biases (Tambe et al., 2019). Such cases have been well documented in recent years - for example, Amazon's AI recruitment tool discriminated against female candidates or the iTutor Group's hiring system was configured in such a way that it rejected female job seekers over 55 and men over 60 years of age (Sheard, 2025). The above examples represent so called algorithmic, and specifically training data and representation bias, and it is where existing beliefs and data would support a particular existing concept. This type of prejudice is only one type of algorithmic bias, and DDDM are also prone to (Alvi, 2025):

- Sampling bias – where dataset does not reflect the actual population, which might be a problem in recruitment tools with real-world applicants.
- Automation bias – tendency for human-makers to trust automated systems regardless if they are flawed or not, which leads to overconfidence and potentially making business decisions on subjective data.
- Confirmation bias – refers to human tendency to see evidence that confirms preexisting beliefs, for instance a recruiter may accept biased AI suggestions only because they align with their own thinking or unconscious stereotypes.

Beyond this technical bias, there are also ethical concerns. Some researchers argue that the use of AI can serve as a convenient means for individuals and organizations to evade accountability, effectively outsourcing ethically questionable decisions to algorithms. As decisions made by AI are driven by heuristics embedded within historical data, any pre-existing bias in that data is likely to be reproduced — without a clear point of human responsibility (Tambe et al., 2019). HR deals with highly sensitive and personal data so the use of analytics in this domain raises serious privacy and ethics questions and the responsible use of data is of the highest importance (The Institute of Data, 2025). Data privacy especially plays a vital role in HR decision-making as it is safeguarding employee rights, and it is aimed to ensure a fair treatment to all employees. HR professionals are bound to respect such privacy and be able to make informed and unbiased decisions. The first step to ensure proper measures, are the legal requirements placed on organizations through compliance and legislations such as GDPR in European Union. GDPR also applies in Poland and together with the Protection of Personal Data Act both governs how HR data must be handled (The Institute of Data, 2025). Non-compliance can result in severe penalties and reputational damage for the business. For instance, in 2020 H&M was fined 35.5 million Euro for their intrusive people analytics where the company was collecting data not related to employment like employee's family situation and religious beliefs without any legal basis to do so (Moss, 2025). It is evident that in line with the privacy of data transparency is also crucial. It is employees' right to know and understand how and where their data is being used, how and where it is collected and finally how it is being used, and who has access to it (Moss, 2025). There have been numerous studies done confirming that when organizations are transparent about their HR analytics practices, they are more likely to build long-term trust with their employees. Moreover, when employees receive clear information on how their information is being used the employee engagement increases by 20% in some cases, and the turnover rate is reduced by 15% (Vorecol, 2025).

Further, it is important that considerations regarding use of DDDM include:

- The need for accountability – it means that HR and managers take responsibility for their actions but also give visibility to certain outcomes, HR's role in this process is to be champions and anchor their practice to other management functions (Loscher, Bader, 2023).

- The need to balance innovation with ethics – analytics can be a powerful tool for HR professionals and organizations to make data-driven decisions related to HRM, however the need to gain insights and test innovative solutions cannot happed at a cost of responsible treatment of employees personal or sensitive information (Vorecol, 2025).
- Stemming from the above, emphasis needs to be placed on informed permission, where individuals are made aware of how their data will be used and are given the choice to opt out. Techniques such as data anonymization and aggregation should be implemented to allow valuable insights without compromising individual identities (Sarioguz, Miser, 2024).
- Finally, the need to adopt robust data security practices, including encryption, secure storage, and regular audits, help maintain the integrity of the information being used. Cultivating a culture of ethical data usage requires ongoing education and awareness within organizations (Sarioguz, Miser, 2024).

Invasive analytics or opaque data practices can erode trust - as one case study noted by SHRM showed that deploying predictive people analytics without transparency led to decreased trust among employees and that although 87% of organizations use analytics, only 19% of HR professionals believed that working with Al-analytics eliminated bias (Alexandria, 2023; Vorecol, 2025). The Institute of Data (2023) does recommend that organizations invest in specific training for ethical considerations for HR professionals so that they are equipped with knowledge and skills to make well informed and responsible decisions when dealing with data-based outcomes. Additionally, HR departments must implement robust data governance: ensuring data is anonymized where possible, used only for legitimate purposes, and protected from breaches. They also need clear ethical guidelines and communication – employees should know what data is collected and why. Cultivating a culture of ethical data usage requires ongoing education and awareness within organizations. Training programs should be established to help employees understand the ethical implications of data-driven decisions and the importance of accountability. An ethical challenge is to find a balance between analytics' insights with respect for individual privacy and fairness (Vorecol, 2025). For example, predictive models might identify an employee as a "flight risk" or "low performer" – using such insights must be handled sensitively and without bias or discrimination (Vorecol, 2025). As technologies such as AI and IoT continue to evolve, these ethical foundations will be critical for ensuring that data-driven innovation aligns with socially responsible decision-making practices.

1.5. Employee perceptions towards data-driven HRM

The integration of algorithms and technology into formal decision-making processes influences employees' experiences and behaviors (Tambe et al., 2019). It is not a new issue in the field of HRM because when the era of Scientific Management introduced systematic rules

for workplace decision-making they were often met with resistance from workers, leading to prolonged tensions between workforce and management (Tambe et al., 2019). For HRM and the business practices such as segmentation of work into simplified tasks were justified as they increased efficiency, however from the perspective of frontline employees, the situation likely resembled today's algorithmic models: decisions appeared to originate from distant departments, were presented as scientifically optimal, lacked transparency, and offered little room for feedback or adaptation (Tambe et al., 2019).

One particularly relevant concern in the context of algorithmic decision-making is its potential to disrupt established relational dynamics in the workplace between supervisors and their teams, and as a result affect trust between both (Tambe et al., 2019). This is because if, for instance, an unpopular shift is assigned by a supervisor, an employee may accept it due to accumulated goodwill or empathy for the supervisor's constraints. When the same decision comes from a software system, no such empathy or informal reciprocity is possible. The algorithm cannot be negotiated with and held accountable, which may lead employees to feel detached, powerless, and less motivated to accommodate organizational demands (Tambe et al., 2019). A study done by the 2025 Edelman Trust Barometer survey reported that 67% of employees doubt the fairness of AI-driven HR decisions, reinforcing the low trust that these tools will provide just decisions (LinkedIn, 2025). Additionally, 79% of job candidates say that they want to be informed and AI is used in hiring (Machell, 2024). A survey among over 2300 HR professionals also emphasizes a growing interest in AI and a conviction that AI in HR should support, rather than replace human judgement (SHRM, 2024). This attitude might have its origins in the publicized issues where some people experienced discrimination due to algorithmic biases, as discussed in previous chapters. Candidates lack trust is increased when supervisors are removed from processes like recruitment, because then it is uncertain whether those supervisors will exhibit the same level of commitment to new hires as they would if they had been personally involved in the selection (Tambe et al., 2019). Lack of transparency in the use of AI in key HR activities can erode trust even further. Experts emphasize that the transparency and explainability are crucial in building trust in HR analytics, and clear and honest communication about how the adopted algorithm, or technology work can alleviate that suspicion (Machell, 2024). On the other hand, it has been proven that when algorithms are capable of visibly updating in response to mistakes, they may be perceived as more legitimate (Tambe et al., 2019). Transparency can improve the acceptance of the use of DDDM - as one expert observed, when candidates see clear guidelines on how their qualifications are being assessed by an AI, it leads to a more positive perception of the hiring process (Machell, 2024). In practice, organizations that share data-driven findings and involve employees in interpreting them tend to see more buy-in. For example, a McKinsey analysis noted that companies using explainable AI and open communication achieved much higher employee adoption of HR analytics systems (LinkedIn, 2025).

The issue of trust and transparency is closely lined with concerns relating to privacy of data, specifically data collection and how it is used once stored in the organizational systems. Studies confirmed that many employees are wary of how their data might be collected and used. For instance, Deloitte found 56% of employees are concerned about the privacy implications of HR analytics, particularly regarding the use of their personal information (SHRM, 2023) Employees worry about how their data are collected and used – for instance, whether organizations monitor their emails. Academic research confirm that algorithmic HR tools can blur the boundary between workplace and personal life, leading to a feeling of constant surveillance. Employees typically cannot easily opt out of workplace monitoring, and this worry about uncertainty where employees' privacy ends can negatively affect well-being in but also outside of work (Leicht-Deobald et al., 2019).

Studies showed that employees are also concerned with the lack of human element in decision-making causing overreliance on data. What this means is that when important decisions are made solely by algorithms, this brings negative reactions from the workforce (Leicht-Deobald et al., 2019). In one experiment, participants viewed algorithmic personnel decisions as less fair and less trustworthy than human decisions, and these decisions also evoked stronger negative emotions (Leicht-Deobald et al., 2019). Academics argued that that over-reliance on rigid, data-driven rules may marginalize human sense-making, effectively crowding out employees' and managers' ability to exercise judgment or show compassion (Leicht-Deobald et al., 2019) and this can translate feeling of being treated as a number rather than a person, further fueling resistance to data-driven solutions. Another factor in shaping employee perceptions is automation of processes. Automation of HR activities decreased the percentage of time spent on transactional activities allowing to focus on transformational HR. This is what allowed the HRM to shift towards modern, strategic HRM (Bauer et al., 2023). However, from the employee's perspective it can bring worries about job security.

What became evident in recent research by CIPD is that attitudes towards DDDM in HR are also affected by the practical implications like skills and knowledge of HR professionals adopting data-driven HRM, proving that the more advanced data-driven solutions the lower is the confidence to conduct advanced analytics by HR professionals (CIPD, 2018). Such lack of knowledge and skills in data literacy is the primary barrier to adopting HR analytics (Deloitte, 2025). This skills deficit has a direct impact on attitudes: HR professionals who feel underprepared or intimidated by analytics may be less trusting of data-driven insights and more reluctant to use them. The literature describes a lack of confidence and confusion among some HR executives in how to properly adopt and leverage analytics (McIver et al., 2018). This is supported by HR professionals in organizations using people analytics, who report varying perceptions and attitudes toward data-driven HRM (Alexandria, 2023). In a recent study 82% of HR processionals said that their organization uses people analytics to assess employee retention and turnover and 71% use people analytics to assess recruitment,

interviewing and hiring. However, despite of such widely adopted use, the professionals feel that (Alexandria, 2023):

- more than half of HR executives whose organisations use people analytics say their organization provides insufficient resources to upskill HR professionals on data literacy (5 %) and to support their data infrastructure (56 %),
- only 29 % of HR professionals whose organisations use people analytics believe their organization's overall data quality is high or very high,
- staggering 95 % of HR professionals whose organisations use people analytics agree it is important to understand the rationale behind an Al algorithm's decisions, and 88 % would not trust the recommendations without this knowledge.

Industry specialist across field of HRM advocate for adoption of best practices for all those organizations wishing to adopt DDDM. They claim that in order for AI technology to be effective it must rest on strong foundations which do include not only a commitment to invest in knowledge and expertise needed to follow best practices (SHRM, 2025) such as to invest in fundamentals – amongst which the key are: an upskill HR data literacy, support data infrastructure, supply data tools and technology, quality of data, understand and be prepared to explain how people analytics is used to make decisions – transparency and elimination of the black box in rationale behind AI-aided decisions. It is also important to implement fair, ethical and responsible uses of people analytics – due to the importance the requirements for audits of systems checking for bias is slowly becoming written into regulations and mandates.

2. Methods

2.1. Research design

This study employed a mixed empirical and theoretical approach, combining a literature review on data-driven HRM with a quantitative survey of employees working in organizations that use AI-enabled HR practices. The research objectives were addressed by analyzing employee perceptions, organizational benefits, and implementation challenges through structured survey data, supported by hypotheses derived from established HRM and data-driven decision-making theory. This method was selected for its suitability and strengths such as adoption of thorough frameworks for confirming or disproving theories, the benefit of standardization, scalability and speed and finally to ensure objectivity and reproducibility for any potential future research (Lim, 2024).

Aim of the quantitative research design is to examine the opportunities and challenges of data-driven decision-making in Human Resource Management. A structured online survey was used as the primary data collection method, enabling hypothesis testing, standardized data gathering, and replicability. The design aligned with the study's objectives to:

- analyze the impact of data-driven decision-making in Human Resource Management (HRM) on organizational efficiency, employee productivity, and engagement,
- identify key barriers to the successful implementation of data-driven HRM, including skill gaps, data quality issues, privacy concerns, and resistance to change,
- explore employees' perceptions of data-driven HRM, focusing on trust, fairness, and the role of transparency in shaping their acceptance of data-driven practice.

2.2. Data collection methods

Quantitative research design offers a potential of delivering measurable results for analysis, however it has to be pointed that there are some potential shortcomings that can hinder the successful analysis when adopting this particular method. The issues may be related to a broader concept that affects contemporary social sciences today which is the connection between the pace of technological development shaping the modern world and the pace of development of research methods and contextual conditions (Komańda, 2011). In this context, engaging in online quantitative research places responsibility on the researcher not only for the design and implementation of the research procedures but also for safeguarding the individuals who participate (Komańda, 2011). To ensure respondents' privacy and confidentiality, the questionnaire did not collect email addresses or other identifying information. Although Google Forms automatically record the completion timestamp, no data such as IP addresses or geographic location were captured.

This study adopted a non-random sampling, because the research question required to focus on a specific sample group of the population. This sampling choice occurred in a judgmental and purposeful strategy and then snowballing method was selected. This practical approach allowed to reach individuals fitting the specific population of people being employed in an organization using data in their decision-making. This sampling method was preferred as it provides a starting point to explore group-specific issues, captures niche viewpoints, avoids low response rates, and is not limited by location (Qualtrics, 2025). However, to mitigate the bias in sampling a snowballing sampling was employed where study subject from several organizations recruited future subjects from among their acquaintances from the same and other workplaces alike (Lim, 2024).

3. Discussion

This study, which was based on a literature review and HR industry publications that discuss the benefits of using data-driven HR practices, examined whether effective implementation of data-driven HRM leads to improved efficiency, productivity, and engagement. A multiple regression model was performed using an implementation index, calculated as the row mean of key survey questions relating to HR efficiency, ease of using HR systems, quality of outcomes, engagement, and the impact of data quality. The analysis shows that employees generally perceive data-driven HRM as contributing positively to efficiency, ease of tasks, and performance outcomes. High agreement rates across respondents' questions indicate strong recognition of the benefits of HR technology. A majority also acknowledges that poor data quality has a clear negative impact, reinforcing the importance of reliable data for effective HR decision-making. The evidence from respondents' responses strongly supports the statement that effective implementation of data-driven HRM leads to improved efficiency, productivity, and engagement. Across multiple questionnaire items, respondents consistently reported positive outcomes associated with data-driven HRM implementation, specifically:

- 77% of respondents (39% Yes, 38% Rather yes) agreed that data is used in their organisation to improve HR efficiency. This high level of agreement affirms that employees perceive data as an enabler of more efficient HR processes.
- A combined 74.2% agreed that data helps make HR tasks easier, reflecting clear productivity benefits.
- 65.4% believe data-driven HR leads to better outcomes than traditional methods.
- 62.9% of employees perceive a positive impact on their own engagement and performance, though this is slightly lower than for efficiency and productivity. Notably, 22% expressed uncertainty, indicating that the link between data use and personal engagement may be less visible or less clearly communicated.

The findings of this study align with a growing body of literature indicating that the adoption of DDDM in HRM enhances organisational performance, particularly in terms of efficiency, productivity, and employee engagement. Empirical evidence from prior research supports this relationship. For instance, studies by McKinsey and CIPD consistently show that organisations with advanced people analytics capabilities outperform their peers in both financial performance and talent outcomes.

The study also looked at the analysis of skills and competencies of professionals responsible for using data and technology in HR. As mentioned, lack of knowledge and skills in data literacy is the primary barrier to adopting HR analytics (Deloitte, 2025). The previously cited SHRM study of almost 2300 HR professionals revelated that about 70% of respondents have experienced challenges such as employee resistance, data privacy issues and not having the resources such as a dedicated role within HR sitting with the HR IT function, to correct

algorithms (SHRM, 2024). The results of this study mirror this sentiment and show mixed levels of confidence in HR's analytical skills: while over half believe HR teams possess the required competencies, a sizable proportion disagrees or is uncertain. Privacy concerns are also divided—almost half of the respondents are worried, while a similar number are not. A strong majority indicate that transparency, human oversight, and clear explanations significantly increase acceptance of data-driven HR decisions. Preferences for traditional HR methods remain notable, with many employees perceiving that managers and colleagues favour conventional approaches. These patterns indicate that barriers exist, especially regarding HR capability, privacy concerns, and resistance to change. It must be noted that there's an overwhelming recognition (95.6% combined Yes and Rather Yes) that poor data quality negatively impacts decision-making and its outcomes. However, when placed against the multiple regression analysis the effect was found but only in a small effect:

- Only 54.8% of employees believe their HR team has the necessary data skills. A substantial 20.8% disagreed, and a high 24.5% were unsure indicating a perceived competence gap. Furthermore, "lack of skills in HR staff" was the second most frequently cited concern in Question 11, reinforcing this perception.
- 82.4% agreed that poor data quality harms decision-making, showing widespread awareness of its importance. However, the relatively low standard deviation (0.98) and small "disagree" segment (5%) indicate that this is a well-established assumption rather than a controversial issue.
- Privacy emerged as divisive. While 47.8% expressed concern, 41.5% did not. The polarisation of responses suggests that privacy is a salient but individualised concern, possibly influenced by trust in employer practices.
- 44.7% of respondents perceive a preference for traditional HR among colleagues/managers. However, 35.8% selected "I don't know," indicating a lack of awareness rather than a clear rejection of new methods. Thus, resistance appears passive or uncertain rather than active.

Finally, the study aimed to identify whether there exists a lack of human intervention as the most significant concern, followed by insufficient HR skills and the risk of bias or discrimination. Research and surveys presented by SHRM, Machell, McKinsey, CIPD and others indicate that transparency and explainability significantly increase employee trust and acceptance even though and despite concerns in this area, and as revealed by this study - a majority trust their organisations to use HR data fairly and would welcome additional transparency. Clear and regular communication was overwhelmingly seen as a way to increase trust. General attitudes toward data-driven HRM vary while a substantive group sees benefits in fairness and objectivity, others are sceptical or neutral, often due to concerns about depersonalisation or over-automation. The results indicate that negative concerns (privacy, bias, fairness) do indeed shape perceptions, while transparency, communication, and fairness significantly improve acceptance. Cconcerns over privacy significantly impact employee's

perception of data-driven HRM. Job security appears not be of a concern, and according to survey responses it has a positive outlook – this mean that according to survey respondents' data-driven can improve their sense of job security. Respondents do not feel the concern of bias is significant and it does not affect their perception of DDDM - 76.1% (48.4% Yes + 27.7% Rather yes) confirm that regular and clear communication about data usage would increase their trust in HR decisions.

Fairness is the key factor determining trust in the data-driven HRM with 33.8% of the sample confirmed that their feelings towards DDDM depends on other factors specifically how the data is used, this acceptance of data-driven HR is contingent on how it is implemented and used. Those statements reaffirmed that regular and transparent communication significantly increases employee trust in data-driven HRM.

The findings of the study indicate a positive perception of data-driven decision-making in Human Resource Management, but they also reveal significant concerns related to lack of skills in HR professionals, loss of human oversight and data privacy. Businesses can address those issues through:

- Continuous learning and development programs focused on HR analytics. HR professionals should be trained in data interpretation, ethical considerations in data use, and effective communication of data-driven insights.
- Establishing formal data governance frameworks, including regular audits and validation protocols to ensure the accuracy, completeness, and relevance of HR data. Implement data stewardship and ownership roles to oversee HR data quality and ensure compliance with organizational standards.
- A human-in-the-loop approach, especially in sensitive HR decisions such as performance appraisals, promotions, and terminations. Data should inform but not override managerial decisions, ensuring that the human aspect of HRM is preserved.
- Clear, accessible communication strategies to explain what HR data is collected, how it is analysed, and how decisions are made.
- Clear, accessible mechanisms for appealing or reviewing data-driven decisions. Through regular fairness audits organisations should ensure that fairness principles are visibly embedded in the design of HR processes and tools.

4. Summary

This paper examined employee perceptions of data-driven decision-making in Human Resource Management with a focus on both the opportunities and perceived challenges. Through a literature review, structured survey and multiple regression analyses, the research explored the effectiveness of data-driven HRM in enhancing HR efficiency, productivity,

and employee engagement, as well as factors that may influence employees' trust and acceptance of these practices.

The findings of the research confirmed that the use of data in HR processes is positively associated with perceived improvements in organizational efficiency, task productivity, and employee engagement. This aligns with existing literature emphasizing the strategic benefits of HR analytics. While the lack of HR analytics skills among HR professionals emerged as a significant barrier, other anticipated challenges - such as poor data quality, resistance to change, and privacy concerns - did not show statistically significant negative effects within the regression model. This suggests that employee perceptions may be more influenced by capability and execution than by the broader conceptual risks of data-driven systems. Concerns about privacy had a measurable negative effect on perceptions of data-driven HRM, validating the importance of ethical data handling. In contrast, concerns about algorithmic bias and job security were not found to significantly influence attitudes in this sample. Among the positive factors, perceived fairness and clear communication were important predictors of trust, while transparency alone did not yield a significant effect, emphasizing respondents' views that how data is communicated is impactful.

From the literature review and the empirical study, it can be concluded that data-driven HRM can bring both opportunities and challenges. Perceived opportunities include:

- using data to improve HR process efficiency within organisation,
- use of data in HR decisions can positively influence engagement and performance,
- regular and clear communication are crucial to increase trust in HR decisions,
- good quality data is seen as essential for realising the benefits of HR analysis.

Perceived challenges include:

- skills gap in areas such as lack of confidence and knowledge in using data analytics effectively among HR professionals,
- risk of dehumanisation mainly lack human intervention in decision-making, closely linked with:
    - over-reliance on data in as opposed to using it in line with human judgement,
    - privacy concerns and lack of transparency.

While the findings provided insight into data-driven HRM supporting research derived from the literature review, several limitations must be acknowledged. The research relies on self-reported data of non-random convenience sample, which may be subject to response bias or inaccuracies that could come from employees' knowledge of internal HR systems. The study was performed as one-time research therefore it does not provide further insight about of how perceptions could evolve over time. The sample was largely composed of educated and younger respondents, which may not fully reflect the broader workforce diversity. The analysis included age as a demographic factor, other potentially influential variables such as a job role, specifically managerial versus non-managerial positions, organizational size or industry were

not included in the data collections. These limitations suggest caution in generalizing the results beyond the studied context.

Future research could explore the development of employee perceptions over longer periods of time. Studies could also investigate sector-specific or role-specific attitudes, particularly among blue-collar or frontline employees. Future research could be supported by qualitative methods such as interviews and focus groups as it could provide deeper insight into how employees interpret fairness, privacy, and managerial transparency in real-world HR decisions.

In summary, this study confirms the potential of data-driven decision-making in Human Resources Management within organizations at the same time emphasizing the importance of employee-centered implementation. Data-driven decision-making may offer opportunities for improving fairness, efficiency, and strategic alignment in HR practices. However, its successful adoption ultimately relies on employee trust, ethical safeguards, and the preservation of human judgment. In recognizing these conditions, organizations can more effectively leverage HR analytics to build not only more efficient but also fairer and more inclusive workplace.

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PERCEPTION OF PRICE IMAGE DIMENSIONS OF TWO COMPETING DISCOUNT RETAILERS: RESULTS FROM AN EMPIRICAL STUDY

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Purpose: This article aims to identify potential similarities and differences in the perceptions of price image dimensions related to the two analyzed discount store brands. This assessment is especially relevant because these two brands vary significantly in size (with approximately 3500 vs. 900 stores) and are involved in a price war, which has resulted in a so-called marketing duopoly, despite the presence of other discount retailers and alternative store formats.
Design/methodology/approach: The content addressed five dimensions of the price image of discount retailers: price-level perception, value for money, price perceptibility, price processibility, and price evaluation certainty. The survey was conducted in 2024 using Computer-Assisted Web Interviewing (CAWI). It included 621 respondents who prefer one of the two discount brands that have been involved in a price war since 2023. A series of one-way ANOVAs was conducted to compare six variables across two discount retailers. For each analysis, F-statistics, partial eta squared effect sizes, and estimated marginal means were reported.
Findings: The research provides a detailed analysis of price image, highlighting similarities in the perception of dimensions associated with perceived value, price level, and price evaluation certainty. However, it also identifies differences in the clarity of price communication, particularly concerning price perceptibility and price processibility.
Research limitations/implications: Although this study revealed statistically significant differences, the small effect sizes indicate limited practical relevance. Therefore, conclusions and recommendations should be interpreted with caution. Future research should consider longitudinal designs, regional analyses, and more advanced statistical approaches to address current limitations and deepen understanding of the observed patterns.
Originality/value: This article represents the first attempt to conduct an in-depth examination of the price image of retailers operating in the Polish market. In research, the price image is usually treated as a single variable, without specifying its components. In this research, two discount retailers involved in a price war were analyzed based on the five dimensions of price image identified in the literature. Given the challenges associated with capturing a price war as a market phenomenon, the findings presented in this study are particularly valuable.
Keywords: price image, discount retailer, price communications, price competition, price war.
Category of the paper: research paper.

1. Introduction

Consumer price perception is the mental process through which individuals interpret and assign meaning to price-related information. How consumers perceive a store's pricing plays a key role in shaping their information-seeking behavior, choice of store, and purchasing decisions (Lii et al., 2023). Zielke et al. (2023) indicated that effectively managing price perceptions is crucial for brand managers because a brand's price image can act as a significant filter, influencing customer preferences and purchase intentions even before they begin searching for price information on a specific product. Scholars have highlighted the relevance of examining price image, as it plays a crucial role in shaping consumers' price perceptions and influencing their behavioral intentions (Chang, Wang, 2014). Store image is important for retailers and marketing managers' business strategies, as it ensures market differentiation (Graciola et al., 2020), with store price image representing a key component of the overall store image. The issue of price image is complex, especially in light of the growing awareness of its multidimensional nature (Bondos, 2015). As early as the 1970s, definitions began to identify the essence of price image (e.g., "a 'buyer attitude towards price on the assortment level" (Zielke, 2011, p. 332), although they did not yet reflect the multidimensional nature of the concept. Zielke (2006, p. 299) defined a price image as "a multidimensional latent variable that consists of subjective beliefs and feeling about the pricing activities of a retailer's company, store, or category". In the view of Hamilton and Chernev (2013), price image reflects consumers' general beliefs about the price levels they associate with a given retailer.

In today's competitive market environment, in-store promotions and price discount tactics are crucial strategies used by marketing practitioners to attract customers (Park, Jang, 2025). Using AI for pricing is becoming increasingly common. AI can adjust prices in real-time and use personal data to predict buying behavior and offer personalized prices (Chen et al., 2024; Jung et al., 2024). While price promotions are considered an important method for boosting business performance, it is important to recognize that their results can vary because managers typically implement a mix of different promotional approaches (Niu et al., 2024). At times, the competition between retailers becomes so intense that it is justified to refer to the phenomenon as a price war.

According to literature, a price war is a particularly intense form of price-based competition that arises when one or more firms decide to substantially lower their prices to gain a strategic advantage or expand their market position. A price war describes a situation where companies compete for market share by reducing their prices (Cheng, 2024). It constitutes one of the most intense forms of competitive interaction in the marketplace (Heil, Hensen, 2001). This initial price action often provokes similar responses from competitors, resulting in a downward spiral of price cuts and increased market pressure. Such situations are typically driven by factors such as market saturation, the entrance of new competitors, declining profitability, or intentional

competitive strategies. While price wars may offer short-term gains for consumers, they often lead to shrinking profit margins for firms and can negatively impact long-term market dynamics and stability (Nivornusit et al., 2024). Price wars have become a growing trend in numerous sectors of the market (Krämer et al., 2016). At the beginning of the 21st century, the level of understanding of the unique phenomenon of market competition known as price wars was limited, as little was known about their nature and how they emerge (Heil, Helsen, 2001). However, despite the limited understanding of the phenomenon, price wars among large retailers were considered common (Heerde et al., 2008). Price wars are increasingly frequent because managers often perceive changing prices as a simple, fast, and easily reversible move (Rao et al., 2000).

Numerous typical price-related differences exist between online and offline buying processes (Berends, Gerpott, 2025). This study focuses specifically on the formation of price image within the offline retail environment. Competitive pricing involves all actions and strategies related to setting product prices while taking competitors into account. It goes beyond simply matching rival prices, encompassing a broader analysis of both current and anticipated pricing behaviors of competing firms, to achieve long-term profit maximization (Gerpott, Berends, 2022).

Most price wars begin unintentionally, often due to minor misunderstandings or misinterpretations of market conditions. It is uncommon for a price war to be launched as a planned competitive strategy – and even less common for one to end satisfactorily (Garda, Marn, 1993). However, according to the authors, the context of the price war described in the article should not be considered accidental. In the analyzed case, we observed a price war initiated by large retailers. During retailer-initiated price wars, hundreds of brands are affected simultaneously, which influences both brand and retailer positioning (Sotgiu, Gielens, 2015).

This article examines price competition between two major discount retailers operating in the Polish market. The ongoing price war between them serves as a clear example of competitive pricing. Both chains set their prices with the competitor in mind, yet do not simply copy each other blindly. Instead, they continuously monitor each other's pricing strategies and respond to changes in order to attract customers while aiming to maximize their profits. Such actions reflect the essence of competitive pricing.

In the pricing management literature, the issue of price communication is not sufficiently emphasized (Krämer, 2020). This article aims to identify potential similarities and differences in the perceptions of price-image dimensions across the two analyzed discount-store brands. The primary source for the study and subsequent analyses was the article by Zielke (2010), which defined the dimensions of price image. Although the concept of price image dimensions has been considered in various ways in later publications (Susanto et al., 2023; Zielke, 2011, 2018; Hamilton, Chernev, 2013; Chang, Wang, 2014; Amara, Bouslama, 2011), the authors focused on Zielke's (2010) framework. Below, each of the five dimensions is presented and explained.

Price-level perception refers to how consumers assess whether prices are high or low, without necessarily considering differences in product quality. This perception often starts at the individual product level but can influence views of the overall price level of an entire store. At the category, store, or retailer level, price-level perception is often used interchangeably with the term price-level image. When it comes to individual products, consumers form price-level perceptions by comparing a product's price to a benchmark, commonly called the reference price (Zielke, 2010; Roth et al., 2017).

Value for money is commonly understood as a balance between what is given and what is received (Zeithaml, 1988). In the retail context, it represents the result of a trade-off between the costs incurred and the benefits gained from both product and store attributes. While price-level perception and value for money are seemingly interconnected, a retailer may be evaluated differently on each dimension (Zielke, 2010). *Price perceptibility* describes the degree to which customers can effortlessly and clearly identify price information in a retail setting, reflecting how visibly and accessibly prices are presented on products or shelves. In this context, practices related to price labelling play an important role.

Price processibility describes how easily consumers can mentally process and compare the prices of different product options while shopping at the point of sale. Zielke (2010) suggested that although price labelling can serve as a precursor to price perceptibility, the level of price processibility may be influenced by factors such as the use of unit pricing or the organization of shelf displays. And finally, price e*valuation certainty* describes how easily consumers can assess prices ("how easily customers perceive the price-evaluation process" Zielke, 2010, p. 751). Such as difficulty may relate not only to evaluating the prices of individual products, but also to judging the overall price positioning of an entire store. Researchers emphasize the distinct nature of this dimension of price image compared to price processibility and price perceptibility, and highlight its connection to the consumer's level of price knowledge.

2. Methods

A series of one-way ANOVAs was conducted to compare five variables across two discount retailers involved in a price war. The set of variables comprised five dimensions of price image identified by Zielke (2010). For each analysis, the F statistic and effect size (measured by partial eta squared) were reported. Estimated marginal means were used to illustrate group differences between the retailers. All analyses were performed using SPSS, with the significance level set at α=.05. The variables included in the one-way ANOVAs were derived by averaging the items that define each construct.

The individual variables included in the analysis were adapted from the scientific literature (Zielke, 2010) and defined as presented below.

Price level. PL1: *Prices at discount stores are typically low*; PL2: *You can find affordable products at discount stores*; PL3: *The prices of products in discount stores are lower than those in non-discount stores*; PL4: *Non-discount stores tend to be more expensive than discount stores.*

Price perceptibility. PPe1: *In discount stores, prices are clearly visible*; PPe2: *In discount stores, it is easy to see the price of a product*; PPe3: *In discount stores, prices are easy to identify compared to other store formats.*

Value for money. VfM1: *The prices at discount stores are reasonable considering the value I receive for my money*; VfM2: *Prices at discount stores are not too high to what I get for my money*; VfM3: *Discount stores offer a good balance between product quality and price*; VfM4: *When compared to other types of stores, the price-to-quality ratio of products in discount stores is favorable*; VfM5: *The price-to-quality ratio of products in discount stores is better than in other store formats.*

Price processibility. PPr1: *In discount stores, it requires considerable effort to compare the prices of various products*; PPr2: *In discount stores, finding the best-priced product in a category takes a significant amount of time*; PPr3: *In discount stores, I doubt that the price on the shelf will match the one at checkout.*

Evaluation certainty. EC1: *I cannot evaluate discount stores based on their price levels*; EC2: *I find it challenging to assess the overall price levels of discount stores*; EC3: *I find it difficult to evaluate the overall price level of discount stores*; EC4: *I am unable to assess discount stores based on their pricing levels.*

3. Results

3.1. Research sample characteristics

The survey was conducted in 2024 using the Computer-Assisted Web Interviewing (CAWI) technique. The research sample included 621 respondents, with 317 (51.0%) preferring one discount retailer (A) and 304 (49.0%) the other (retailer B), both engaged in a price war. Slightly over half were women (52.2%), while men comprised 47.8%. Respondents were adults categorized into age groups: 18-24 years (5.5%), 25-34 years (26.4%), 35-44 years (24.3%), 45-54 years (18.7%), and 55 years and older (25.1%). Among the household categories, two-person households made up the largest share of the survey sample at 38.6%, followed by three-person households at 23.0%, four-person households at 17.2%, and one-person households at 13.7%. Large households with five or more members were the least represented at 7.5%. The survey sample consisted mainly of households without children (66.0%), followed by those with one child (19.5%), two children (11.6%), three children (2.6%), and four or more

children (0.3%). Regarding income, most respondents (69.6%) were main earners, 19.0% were sole earners, and 11.4% relied on others for support.

The sample accurately reflects the population in terms of gender and place of residence, with each voivodeship represented in proportion to its size relative to the country. The spatial scope of the study was a crucial factor because the market presence of the two analyzed brands varies across the country, resulting in a different distribution of their stores.

The study focused on two discount retailers, A and B, who had already been engaged in an intense price competition (a so-called price war) for several months at the time of the research. Therefore, respondents had been exposed to their price-focused communication efforts long enough to justify examining their behavior in the context of the price war. Retailers A and B are two leading discount chains in Poland, but differ in several ways. Retailer A, owned by Portuguese company Jerónimo Martins, entered the Polish market in 1995 and operates over 3700 stores as of 2024. Retailer B, part of the German Schwarz Group, opened its first Polish store in 2002 and now has around 900 stores. Both focus on low prices and private-label products, but there are differences in how many private-label ("own brand") products they offer: B's assortment has one of the highest shares of private-label FMCG – about 62%. Retailer A also has a high share, but slightly lower, approximately 50% for FMCG products under its own brands.

3.2. Findings

The analysis was performed using the General Linear Model (GLM) procedure in SPSS, with estimated marginal means plotted to illustrate the direction and magnitude of the effect.

In the first stage, the analysis included five dimensions of price image. A statistical significance test (at the $p < 0.05$ level) revealed no significant differences in three of the dimensions between two groups of consumers with a strong preference for a particular discount retailer (A or B):

- Price level: similar values across groups, approximately 3.6 on a 5-point Likert scale.
- Value for money: approximately 3.5 on a 5-point Likert scale.
- Price evaluation certainty: approximately 2.8 on a 5-point Likert scale.

The lack of significant differences in perceived price level, value for money, and price evaluation certainty suggests a convergence in consumer perceptions of discounters engaged in the price war. This may indicate that, despite competitive pricing strategies, these brands are not differentiating themselves in the eyes of consumers on these dimensions.

Interestingly, considering the items that define price evaluation certainty, the relatively neutral score (~2.8) may indicate a lack of pricing transparency or complexity in price structures, suggesting an area for potential improvement (Fig 1[1]).

[1] Due to space limitations, the article includes only the charts related to variables with statistically significant differences and notably distinct values.

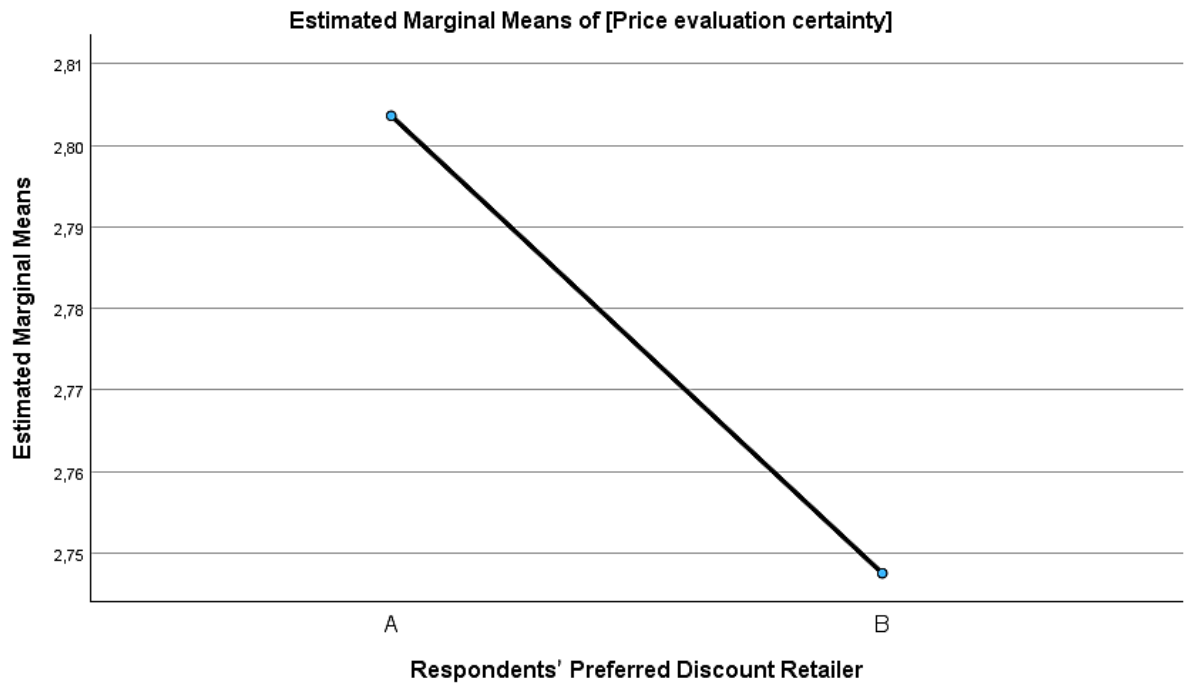

Figure 1. Differences in Price Valuation Certainty of Discounters Involved in the Price War.
Source: Own work.

A one-way analysis of variance (ANOVA) was conducted to examine whether the levels of price perceptibility and price processibility differ depending on consumers' preference for a discount retailer involved in a price war. Statistically significant and interesting differences were identified in two dimensions:

- *Price perceptibility* – a higher level was attributed to discounter B compared to discounter A (Fig. 2), $F(1, 619) = 10{,}206$, $p = .001$.
- *Price processibility* – a higher level was reported for discounter A (Fig. 3), $F(1, 619) = 7{,}311$, $p = .007$.

However, to interpret these results accurately, it is important to consider how each variable is defined, particularly the individual items that create these dimensions.

Taking this into account, discounter B is actually evaluated more favorably in both dimensions – in terms of price perceptibility, higher values indicate greater ease in noticing and recognizing prices, while for price processibility, lower values reflect lower cognitive effort and fewer doubts during the price evaluation process. Thus, although raw scores suggest mixed results, a closer look at the scale structure reveals that discounter B performs better on both dimensions from the consumer's perspective.

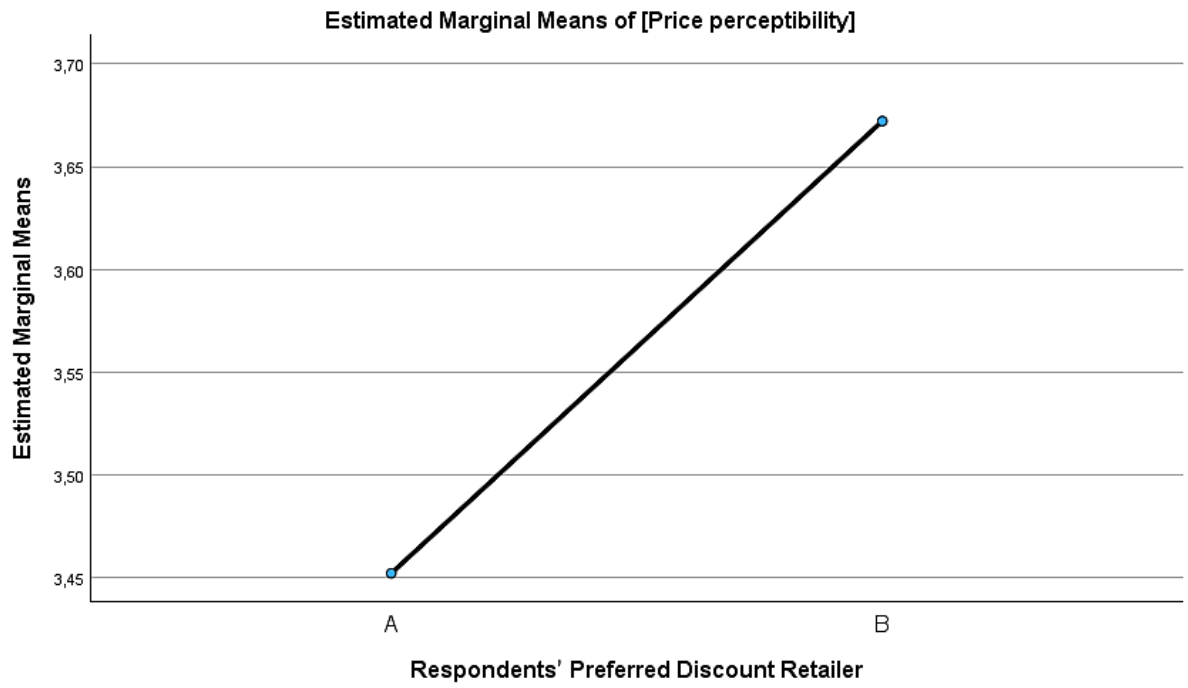

Figure 2**.** Differences in Perceived Price Perceptibility of Discounters Involved in the Price War. Source: Own work.

A one-way analysis of variance (ANOVA) was conducted to examine whether the independent variable q1 significantly affects the level of the dependent variable price perceptibility (Fig. 1). The partial eta-squared value ($\eta^2 = .016$) indicates that q1 explains 1.6% of the variance in the dependent variable. Although the effect is statistically significant, its strength is small (according to the Cohen's (1988) interpretation of $\eta^2 < 0.01$ negligible; $0.01 \leq \eta^2 < 0.06$ small; $0.06 \leq \eta^2 < 0.14$ medium; $\eta^2 \geq 0.14$ large). Additionally, the statistical power of the test was .891, meaning there was an 89.1% chance of detecting an effect if one truly exists. This suggests that the test had adequate statistical power.

In summary, the ANOVA revealed a significant effect of q1 on price processibility $F(1, 619) = 10.21$, $p = .001$, $\eta^2 = .016$. Although the effect was statistically significant, its magnitude was small.



Figure 3. Differences in Perceived Price Processibility of Discounters Involved in the Price War.
Source: Own work.

A one-way analysis of variance (ANOVA) was conducted to examine whether the independent variable q1 significantly affects the level of the dependent variable price processibility (Fig. 2). The partial eta-squared value ($\eta^2 = .012$) indicates that q1 explains 1.2% of the variance in the dependent variable. Although the effect is statistically significant, its strength is small (according to the Cohen's (1988) interpretation of $\eta^2 < 0.01$ negligible; $0.01 \leq \eta^2 < 0.06$ small; $0.06 \leq \eta^2 < 0.14$ medium; $\eta^2 \geq 0.14$ large). Additionally, the test's statistical power was .770, meaning there was an 77.0% chance of detecting an effect if one truly exists. This suggests that the test had adequate statistical power.

In summary, the ANOVA revealed a statistically significant effect of retailer preference (q1) on price processibility, $F(1, 619) = 7.311$, $p = .007$, $\eta^2 = .012$. Although the effect was significant, its magnitude was small.

4. Discussion

The issue of a retailer's price image is an important research topic because shopping intentions and store choice are influenced by price image (Zielke, Toporowski, 2012). Price image can significantly impact sales performance, making it crucial for managers to pay attention to it (Elshiewy, Peschel, 2022). The development of price image is a dynamic process (Lourenço et al., 2015), and given the dynamic nature of the retail environment, this issue warrants further research attention. We believe that the research context addressed in this

article, namely retailer-initiated price wars, will contribute to a better understanding of price wars, particularly in terms of price communication and consumer perception.

This article aimed to identify potential similarities and differences in the perceptions of price-image dimensions across the two analyzed discount-store brands. The results of the study indicate that consumers do not differ significantly in their overall assessment of price levels, perceived value, or certainty regarding price evaluation, regardless of their preferred retailer. However, differences emerge in operational aspects related to price clarity and readability. This suggests that retailers may vary in how they present and communicate prices, even if the actual price levels are perceived similarly.

A noticeable difference exists between discount retailer A and B in the share of private label products in their assortments. While private labels account for approximately 70% of B's offerings, retailer A's share is significantly lower – estimated at around 40-50%. This distinction seems to be reflected in consumer perceptions: in our study, consumers who prefer retailer B rated their preferred retailer significantly higher on the dimension of price processibility than consumers who prefer retailer A rated their own preferred retailer. According to Zielke (2010), price processibility tends to improve when national brands are positioned near private labels of similar quality. The market reality appears to confirm this idea – a strong presence of private labels may positively influence consumers' ability to process and evaluate prices, likely because of simpler price structures and less ambiguity.

As mentioned earlier, the relatively low score on price evaluation certainty may indicate a lack of transparency or complexity in pricing, which could be an area for improvement for both retailers. In the context of the lower consumer ratings for discount retailer A compared to retailer B regarding price communication, it is important to highlight specific practices by retailer A that have been negatively evaluated by the Polish Office of Competition and Consumer Protection (UOKiK). In 2020, UOKiK fined retailer A for discrepancies between shelf prices and checkout charges, as well as for missing price information – practices considered unfavorable to consumers. More recently, in 2025, UOKiK initiated an investigation into unclear pricing communication related to multi-item purchases (UOKiK, 2025). These are just two examples of irregularities in price communication identified by the regulatory authority. As shown by the findings in this article, such practices harm consumers' perceptions of overall price transparency.

5. Summary

The analysis showed that during the price war between the two discount retailers, their customers did not notice significant price differences. However, they did notice differences in how prices were communicated, specifically in perceived price processibility and

price perceptibility. Importantly, differences in price clarity and readability can influence shopping comfort, consumer trust, and retailer preference. In practice, this means that how prices are presented and transparency can shape brand perception and consumer choices, even when there are no perceived differences in value for money.

In the authors' view, the findings provide a strong basis for the conclusion that a price war alone may not be sufficient – if prices are poorly communicated, the intended competitive advantage may be lost.

Despite using competitive pricing strategies, the two discount retailers analyzed do not differ significantly in the eyes of consumers across three key areas: price level, perceived value, and confidence in price evaluation. The authors believe that the lack of differences in these important aspects should not be seen as a sign of ineffective pricing strategies. Instead, the ongoing price war between the two retailers seems to create a mutually beneficial effect: it boosts each brand's position in the minds of its respective customers. This intense pricing rivalry – highlighted by messages like "retailer A is more expensive than B" (or vice versa, depending on the source) – results in a kind of duopoly within the FMCG market. The aim is not necessarily to make consumers loyal to retailer A switch to retailer B, but rather to reinforce the idea that there are no real options beyond these two leading players.

The analyses presented provide interesting insights; however, they are also subject to certain limitations, of which the authors are aware. The one-way ANOVA method allows for detecting statistically significant differences between groups in the studied variables, but it has its constraints. Primarily, ANOVA examines only mean differences and does not account for potential confounding factors or interactions between variables that might influence the results. In this study, statistically significant differences were found between the ratings of the two analyzed retailers, but the effect sizes were small. This indicates that, although the differences are statistically valid, their practical significance is limited. Therefore, caution is warranted when drawing conclusions and making practical recommendations based on these findings. Additionally, due to the cross-sectional nature of the data, causal relationships cannot be established.

Future research could benefit from expanding the current analytical approach beyond one-way ANOVA by utilizing multifactorial designs or multivariate analyses. These methods would allow for the exploration of interactions between variables, such as the relationship between brand preference and customer characteristics, leading to a more comprehensive and nuanced understanding of consumer behavior. Additionally, the share of private-label products in discount retailers' assortments may represent a relevant contextual factor for future research, as incorporating assortment structure variables into the model could provide a more comprehensive explanation of price image perceptions. Finally, conducting longitudinal studies would be valuable for observing changes over time and establishing causal relationships between the studied variables, thus addressing the limitations of cross-sectional data. Given the spatial variability in store distribution and market penetration, further studies focusing on

specific regions or markets are recommended. This focus would enable a deeper investigation into local consumer behavior patterns and retailer strategies, which may vary significantly across different geographic areas.

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THE ROLE OF ASYNCHRONOUS AND SYNCHRONOUS COMMUNICATION IN HYBRID IT PROJECT TEAMS

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Purpose: the aim of this article is to present the results of research about determining whether and how synchronous and asynchronous communication affect the effectiveness of cooperation in hybrid project teams in the IT industry.
Design/methodology/approach: a review of the literature on synchronous and asynchronous communication in project teams and an empirical study in the form of a survey conducted among employees of hybrid IT teams. The research method used was quantitative analysis of the survey results.
Findings: it was established that the choice between synchronous and asynchronous communication is strongly dependent on the type and complexity of the tasks performed, and that the predominance of asynchronous communication can negatively affect team cohesion. The study also showed that IT team members recognise the need to maintain a balance between both forms of communication, as their balanced use promotes effective collaboration and quality of project work. Three of the five research hypotheses were confirmed, including the main one concerning the positive impact of the harmonious use of synchronous and asynchronous communication on the effectiveness of hybrid project teams.
Research limitations/implications: the study has several limitations, primarily related to its small and deliberately selected sample, which makes it impossible to treat the results as fully representative of the entire IT industry.
Practical implications: the results of the study indicate that organisations should consciously balance synchronous and asynchronous communication. The appropriate choice of communication mode improves work coordination, team cohesion and overall project effectiveness. Companies can use these findings to create clear communication rules, implement appropriate digital tools, and train teams in communication skills, which can translate into better project goal achievement and more efficient hybrid work management.
Social implications: The study highlights the importance of conscious and balanced communication in a hybrid work environment, which can contribute to improving employee well-being, reducing the stress associated with constant availability, and better work-life balance. The findings may support the development of more socially responsible organisational practices, which in the longer term may have a positive impact on employees' quality of life and social relationships.

Originality/value: a novelty is the detailed analysis of the relationship between communication mode and task complexity, and the identification of the practical consequences of the dominance of asynchronous communication for team cohesion. The research results are a valuable source of knowledge for project managers, HR specialists, team leaders and researchers involved in communication and management of distributed teams.
Keywords: synchronous communication; asynchronous communication; hybrid project teams; IT industry; team collaboration effectiveness.
Category of the paper: research paper.

1. Introduction

Contemporary organisations, especially those operating in the IT industry, increasingly function in a hybrid work environment that combines elements of remote and stationary work. Dynamic technological changes, globalisation of teams and the growing complexity of projects make effective communication one of the key factors determining the success of project undertakings. In such conditions, communication plays not only an informational role, but also a coordinating, organisational and integrating one, directly influencing interpersonal relationships, the effectiveness of cooperation and the team atmosphere (den Otter, Emmitt, 2007; Muszyńska, 2018, 2020; Geyer et al., 2001; Křečková et al., 2022).

One of the most important challenges in hybrid teams is choosing the right forms of communication. The literature emphasises that synchronous communication, taking place in real time, e.g. during meetings or conversations, promotes quick problem solving, enables immediate clarification of ambiguities and strengthens social bonds between team members. Asynchronous communication, on the other hand, including e-mails and text messengers, allows for time flexibility, promotes thoughtful decisions and leaves a permanent record of agreements, which increases the transparency of project processes. Both modes of communication have their advantages and limitations, and choosing the right one is crucial in the context of tasks of varying complexity and interdependence between team members (Spinach AI, 2025; Daniere, 2024; Major, Spałek, 2017).

Previous research indicates that the effectiveness of communication in distributed teams largely depends on the complexity of the tasks and the level of interdependence between their performers. In the case of high complexity or the need for rapid coordination of activities, synchronous interactions are preferred, as they enable the ongoing exchange of knowledge and joint problem solving (e.g. daily stand-up meetings in agile methodologies). On the other hand, tasks requiring accuracy, reflection or documentation can be more effectively supported by asynchronous communication tools (Velentzas, Broni, 2014; Frączek, 2012).

Despite the growing importance of communication in hybrid teams, the literature still points to a significant **research gap** in the area of specific relationships between the form of communication and the effectiveness of project collaboration in the IT industry. Previous

studies have often focused on general communication models, without taking into account the specifics of contemporary, flexible work environments or the challenges arising from the parallel use of multiple communication tools.

A total of 32 scientific articles corresponding to the thematic assumptions of the article were identified in the literature review (a scoping literature review' was used). For the inclusion criteria, the PCC (Population-Concept-Context) framework was applied. Literature was sought concerning population (who are we studying?): project team members, hybrid, remote or dispersed teams; for the concept (what are we studying?): synchronous communication, asynchronous communication, communication management in teams, the impact of communication on: efficiency, collaboration, team cohesion; in the context (where/ under what conditions?): hybrid working environment, distributed teams, IT/ agile/ project management projects. The following exclusion criteria were established: inappropriate population (no link to teams), inappropriate concept (no reference to synchronous/ asynchronous communication or communication within teams), inappropriate context (lack of context: teamwork, projects, organisational environment), and publication types (blogs, opinions, popular science articles, lack of peer review).

After eliminating duplicates, 21 unique publications remained. Based on their content, four main thematic areas were developed, which concern considerations around the most important aspects related to communication in project teams, both in the context of practices, tools, and factors influencing the effectiveness of this communication. The detailed assignment of individual articles to the relevant sections of the analysis is presented in Table 1.

Table 1.
List of publications found in the review, taking into account their use

No.	Publication title (in some cases, the title has been translated into English)	Sections of the analysis	Footnote
1	Communication management practices in international project teams based on the example of projects co-financed by European funds	Communication in project teams; Synchronous and asynchronous communication tools used in the IT industry	(Muszyńska, 2020)
2	Monitoring and measuring communication efficiency in distributed project teams	Communication in project teams	(Muszyńska, 2018)
3	Course Transformation From Synchronous To Asynchronous Using Technology	Synchronous and asynchronous communication tools used in the IT industry	(Ali Mehrabian, 2009)
4	Managing Effectiveness of Asynchronous and Synchronous Design Team Communication	The impact of communication on the effectiveness of project teams	(den Otter, 2009)
5	Task virtuality and its effect on student project team effectiveness	The impact of communication on project team effectiveness	(Pineda, 2015)
6	The role of asynchronous discussions in increasing the effectiveness of remote synchronous requirements negotiations	The impact of communication on the effectiveness of project teams	(Damian et al., 2006)
7	Exploring the effectiveness of team communication: Balancing synchronous and asynchronous communication in design teams	Communication in project teams	(den Otter, Emmitt, 2007)

Cont. table 1.

8	Synchronous Collaboration Technology Use in Teamwork	The impact of communication on the effectiveness of design teams; The impact of task type and project complexity on communication	(Sundaravej et al., 2015)
9	Using collaboration technology to facilitate face-to-face and distributed team interactions	Synchronous and asynchronous communication tools used in the IT industry	(Chen, 2004)
10	Design Team Communication and Design Task Complexity: The Preference for Dialogues	The impact of task type and project complexity on communication	(den Otter, Emmitt, 2008)
11	Your teammate just sent you a new message! The effects of using Telegram on individual acquisition of teamwork competence	Synchronous and asynchronous communication tools used in the IT industry	(Conde et al., 2021)
12	Integrating emerging topics through online team design in a hybrid communication networks course: Interaction patterns and impact of prior knowledge	The impact of communication on the effectiveness of project teams	(Reisslein et al., 2005)
13	Project Management Communication Planning: An Improved Optimisation Model With Additional Recipients and Individualised Weights	Communication in project teams	(Křečková et al., 2022)
14	Using Communication to Mitigate the Challenges of Outsourced Projects	The Impact of Communication on the Effectiveness of Project Teams	(Bandezi, 2019)
15	The Effect of Asynchronous Communication on the Relationship Between Intragroup Conflicts and Transition Processes	The impact of communication on the effectiveness of project teams; The impact of task type and project complexity on communication	(Tschas, 2017)
16	Information, Technology and Information Worker Productivity: Task Level Evidence	The impact of task type and project complexity on communication	(Aral et al., 2007)
17	Analysing the social knowledge construction behavioural patterns of an online synchronous collaborative discussion instructional activity using an instant messaging tool: A case study	Synchronous and asynchronous communication tools used in the IT industry	(Huei-Tse Hou, 2011)
18	Communication in Virtual Teams: Ten Years of Experience in Education	Synchronous and asynchronous communication tools used in the IT industry; The impact of communication on the effectiveness of project teams; The impact of task type and project complexity on communication	(Rutkowski et al., 2008)
19	A team collaboration space supporting capture and access of virtual meetings	Communication in project teams	(Geyer et al., 2001)
20	Communication, collaboration, and project management tools for producing and managing group projects at a distance. (Ends and Means)	Synchronous and asynchronous communication tools used in the IT industry	(Milman, 2011/2012)
21	State Treemap: an awareness widget for multi-synchronous groupware	Synchronous and asynchronous communication tools used in the IT industry	(Molli et al., 2001)

This article addresses an identified gap. The **aim of this article** is to present the results of research about determining whether and how synchronous and asynchronous communication affect the effectiveness of cooperation in hybrid project teams in the IT industry. The article is based on a review of the literature and the results of empirical research.

In light of the growing popularity of remote and hybrid work, the results of communication research are becoming particularly relevant for both management practitioners (project managers, HR specialists, team leaders) and researchers involved in the development of modern collaboration models. The article adds value by providing a current analysis of communication practices in the IT industry and indicating directions for further research on improving communication in decentralised project environments.

2. Methods

The methodological approach of this study combines a literature review with an empirical quantitative investigation, allowing for an in-depth exploration of communication practices within hybrid project teams in the IT industry. The research process began with a literature review of academic and industry literature on communication in project teams, with particular emphasis on the distinction between synchronous and asynchronous communication, the impact of communication on project effectiveness, and the role of task complexity in determining communication needs. The literature review followed a structured process involving the identification, selection, and synthesis of sources relevant to communication models, project management methodologies, and hybrid work environments.

Based on literature review, **one main hypothesis and four supporting hypotheses were proposed**. The main hypothesis (also referred to as H5) was *The effectiveness of hybrid project teams in the IT industry is highest when they use synchronous and asynchronous communication to a similar extent*. This assumption is based on an analysis of the literature indicating that the effectiveness of project teams does not depend solely on one dominant form of communication. Teams that are able to flexibly adapt their communication methods to the specifics of a project situation achieve better results than those that consistently limit themselves to one method. Skilful combination of synchronous and asynchronous communication allows for better management of working time, increased responsiveness and higher quality of decisions. The supporting hypotheses were as follows:

H1 - *The complexity of tasks determines the choice of communication mode*. The literature on the subject emphasises that more complex tasks, characterised by greater ambiguity and interdependence, require more frequent and interactive information exchange. In such cases, synchronous forms of communication, which allow for immediate clarification of issues and

joint decision-making, work better. On the other hand, asynchronous messages are sufficient for simple and repetitive tasks, as they help to avoid information overload.

H2 - *There is a relationship between multitasking and preferred form of communication*. The analysis indicates a potential relationship between the number of tasks performed in parallel and the choice of preferred communication method. People who perform multiple tasks simultaneously are more likely to use asynchronous tools, which allow for greater time flexibility and more effective information management. Employees focused on a single activity prefer synchronous communication, which supports the ongoing exchange of information and reduces response times.

H3 - *An excessive reliance on asynchronous communication can weaken team cohesion*. The results of the literature review suggest that the dominance of asynchronous communication can lead to a decline in team integration, increased relational distance, and difficulties in resolving conflicts. The lack of direct interaction weakens engagement, limits the opportunity to strengthen social bonds, and can result in a growing sense of isolation among team members.

H4 - *Too many communication tools reduce the effectiveness of project teams in the IT industry*. The analysed literature indicates that an excess of communication platforms and channels can cause information overload, disintegration of information, and difficulties in managing data flow. Teams using multiple uncoordinated tools encounter problems with communication transparency, leading to errors, delays, and a decline in overall productivity.

The empirical component consisted of a **survey** targeted at individuals working in hybrid project teams in the IT sector. Data collection was conducted through an online questionnaire (with 36 questions, see Appendix 1), enabling respondents to share their perceptions and experiences regarding communication practices, preferred communication modes, and challenges associated with hybrid collaboration. The survey included closed-ended questions designed to measure the relationship between communication practices and team effectiveness, as well as demographic and contextual questions that allowed for segmentation of responses by role, experience level, and work model. This method was particularly suited to the exploratory nature of the study, providing a quantitative basis for analysing patterns and correlations within the target population.

The sample was selected using a purposive, non-random sampling strategy, focusing on IT professionals employed in organisations operating in a hybrid model. A total of 86 people working in the IT industry completed the survey. For further analysis, **50 responses** from respondents declaring a hybrid working mode (combining remote and office work) were included, in accordance with the research project assumptions. The final sample consisted mainly of specialists in the early and mid-stages of their careers, working predominantly in small project teams typical of agile IT environments. This demographic profile provided valuable insights but also introduced limitations regarding representativeness.

Data analysis included **descriptive statistics (mean, standard deviation, variance) and relational analysis (Spearman's rank correlation coefficient, the Kruskal-Wallis test)**, enabling the exploration of dependencies between communication modes, task characteristics, and perceived team effectiveness. Selected calculations are included later in the article. The quantitative findings were then integrated with insights derived from the literature review, supporting a multi-layered interpretation of communication behaviours in hybrid project settings.

3. Results and discussion

The analysis of the survey data revealed several significant patterns regarding communication practices in hybrid IT project teams. Table 2 summarises the list of hypotheses along with the results of their verification in the study.

Table 2.
Summary of hypothesis verification

Hypothesis	Description	Verification
H1 - supporting hypothesis	The complexity of tasks determines the choice of communication mode	accepted
H2 - supporting hypothesis	There is a relationship between multitasking and the preferred form of communication	accepted
H3 - supporting hypothesis	An excessive predominance of asynchronous communication weakens team cohesion	not accepted
H4 - supporting hypothesis	Too many communication tools reduce work efficiency	not accepted
H5 - main hypothesis	Team efficiency is highest when there is a balance between synchronous and asynchronous communication	accepted

Hypotheses H1 and H2 were accepted both in the literature and in the research data. Both theory and practice prove that the choice of communication form should depend on the complexity of the task. Synchronous communication works better for ambiguous tasks or those requiring immediate coordination, while asynchronous communication is more conducive to simple tasks or those requiring concentration. Multitasking also shows a relationship with the choice of communication form, people managing multiple threads are more likely to choose forms that allow them to work at their own pace. On the other hand, hypotheses H3 and H4, although inspired by the literature, were not accepted. Although the literature warns against excessive asynchronous communication as a factor that weakens team integration and morale, the survey respondents did not perceive any clear negative effects of this phenomenon. It is possible that organisations effectively compensate for these shortcomings through other practices (regular synchronous meetings, integration activities, rotational office work). Similarly, the number of tools used was not considered by respondents to be a factor reducing

efficiency, which may indicate adaptation to a multi-platform environment or effective communication management.

To better illustrate why hypotheses H3 and H4 were not accepted, the following part of this chapter presents an analysis of the results for the questions relating to them, along with statistical calculations.

The hypothesis H3 concerned the potential effects of the dominance of asynchronous communication on team cohesion and integration. The literature on the subject has indicated that a lack of face-to-face interaction may lead to reduced engagement, difficulties in building relationships, and a sense of isolation within the team. The study sought to verify the extent to which these concerns are reflected in the opinions and experiences of the respondents. The analysis covered questions regarding perceptions of the frequency of team-building meetings, the perceived atmosphere and unity within teams where written communication predominates, and the team-building practices employed within teams.

The first key question in this context was question (question 26) concerning the lack of online or offline meetings, which leads to a weakening of team cohesion. Most participants recognise the role of synchronous meetings in strengthening team bonds. 68% of respondents agreed that the lack of regular live interactions weakens integration. 16% of respondents disagreed, whilst the remaining 16% chose the neutral option. This result indicates that over two-thirds of employees consider face-to-face meetings, whether online or offline, to be an important factor in team cohesion, and that their absence may lead to a loosening of bonds and a sense of community.

Opinions proved to be somewhat more varied in next question (question 27), which had a slightly opposite tone. 64% of respondents agreed with the statement that a team can remain cohesive and understand each other well, even if asynchronous communication predominates. Of these, 28% selected ‘strongly agree’ and 36% ‘somewhat agree’. At the same time, 14% of respondents expressed the opposite view. There was also a relatively large neutral group, accounting for 22% of responses. These results suggest a certain division of opinion. The majority believe that even with mainly written communication, it is possible to maintain good cooperation and understanding within a team; however, a significant minority have doubts about this or deny such a possibility. It can be assumed that the respondents’ personal experiences influence these assessments - those who have worked in teams that mainly use asynchronous channels but maintain a good atmosphere will be inclined to agree. Others, who have felt the negative effects of a lack of meetings, will more often be among the sceptics.

In question 28, we again see many affirmative responses. 74% of respondents consider regular meetings important for maintaining a sense of belonging (36% strongly agree, 38% somewhat agree). Only 8% dispute this claim (6% ‘somewhat disagree’, 2% ‘strongly disagree’), whilst 18% remain neutral. This result, combined with the outcome of question 26, highlights the key role of meetings, which relates not only to the aspect of integration (social

bonds) but also to the subjective feeling of being part of a team. For many employees, regular real-time contact, even if remote, is an essential element of team building.

When comparing the answers to questions 26-28, a certain apparent inconsistency can be observed, as on the one hand the majority say 'yes, meetings are important and the lack of meetings harms integration', whilst on the other hand the majority state 'despite the predominance of asynchronous communication, the team can still be cohesive'. It seems that respondents recognise a certain balance and boundary conditions here. The most likely interpretation is that occasional or limited meetings are important for team cohesion, but at the same time, the mere predominance of written communication tools does not necessarily preclude team cohesion, provided that other factors such as good relationships, shared values, and occasional team-building activities are in place. In other words, people believe it is possible to maintain a cohesive team even when communication is largely asynchronous, but at the same time they appreciate the role of meetings and team-building activities in fostering team spirit.

TableBłąd! W dokumencie nie ma tekstu o podanym stylu.**3.**
Mean, standard deviation and variance of responses to questions 26-28

Question number	Mean	Standard deviation	Variance
Question 26	3.86	1.18	1.39
Question 27	3.73	1.05	1.09
Question 28	3.98	0.98	0.96
H3	3.86	1.07	1.15

For clarity, Table 3 summarises the mean scores, standard deviations and variances for questions 26-28. These means are, respectively: 3.86 (question 26), 3.73 (question 27) and 3.98 (question 28). We can therefore see that the highest mean is for question 28, which means that respondents were most likely to agree with the general statement regarding the importance of regular meetings. A slightly lower average (though still above the neutral value of 3) for question 27 confirms that opinions were more varied here. The variance of responses to question 27 (1.09) is also higher than for question 28 (0.96), reflecting the divergence of opinion. The overall H3 index, which is the average of these three questions, is 3.86, suggesting moderate support for the hypothesis that team cohesion is at risk when asynchronous communication predominates. Respondents tend to highlight the importance of meetings, but do not rule out the possibility of maintaining integration in remote working conditions.

In question 11, where respondents indicated how often their team organises scheduled meetings (online or offline) attended by many members. 42% of respondents state that their team meets daily for short status updates. A further 28% indicate that meetings take place several times a week (2-4 times). 20% of teams meet once a week. There are few instances of lower frequencies - 6% answered 'once a month', and only 2% (1 team) meet less than once a month. These figures show that most hybrid IT teams practise frequent, regular synchronisation meetings. Combined with the earlier results, it can be concluded that respondents generally work in teams where the lack of face-to-face contact is not total.

This is an important observation, suggesting that despite the dominance of digital tools, the rhythm of team work still includes a significant synchronous component. Hence, perceptions regarding integration (questions 26-28) were formulated through the lens of teams that do, however, hold a certain number of meetings, which may explain why many people believe the team is cohesive even when asynchronous communication predominates (since some meetings do take place, complete isolation is difficult to achieve).

Respondents were then asked how they most frequently communicate with their team members daily (question 12). Respondents could select only one primary channel for daily communication. The data shows a dominant preference for text-based messaging (chats), which was selected by 64% of respondents. Online meetings came second as the main form (14%), and face-to-face conversations came third (12%). Few respondents cited telephone calls or text messages as their main channel (4% each). This suggests that, in the teams surveyed, asynchronous communication theoretically dominates day-to-day work - which is, in fact, typical of dispersed, hybrid environments using tools such as Teams or Slack. It is worth bearing in mind, however, that synchronous communication involves more time per 'use' (a meeting lasts longer than a brief chat conversation), so it cannot be unequivocally stated that asynchronous communication significantly predominates.

In addition to project meetings, respondents were also asked about informal activities. 70% of respondents answered "Yes", which means that some form of additional team building takes place in their teams (whether regular or occasional). 30%, however, indicated a lack of such practices. This split suggests that most teams are aware of the need to build additional social bonds and strive to do so, yet in a significant proportion (one in three teams) they do not go beyond basic professional contacts. Teams without team-building activities may be more vulnerable to a decline in cohesion when working remotely or in a hybrid model, as the lack of informal bonds and opportunities to build trust can exacerbate the isolation inherent in asynchronous communication. Considering this, in teams where 30% of respondents are concerned, the risk of weakened cohesion (highlighted in the hypothesis) could be higher if, in addition, communication is highly asynchronous. Unfortunately, a detailed examination of this aspect clearly exceeds the scope of the data collected, but it is worth noting this relationship as context.

TableBłąd! W dokumencie nie ma tekstu o podanym stylu.**4.**
Spearman's correlation between the frequency of team meetings (question 11) and the perceived role of meetings in team integration (question 26)

Variable A	Variable B	Spearman's correlation (ρ)	p
Question 11	Question 26	0.083	0.566

TableBłąd! W *dokumencie nie ma tekstu o podanym stylu.* shows the Spearman's correlation between the actual frequency of team meetings and the perceived role of meetings in team cohesion. The result obtained, p = 0.566, indicates no correlation. In other words,

respondents from teams that meet very frequently do not differ significantly in their views from those in teams that meet less often. Both groups are capable of both agreeing and disagreeing with the statement that a lack of meetings weakens integration. This is an interesting observation, as one might expect that those who meet infrequently would feel the lack of meetings more keenly and agree more strongly with question 26; however, the results do not support this. Perhaps this stems from the fact that even teams with a low frequency of meetings try to compensate for this with other forms of contact, or from the fact that the frequency of formal meetings does not always translate into a sense of integration.

Table 5.
Kruskal–Wallis test to assess the impact of the form of daily communication (question 12) on perceived team cohesion (question 27)

Variable A	Variable B	Kruskal–Wallis	p
Question 12	Question 27	0.58	0.748

Table 5 presents the Kruskal-Wallis test, which examines whether people who communicate mainly synchronously daily assess the statement regarding team cohesion differently when asynchronous communication predominates, compared to those who mainly use asynchronous channels. The test results did not reveal any significant differences.

To carry out a further analysis examining how respondents' daily communication patterns influence their average level of agreement with the statement regarding the importance of synchronous communication in maintaining a sense of team cohesion, it was necessary to categorise the various forms of communication into synchronous and asynchronous. The responses "Face-to-face conversation", "Online meeting" and "Telephone conversation" were classified as synchronous, whilst "Slack, Discord text chat" and "Text message (SMS)" were classified as asynchronous. This made it possible to conduct a statistical test despite the multi-categorical nature of question 12.

The respondent groups do not differ significantly in their responses to question 27. This means that even those who communicate predominantly asynchronously daily are neither more nor less convinced of the possibility of maintaining team cohesion than those who use synchronous communication more frequently. This result may indicate that the perception of team cohesion is shaped by many factors, and the preference for communication channels alone (which is partly a personal choice and partly a function of the team's specific work) does not determine opinions on integration. People who mainly write daily may perceive both the pros and cons of such a situation, just as those who talk a lot do. There is no simple division here where 'chat advocates downplay the issue of cohesion and 'meeting advocates exaggerate it.

The results of the analysis are inconclusive as to whether the hypothesis should be accepted or rejected. Most respondents agree that the lack of face-to-face meetings has a negative impact on team cohesion and that regular meetings are important for a sense of team spirit. This supports the argument that a complete reliance on asynchronous communication would be

detrimental. At the same time, however, some respondents believe that a team can remain cohesive even with a predominance of written communication, suggesting that asynchronous dominance is not automatically a death knell for cohesion, provided the team finds other ways to maintain bonds. The actual practices of many teams (frequent status meetings, team-building activities in 70% of teams) mean that few experience a complete predominance of asynchronous communication. Hence, Hypothesis 3 can be considered largely accepted in terms of the direction of the effect, but its practical significance appears limited, as few teams allow for such an extreme predominance of asynchronous communication that their cohesion would be seriously compromised. Statistical analyses such as the Kruskal-Wallis test and Spearman's rank correlation did not reveal statistical significance between the variables under study, which weakens the strength of the empirical acceptance of this hypothesis. Consequently, although the direction of the observed relationships is partly consistent with the hypothesis, the lack of statistical significance does not allow for its definitive acceptance. Hypothesis H3 can therefore be considered partially supported at the interpretative level; however, from the point of view of statistical rigour, it must be rejected.

The hypothesis H4 put forward in this article focused on the statement that 'an excessive number of communication tools in use reduces the efficiency of project teams in the IT sector'. An excess of disparate platforms (email, various instant messengers, task management systems with built-in chat) can lead to information chaos, cause problems in finding information and generate additional "communication work", which ultimately results in a decline in team productivity. To test this hypothesis, the survey included questions regarding perceptions of the number of tools within the team, the perceived consequences of using multiple channels, and opinions on the potential unification of communication tools.

Question 29 addressed the issue of the subjective perception of a decline in one's own efficiency when switching between multiple tools. In this case, opinions are divided, although responses indicating a problem still predominate. 56% of respondents admit (including 26% strongly, 30% somewhat) that switching channels and using multiple communication applications has a negative impact on their productivity. 20% disagree with this (14% somewhat disagree, 6% strongly disagree), and 24% have no firm opinion (neutral response). These responses suggest that over half of employees experience some inconvenience associated with using different tools simultaneously; even if they do not consider the number of tools to be 'too high', the very necessity of switching between, for example, email, a messaging app and a task management app can be perceived as a factor slowing down their work. People accept the number of tools as necessary, but at the same time they recognise the downsides of this situation in their day-to-day work.

Question 30 was about the use of too many different applications for communication within the respondents' project teams. The results here are clear-cut, as many as 76% of respondents disagree with the statement that their team uses too many tools (including 50% who strongly disagree and 26% who somewhat disagree). 12% responded neutrally, and only 12% perceive

this as a problem (4% strongly agree and 8% somewhat agree). This means that in the vast majority of the teams surveyed, the number of communication channels used is perceived as reasonable and not excessive.

The survey also covered potential solutions, asking for views on the need to unify tools. 50% of respondents agree that having different tools is justified by the lack of a single universal solution. 28%, on the other hand, disagree, believing that perhaps a single tool might suffice after all. 22% responded neutrally. This distribution indicates a division of opinion, as half of the respondents believe that the status quo (several tools) is necessary and that it makes no sense to hope for a single ideal tool, whilst over a quarter are more critical, likely leaning towards the view that multiple tools are, after all, unnecessary complications.

The next question, number 32, concerned a very specific negative consequence of a potential surplus of tools. 52% of respondents do not frequently have difficulty finding the information they need. 34% tend to disagree, and 18% strongly disagree that they often have such a problem. 20% of respondents are neutral, which can be interpreted as 'sometimes, but not very often' or as having no opinion. In contrast, 28% agree that they often find themselves unable to locate something due to fragmented communication (16% somewhat agree, 12% strongly agree). This indicates that over a quarter of employee's experience information chaos resulting from multiple channels. However, the majority (over half) do not consider this a frequent problem, which may mean that their teams have reasonably well-organised communication practices. Overall, this result is consistent with question 30, because if the majority do not think there are too many tools, then the majority also tend to cope well with finding information.

Question was about readiness to consolidate communication into a single tool. Here again, a diversity of views is evident, with a slight majority in favour. 50% of survey participants agree (18% strongly agree, 32% somewhat agree) with the statement that standardising communication tools would improve their team's work. 20% disagree (14% somewhat disagree, 6% strongly disagree), whilst 30% remain neutral. When combined with the results of question 31, we get an interesting picture, as half of the respondents say "yes, a single tool would improve work", but at the same time half say, "many tools are needed, because one is not enough". This may suggest that these are not the same groups of respondents. Of course, some people may have agreed with both statements at the same time, which may seem contradictory, but is possible if we interpret "no single tool meets all needs" as a description of the current situation, and at the same time "a single tool would streamline work" as an expression of the desire for such a tool to exist. Perhaps some respondents believe: "Yes, we currently have to use many tools because there is no single ideal one (agreeing with question 31), but if such a single, coherent tool existed, it would make our lives easier (agreeing with question 33)". Others may hold the opposite view: "We do not need a single tool (I disagree with question 33), because various specialised tools are better (I agree with question 31)".

To understand this better, the consistency of responses between questions 30 and 33 was examined, which will be discussed in more detail below.

Table 6.
Consistency of responses regarding the perception of an excess of communication tools (question 30) and the need for a single, universal tool (question 33)

	Low agreement with question 33	Moderate agreement with question 33	High agreement with question 33
Low agreement with question 30	8	12	18
Moderate agreement with question 30	0	3	3
Strong agreement with question 30	2	0	4

The table 6 shows the concordance matrix for these two questions. Responses have been grouped into categories of low (1 and 2), medium (3) and high (4 and 5) agreement. Among those who do not see themselves as having an excess of tools at all (low agreement with question 30), as many as 18 strongly agree that a single tool would improve their work (high agreement with question 38). A further 12 in this group hold a neutral view on the matter, whilst only 8 show low agreement with question 33, meaning they do not believe in the effectiveness of a single universal tool. This suggests that even many people who do not perceive the current number of tools as a problem recognise the potential in the idea of unification. Conversely, among those who moderately agree that there are too many tools (moderate agreement with question 30), opinions on unification were divided. A few people are neutral or in favour, a few against (this category is small, so it is difficult to draw conclusions). In contrast, in the group that clearly believes there are too many tools (high agreement with the question, 30), the majority (numbering just 4 people) also strongly support the idea of a single tool, which is logical, as for them integration would be the solution to the perceived problem. Interestingly, there are also two people who, although they believe there are too many tools, do not agree that a single tool would help. Perhaps they are sceptical about the feasibility of such a tool or have had bad experiences with 'all-in-one' solutions. Overall, however, the table shows that the idea of a single tool has considerable support even among those satisfied with the current situation. This can be interpreted as a general desire to simplify the working environment.

Table 7.
Mean, standard deviation and variance of responses to questions 29-33

Question number	Mean	Standard deviation	Variance
Question 29	3.53	1.20	1.39
Question 30	1.94	1.24	1.53
Question 31	3.31	1.22	1.48
Question 32	2.27	1.26	1.58
Question 33	3.43	1.10	1.27
H4	2.90	1.20	1.45

Table 7 summarises the mean responses, standard deviations and variances for questions 29-33. The very low mean for question 30 (1.94) is striking (the lowest of all the questions discussed), which confirms the earlier analysis: the majority of respondents do not believe that there is an excess of communication tools in their teams. The mean for question 32 is also quite low (2.27), indicating that the problem of information fragmentation is more often denied than acknowledged. In contrast, question 29 has an average of 3.53, which indicates moderate agreement with the proposition that efficiency declines when there are many tools - that is, respondents here were more inclined to agree, even though they do not consider the number of tools to be excessive (a possible interpretation is: "we don't have too many tools, but switching between them still tires me out sometimes"). The averages for question 31 (3.31) and question 33 (3.43) confirm that opinions regarding the need for multiple tools versus a single tool are balanced, with a slight indication of a desire for simplification. The standard deviations for these questions (1.27-1.58) are slightly higher than for many previous topics, which indicates considerable diversity of views within the study group - the issue of tools is not clear-cut and elicits differing opinions.

Table 8.
Spearman's correlation between switching between communication tools (question 29) and the assessment of their excess in the team (question 30)

Variable A	Variable B	Spearman's correlation (ρ)	p
Question 29	Question 30	0.332	0.018

An analysis of the correlation between questions 29 and 30 was also carried out to check whether people who feel a decline in efficiency when using many tools also tend to believe that their team has too many of these tools. Table 8 shows the Spearman's correlation coefficient for these two variables. A value of $\rho = 0.332$ was obtained at $p = 0.018$, indicating a significant, moderate positive correlation. As one might expect, respondents who claim that switching between multiple channels reduces their efficiency are also more likely to feel that their team uses too many applications. A negative perception of the number of tools goes hand in hand with the belief that this number is excessive. This is a consistent picture, because if someone considers the number of tools to be reasonable, they are unlikely to feel inefficient because of them, whereas those who feel frustrated by switching between programmes are more likely to say that there are simply too many of them. This correlation provides empirical support for Hypothesis 4 at the individual level, as it shows that for some people, the excess of tools is a real problem which they perceive as a drop in productivity. Nevertheless, it is worth remembering that since many respondents do not perceive this 'excess' in their own case, the problem does not appear to be widespread across the entire sample (hence the average for question 30 was low, and the correlation, though significant, applies only to those who selected higher values on both questions).

Question 14 was a multiple-choice question in which respondents were asked to indicate all the tools they use regularly for teamwork. The available options included popular messaging apps and platforms such as Slack, Discord, Microsoft Teams, Google Meet, Zoom, email, and the option to add others. Email and Microsoft Teams are the most frequently used - 60% and 58% of respondents, respectively, use them regularly. Messaging apps such as Slack (26% use it daily) and Discord (24%) are also very popular, although it should be noted that teams usually use just one of these tools. Among meeting tools, Google Meet dominates (34% of responses), whilst Zoom is used by only 6% of respondents, which may be because some companies standardise on Google or Microsoft solutions. Among the 'Other' tools listed were, among others, Outlook, Webex, Notion, WhatsApp and SMS. However, these were isolated cases. Generally, the respondents usually use several complementary tools, and many of the chosen platforms serve different functions (chat, meetings, documentation), so a certain number of tools seems unavoidable, which explains the answers to question 31 (half believe that one tool cannot replace them all). On the other hand, the appearance of so many names (even if only mentioned once) in the responses indicates that, on a cross-team basis, there is a wide variety of technologies in use.

In addition, the actual number of tools used by individual respondents and their perceptions regarding the fragmentation of information were examined. To conduct this study, the number of tools each respondent uses for their daily work was counted. It is worth noting that the numerical distribution is not proportional, as the majority of survey participants indicated 2 or 3 tools used regularly, whilst only a few mentioned 4 or more. It was found a certain correlation - those using only 1 or 2 tools have a lower average level of agreement (closer to 2.0, i.e. 'somewhat disagree'), whilst in the group using 3 tools the average response is slightly higher (closer to 3.0, neutral), and for the group using 4 or more tools it is even higher (above 3.0). Given the disparity between the groups, the trend is as expected - the more different communication tools someone uses, the more likely they are to feel overwhelmed by information.

Answers for question 33 - "A single, universal communication tool would improve my team's work" show differences in attitudes towards a single universal tool depending on the team role. Neutral attitudes were predominant among managers, accounting for as much as 44%. The remaining responses are split between moderate and strong support, with 31% 'somewhat agreeing' and 25% 'strongly agreeing'. No one in this group expressed opposition to the idea of tool unification. This suggests openness to the concept, but also a certain caution in giving it unequivocal support. In the case of the operational group, the distribution of responses to the statement " " is more varied. 47% of respondents agreed that a single tool would improve the team's work, with 32% agreeing moderately and 15% strongly. On the other hand, as many as 30% of respondents in this group disagreed, indicating the presence of significant doubts. It can be assumed that for some operational staff, the ability to adapt tools

to their own preferences and the specific nature of their tasks is important, which may raise concerns about excessive standardisation.

The survey yielded mixed results regarding the assumption that an excess of communication tools reduces team efficiency. On the one hand, over half of the respondents feel that their own productivity suffers when they must use multiple channels, and they identify specific problems (such as difficulty in finding information). These individuals are also more likely to feel that their team has too many tools, which supports the hypothesis that an excess of tools has a negative impact on work. On the other hand, the majority of respondents do not perceive the number of tools in their team as excessive. For these individuals, the issue of fragmented communication is not a serious problem, perhaps because in practice they use only 1-2 main tools, which is a manageable situation. As a result, Hypothesis 4 could only be accepted for a subset of the surveyed group where multiple platforms are actually used, and people feel overwhelmed by this. Across the entire sample, the impact of the number of tools on efficiency is not so clear-cut (as evidenced by the relatively low average scores for responses denying an excess). It is worth noting that a significant proportion of respondents see a potential benefit in unifying tools, suggesting that, as a preventive measure or looking ahead, they would be keen to simplify communication to ensure the risk of reduced efficiency does not increase. Overall, as there are no clear-cut results, hypothesis 4 is not accepted.

Hypothesis H5, adopted in the study, was of key importance. It refers directly to the main aim of the study, i.e. assessing the impact of communication on the effectiveness of IT project teams. Both the literature and the survey results consistently indicate that the quality of communication is one of the main factors determining the effective work of a project team. Project management theorists have long emphasised that communication failures can jeopardise even perfectly planned projects. Empirical results have confirmed this view. Teams assessed (by their members) as communicating better achieved higher performance. This observation has broad practical implications, as it highlights the need to invest in communication skills and in tools and procedures that support the efficient flow of information within organisations. In other words, the confrontation of theory with practice confirmed the universal importance of effective team communication described in the literature, while also highlighting areas where modern teams have developed effective solutions to mitigate potential problems. From a broader perspective, the results of the synthesis indicate that communication in hybrid project teams is evolving as organisations adapt to new working realities. Theoretical models of communication must take into account the growing role of technology and changes in the ways of building remote relationships. Practice shows that with the right approach combining the right tools, transparent procedures and a supportive organisational culture, hybrid teams can achieve high efficiency, rivalling traditional teams working exclusively in the office.

This study therefore makes an important contribution to the knowledge of communication in distributed teams, confirming some of the existing theoretical findings and extending them to the current context of IT teams operating in a hybrid model.

The conclusions drawn can be put to practical use in improving communication strategies in organisations, while also pointing the way for future research on improving communication in a changing project work environment.

4. Summary

This study examined the role of synchronous and asynchronous communication in hybrid IT project teams, emphasising how communication practices influence team effectiveness, cohesion, and overall project performance. The findings demonstrated that the choice of communication mode is strongly shaped by task characteristics: synchronous communication is better suited for complex, interdependent, or ambiguous tasks requiring immediate clarification of, while asynchronous communication supports activities demanding precision, documentation, and flexible time management. Importantly, the results confirmed that maintaining a balance between these two modes is essential, thoughtful integration of both forms enhances collaboration and supports efficient project execution.

The analysis also showed that effective communication depends not on the number of tools used but on clear communication norms and purposeful tool selection, reinforcing the importance of strategic communication planning within organisations. Both the literature review and empirical data underscored that hybrid teams must continuously refine communication practices as they adapt to evolving work models and increasing digitalisation of collaboration processes. Overall, the study contributes valuable insights for researchers and practitioners by offering evidence-based recommendations for optimising communication in hybrid project environments.

Future research on communication in hybrid IT project teams should incorporate mixed-methods approaches, combining quantitative surveys with qualitative interviews for deeper insight into interpersonal and organizational dynamics. It would also be valuable to examine culturally diverse and globally distributed teams, where communication norms differ.

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Appendix

Research survey on the role of communication in hybrid project teams in the IT industry (questions)

1. What is your role in the project team?
2. How long have you been working in the IT industry?
3. What is your current work mode?
4. How many members does your project team usually consist of, including yourself?
5. How do you prefer to communicate with team members?
6. When you have a complex or unclear task to discuss, which form of communication do you prefer to use to clarify any doubts?
7. In what situations do you decide to meet offline or online instead of writing a message?
8. How often during online meetings (e.g. video conferences) do you perform other tasks at the same time?
9. What do you usually do during a typical online meeting where you are not have to speak?
10. If you are very busy (you have several tasks "running" at once), how would you prefer your colleague to communicate a new task or urgent question to you?
11. How often does your team organise scheduled online meetings or offline meetings in which most team members participate?
12. How do you most often communicate with your team members? on a daily basis?
13. Does your team engage in additional team-building activities?
14. Which communication tools do you use regularly in teamwork?
15. How would you rate the current ratio of synchronous to asynchronous communication? asynchronous communication in your team?
16. How would you rate the effectiveness of communication in your team?
17. What do you associate most with the advantage of asynchronous communication in a team?
18. Complex issues are best discussed in face-to-face conversations: online or offline.
19. I prefer to deal with simple matters in writing (e.g. by e-mail or chat) rather than in meetings.
20. When a task is unclear or complicated, it is more important to be quick live contact is more important than a polished written message.
21. I avoid organising meetings if the topic can be easily explained asynchronously (via message).
22. Frequent status meetings interrupt my work and make it difficult concentrate.
23. I prefer to receive a message (e.g. in a chat) rather than a phone call when I am busy performing tasks.

24. I sometimes perform several tasks at once at the expense of communication quality communication (e.g. I don't catch everything at a meeting because I'm doing something else at the same time).
25. The possibility of asynchronous communication helps me manage better multiple tasks simultaneously.
26. Lack of online or offline meetings weakens team integration.
27. Even with predominantly asynchronous communication, the team can be harmonious and understand each other well.
28. Regular online or offline meetings are important for maintaining a sense of being part of the team.
29. Switching between multiple communication tools reduces my work efficiency.
30. I think that our team uses too many different applications for communication.
31. Various tools are needed because no single one will suffice all of our team's communication needs.
32. I often have trouble finding information because it is scattered throughout various communication channels.
33. A single, universal communication tool would improve my work team.
34. Too much communication takes place synchronously, which reduces our productivity (too many meetings, not enough time to work in concentration).
35. Too much communication takes place asynchronously, which decisions are made more slowly, and information easily escapes us.
36. The right balance between meetings and offline communication has a positive affects the effectiveness of our work.

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PSYCHOLOGICAL AND BEHAVIORAL DETERMINANTS OF CONSUMER VULNERABILITY TO DARK AI PATTERNS IN E-COMMERCE

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Purpose: The aim of the article is to analyze the relationship between psychological and behavioral factors and consumer susceptibility to manipulations such as Dark AI Patterns in e-commerce.
Design/methodology/approach: The survey was conducted using a survey method in 2025 on a sample of 429 respondents, using the analysis of descriptive statistics and the Pearson correlation.
Findings: The results indicate significant positive and negative relationships between the analyzed variables and susceptibility to algorithmic manipulation.
Research limitations/implications: The study is based on declarative data and is cross-sectional, which limits the possibility of generalizing results and inferring cause-and-effect relationships.
Practical implications: The results underline the importance of transparent design of AI systems and strengthening consumer awareness.
Originality/value: The article brings value by analyzing the relationships between the determinants of vulnerability, building on existing research in this area.
Keywords: dark AI patterns, consumers, e-commerce, company, manipulations.
Category of the paper: research paper.

1. Introduction

Nowadays, the e-commerce environment is undergoing constant and dynamic changes. They remain a consequence of rapid digitization, the intensive development of digital technologies, and in particular solutions based on artificial intelligence (AI). Undoubtedly, modern technologies contribute to increasing the efficiency of procurement processes. They also improve the user experience through personalization and automation. However, at the same time, they create conditions that are conducive to the use of increasingly advanced

techniques to influence consumer decisions. The scientific literature emphasizes the fact that the mechanisms referred to as Dark AI Patterns can be considered as a development of classical manipulation techniques, which are enhanced by the ability of algorithms to analyze data and predict user behavior (Maciaszczyk et al., 2026). However, it can be said that these interactions have a real impact on purchasing decisions and consumer impulsivity. This is confirmed by the results of empirical research (Gąsiński et al., 2026).

The growing scale and complexity of these phenomena make them an important and current research problem. Studies indicate that Dark AI Patterns are becoming an integral element of digital marketing strategies, exploiting cognitive biases, time pressure, and information asymmetry to shape consumer behavior (Singh et al., 2024, 2026; Marwaha et al., 2026). At the same time, the use of AI in recommendation systems and interface design increases the effectiveness of these mechanisms, often limiting consumer autonomy and blurring the boundary between support and manipulation (Silva et al., 2026; Spasovski, Jönsson, 2025).

Addressing this issue becomes fully justified, covering both the cognitive and practical dimensions. Therefore, it becomes necessary to determine the level of susceptibility of consumers to manipulation, as well as to diagnose the mechanisms that underlie it. Previous research has focused mainly on identifying the level of vulnerability to Dark AI Patterns in the e-commerce environment (Maciaszczyk et al., 2026) and analyzing their impact on purchasing decisions and consumer impulsivity (Gąsiński et al., 2026).

In parallel, the literature emphasizes the multidimensional nature of manipulation in e-commerce, combining technological, behavioral, and psychological aspects. Research highlights the role of factors such as trust in platforms (Beatty et al., 2011), personalization (Widyatmoko, 2025), and the increasing importance of user-generated content and opinion systems, which may also be subject to manipulation (Wang et al., 2023, 2024; Xu et al., 2015). Moreover, the development of AI-based tools enables more advanced forms of influence, including adaptive content, emotional targeting, and automated manipulation detection systems (Avolicino et al., 2022; Al Wahshat et al., 2023).

However, knowledge about the relationship between psychological and behavioral factors and susceptibility to such influences still seems insufficient. Despite the growing body of research, there is still a noticeable gap in the literature regarding the integrated analysis of psychological and behavioral determinants of consumer susceptibility to such manipulative mechanisms. In particular, insufficient attention has been paid to the relationships between variables such as trust in AI, perception of personalization, awareness of algorithms, and critical attitudes toward marketing messages, and their combined effect on vulnerability to manipulation.

Taking into account economic practice, this problem assumes a key role for the design of sales systems, which should balance efficiency with respect for user autonomy. Addressing this research gap is important both from a theoretical and practical perspective. From a theoretical standpoint, it contributes to a better understanding of the mechanisms underlying consumer

behavior in highly automated digital environments. From a practical perspective, it provides guidance for the design of more transparent and ethically responsible e-commerce systems, balancing efficiency with respect for user autonomy (Hadi, 2025; Silva et al., 2026).

The article is a continuation and development of previous research on Dark AI Patterns in e-commerce, included in the paper on the level of consumer susceptibility to algorithmic manipulation (Maciaszczyk et al., 2026) and research on the impact of these mechanisms on purchasing decisions and impulsivity (Gąsiński et al., 2026).

Therefore, the main objective of this article is to analyze the relationships between selected psychological and behavioral factors and the level of consumer susceptibility to manipulations such as Dark AI Patterns in the e-commerce environment. Unlike previous studies, this study focuses on the analysis of the relationship between selected psychological and behavioral variables, which include the perception of personalization, trust in artificial intelligence or awareness of algorithms, and the level of susceptibility to manipulation. The study extends previous research by moving beyond a descriptive approach toward a relational analysis that enables the identification of both the direction and strength of relationships between the analyzed constructs.

The article has an added value, which is revealed in the transition from a descriptive approach to relational analysis, allowing for the identification of the direction and strength of the links between the analyzed constructs. The structure of the article includes a theoretical part - it discusses the essence of Dark AI Patterns and the determinants of consumer vulnerability, a methodological part that presents the research assumptions and methods used, an empirical part including the results of statistical analyses, as well as a discussion and conclusions relating to the results obtained and their theoretical and practical implications.

1.1. Istota Dark AI Patterns w e-commerce

The literature on Dark AI Patterns and consumer behavior in e-commerce can be grouped into three main research streams: technological, focusing on algorithmic systems and interfaces; behavioral, analyzing consumer responses and susceptibility to influence; and regulatory-ethical, addressing transparency and user protection. This classification helps organize existing research and highlights the complexity of the phenomenon.

In the literature on the subject, the issue of Dark AI Patterns in the e-commerce environment remains a broad discourse of theoretical and practical analyses. It is seen as an important manifestation of contemporary forms of digital manipulation, combining classic persuasive techniques with the capability's characteristic of the use of artificial intelligence. Literature analysis indicates that the use of recommendation systems and personalization mechanisms leads to greater effectiveness in influencing consumer decisions, while limiting their decision-making autonomy (Maciaszczyk et al., 2026; Gąsiński et al., 2026). In review analyses, there is a view that dark patterns can be considered an integral element of marketing strategies

in e-commerce. These solutions exploit the mechanisms of social influence, time pressure, and information asymmetry (Singh et al., 2024, 2026). In this aspect, the issue of regaining control by users operating in conditions of intensive automation of purchasing processes is of great importance. This is reflected in considerations on consumer autonomy in the era of AI (Silva et al., 2026).

An important stream of research is focused on the analysis of the mechanisms of operation and technological foundations of Dark AI Patterns, which is manifested especially in the area of user experience design and digital interfaces. It should be noted that the automation of manipulation patterns and their adaptation to user behavior contribute to increasing the difficulty of identification and the potential for impact (Spasovski, Jönsson, 2025; Kitkowska, 2025). In experimental studies, attention is paid to the role of emotions and cognitive responses of users. These can be used by AI-based systems to enhance the effectiveness of messages (Avolicino et al., 2022). At the same time, the trend of technical research is developing dynamically, focusing on the identification and automatic detection of manipulative patterns in the digital environment. This is reflected in analyses using machine learning models and pattern detection methods in e-commerce interfaces (Ramteke et al., 2024; Sawant et al., 2025; Kirthiga et al., 2024; Yada et al., 2023).

The above considerations are complemented by contextual and applied research. They relate to specific platforms and market and regulatory conditions. Case studies have revealed a dynamically increasing scale of the use of dark patterns in global e-commerce platforms, which is visible, for m.in, in research on the functioning of selected shopping websites (Erdem, 2026). At the same time, attempts are being made to define strategies to mitigate the negative effects of these phenomena, including through regulatory actions and the design of more transparent systems (Hadi, 2025). The roles of factors such as trust, risk and user diversity in assessing the impact of dark patterns should also be indicated, which indicates the multidimensional nature of the analyzed phenomenon (Marwaha et al., 2026).

1.2. Analysis of consumer vulnerability to manipulation in e-commerce

In the literature on the subject, the issue of consumer susceptibility to manipulation in the e-commerce environment is widely addressed, which is part of a broader stream of research on digital persuasion and influence mechanisms used by sales platforms. The modern shopping environment is constantly saturated with impact techniques, combining elements of dark patterns and digital nudging. They aim to shape consumer decisions in a way that prevents unambiguous identification (Singh et al., 2024). Trust in platforms also plays a big role in the functioning of e-commerce. It can both support the decision-making process and strengthen the vulnerability to manipulative messages (Beatty et al., 2011). At the same time, the rapid development of digitization and cutting-edge technologies is conducive to the use of increasingly advanced forms of influence, such as the manipulation of product images or the

adaptation of content to the individual characteristics of users. This influences the perception of the offer and purchasing decisions (Chatrath et al., 2022; Widyatmoko, 2025). There is also a growing role of reputation manipulation and rating systems, which can artificially shape the perceived credibility of products and sellers (Xu et al., 2015; Zhang et al., 2024).

Literature and practical analyses are focused on the analysis of manipulation mechanisms based on the content generated by users and their impact on consumer behavior. Great importance can be attributed to the manipulation of opinions and reviews. They are one of the most important sources of information in the purchasing decision-making process (Wang et al., 2023, 2024). This phenomenon is taking on more and more complex forms. These include coordinated actions and those using strategic models. This is confirmed in analyses dealing with manipulation on e-commerce platforms (Xu et al., 2025). In parallel, research is being conducted on automatic manipulation detection, especially using advanced language models such as GPT-4 and classification methods based on machine learning (Al Wahshat et al., 2023; Chen, Lin, 2013). There is also a need to take into account the security and integrity aspects of e-commerce systems. Here, countermeasures to more advanced forms of manipulation, including logistical and operational processes, should be indicated (Hao et al., 2026).

The above considerations can be complemented by research that focuses directly on consumer behavior and their reaction to manipulative elements of interfaces and marketing messages. It is indicated that manipulation within the design of the user interface can result in an increase in purchasing impulsiveness and a reduction in the rationality of decisions (Singh, 2025). At the same time, previous research on human-computer interaction indicates the growing importance of the way information is presented and the ability to directly manipulate interface elements, which remains extremely important for shaping the user experience (Capozzo et al., 2003). In this aspect, analyses that concern the issue of consumer susceptibility to manipulations based on artificial intelligence are also of significant importance. They point to the problem of the complexity of the relationship between psychological factors and responses to algorithmic stimuli (Maciaszczyk et al., 2026). These results are part of a broader stream of research on the multidimensional nature of manipulation in e-commerce, encompassing both technological and behavioral aspects, which highlights the need for further analyses to integrate these perspectives.

2. Methods

The aim of the research was to determine the relationship between selected psychological and behavioral variables and the level of consumer susceptibility to manipulations such as Dark AI Patterns in the e-commerce environment. Particular attention was focused on identifying the role of such factors, which included the perception of personalization, trust in artificial

intelligence systems, awareness of algorithms, purchasing impulsiveness, sense of purchase pressure, intensity of use of AI recommendations, and criticism of marketing messages in shaping consumer reactions to algorithmic forms of influence.

The study adopted a research hypothesis – according to it, psychological and behavioral variables remain significantly related to the level of susceptibility to algorithmic manipulation. It was assumed that a higher level of personalization perception, greater trust in AI systems, and more intensive use of AI-based recommendations would foster an increase in vulnerability to such influences. At the same time, it was assumed that the awareness of algorithms and a critical approach to marketing messages will serve as factors that limit susceptibility to manipulation. In addition, it has been assumed that vulnerability to Dark AI Patterns is related to purchasing impulsiveness and a sense of buying pressure.

In connection with the above, research questions have been formulated. They referred to the nature and strength of the relationship between the analyzed variables. It was analysed whether and to what extent the perception of personalization, trust in AI and the intensity of the use of algorithmic recommendations are related to susceptibility to manipulation. In addition, answers were sought to the questions whether awareness of algorithms and criticism of marketing messages show relationships of the opposite nature to vulnerability. The analysis also included the issue of determining the relationship between susceptibility to manipulation and purchasing impulsiveness and the feeling of purchase pressure.

The survey method was adopted as a research method. The survey was conducted in 2025. An online survey questionnaire was used for this purpose. The research sample included 429 respondents who met the criterion of shopping activity in the e-commerce environment. The collected data were subjected to statistical analysis. In the first place, it included the calculation of basic measures of descriptive statistics, such as the mean and standard deviation for individual variables. Next, a relationship analysis was performed using Pearson's linear correlation coefficients. This allowed to determine the direction and strength of the links between the analyzed constructs.

To ensure the reliability of the measurement scales, an approach based on their construction and consistency with previous research was adopted. The measurement items used for the analyzed constructs, such as trust in artificial intelligence, perception of personalization, and algorithm awareness, were multi-item in nature, which allows their internal consistency to be considered satisfactory. In terms of validity, the constructs were operationalized based on a review of the literature on e-commerce, consumer behavior, and the use of artificial intelligence. Content validity was ensured through the alignment of questionnaire items with the theoretical definitions of the analyzed variables. The use of Likert-type scales and their reference to previous studies allow the construct validity to be considered as maintained.

3. Results

The research used empirical data collected as part of a survey conducted among e-commerce users. The analysis was based on a set of variables. They included both reactions to selected forms of algorithmic influence, as well as psychological constructs that related to the functioning of consumers in the digital environment, such as the perception of personalization, trust in artificial intelligence systems, awareness of algorithms, purchasing impulsiveness and a sense of purchase pressure. These variables were assigned numerical values, based on a five-point measurement scale. This allowed for further statistical analyses, including correlation analysis.

In the course of the research, preliminary characteristics of the variables used in the further analysis of the relationships were made, including both the level of susceptibility to algorithmic influence and selected psychological and behavioral constructs. The analysed variables were measured using a five-point scale, allowing for their quantitative interpretation.

The average level of vulnerability to manipulation of the Dark AI Patterns was at the level of 3.00. This indicates a moderate susceptibility of respondents to the influence of this type of stimuli. Similar values were recorded in the case of purchasing impulsivity (M = 2.97) and the feeling of buying pressure (M = 3.05). This suggests a relative balance between spontaneous responses and perceived situational influence.

With regard to psychological variables, the highest average value was obtained for trust in AI systems (M = 3.25). This confirms the relatively high level of acceptance and positive assessment of the algorithms by respondents. Slightly lower values were observed in the perception of personalization (M = 3.18) and the intensity of using AI-based recommendations (M = 3.21). Such variables indicate a moderate, but noticeable level of contact with algorithmic solutions in the procurement environment.

A relatively lower level of was obtained in relation to the awareness of algorithms (M = 2.89). This confirms the limited knowledge of the mechanisms behind the functioning of recommendation systems. On the other hand, criticism of marketing messages reached an average value of 3.12, which suggests a moderate value, which "stands" behind the tendency of respondents to reflectively evaluate the content presented.

The variation of responses, measured by standard deviation, was included in the range from 0.68 to 0.81, confirming the moderate level of dispersion of the results and the relative homogeneity of the tested sample in terms of the analyzed variables. The obtained statistical parameters can be considered as the basis for further analyses of the relationships between variables. This is mainly possible in terms of identifying the direction and strength of the links between psychological constructions and susceptibility to algorithmic manipulation.

On the basis of the presented characteristics of the variables, the analysis of the Pearson linear correlation was performed. Its results are presented in Table 1. Thanks to the results obtained, it is possible to identify the direction and strength of the relationship between the analyzed psychological and behavioral constructs and susceptibility to manipulation such as Dark AI Patterns.

Table 1.
Relationships between psychological and behavioral variables and susceptibility to Dark AI Patterns (Pearson correlation coefficients)

Variable	Susceptibility to AI Manipulation	Impulsive Buying	Perceived Purchase Pressure
Perceived Personalization	0.42	0.38	0.35
Trust in AI	0.47	0.33	0.29
Algorithm Awareness	-0.44	-0.31	-0.28
Intensity of AI Recommendation Use	0.39	0.36	0.41
Critical Attitude toward Marketing Messages	-0.36	-0.40	-0.34

Source: Own study.

In the first place, a positive relationship can be noted between the perception of personalization and susceptibility to algorithmic manipulation (r = 0.42). This indicates a moderate strength of the connection. In addition, at the same time, the perception of personalization is positively correlated with purchasing impulsivity (r = 0.38) and the feeling of buying pressure (r = 0.35), indicating the co-occurrence of these phenomena in consumer behavior.

The highest value of the correlation coefficient in relation to susceptibility to manipulation was recorded in the case of trust in artificial intelligence (r = 0.47), which indicates a relatively stronger relationship compared to the other variables. This variable also shows positive correlations with purchasing impulsivity (r = 0.33) and the feeling of buying pressure (r = 0.29), despite the fact that their strength is slightly lower.

In the case of awareness of the algorithms' operation in the course of the research, negative values of correlation coefficients were obtained in all analysed relationships. The correlation with manipulation susceptibility is r = -0.44, indicating a moderate inverse relationship. A similar trend was affected in relation to purchasing impulsivity (r = -0.31) and the feeling of purchasing pressure (r = -0.28). The strength of these relationships remains at a moderate level.

Positive dependencies are also noted in the case of the intensity of use of AI-based recommendations. The correlation with manipulation susceptibility is r = 0.39. On the other hand, with purchasing impulsiveness, it is r = 0.36. The highest value in this case was obtained for the relationship with the feeling of purchasing pressure (r = 0.41), confirming a clear link between this variable and the perceived situational impact.

When it comes to the critical attitude towards marketing messages, each of the correlation coefficients received assumes negative values. In the case of susceptibility to manipulation, the value of r = -0.36 can be indicated for a moderate inverse relationship, while in relation to purchasing impulsivity, the value of r = -0.40 was recorded. This is one of the higher absolute

values in the analyzed matrix. In turn, the correlation with the feeling of buying pressure reached the level of r = -0.34.

The results, presented in Table 1, indicate the presence of both positive and negative relationships between the analysed variables, and their strength ranges from weak to moderate.

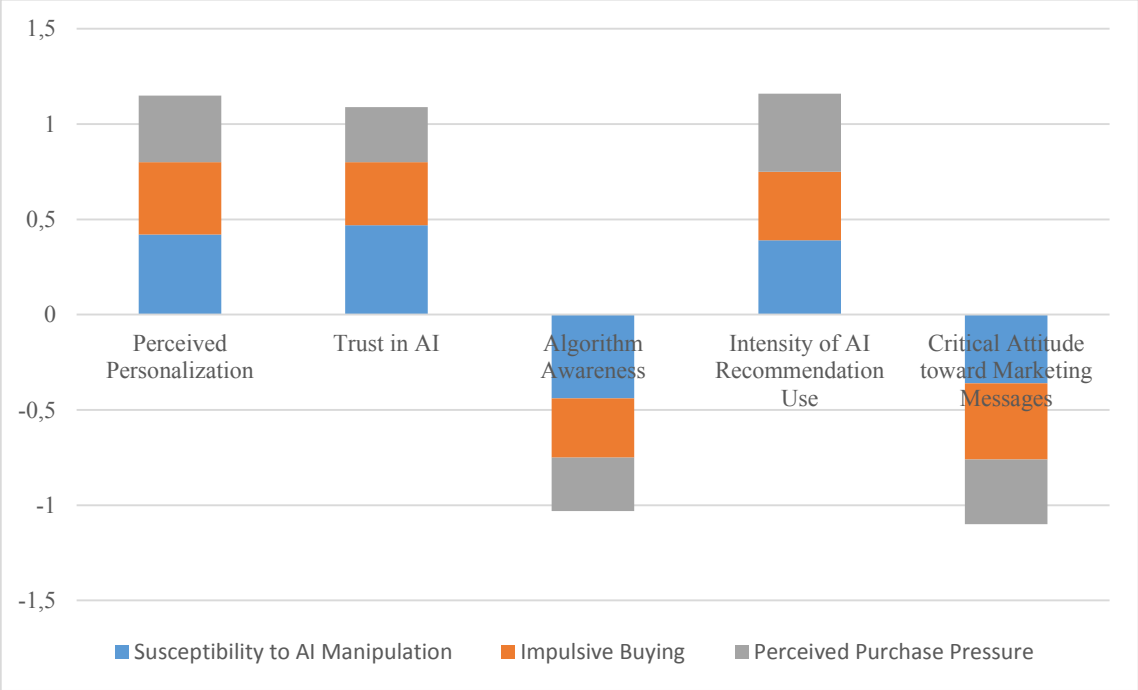

Figure 1. Stacked column chart.

Source: Own study.

On the basis of the correlation analysis presented in Table 1, a visualization of the results in the form of a cumulative column graph is presented (Fig. 1). It allows for a synthetic approach to the relationships between the analyzed variables. Figure 1 reflects both the direction and the relative strength of the links between psychological and behavioural factors and manipulation vulnerability and related consumer responses. This makes it easier to compare their meanings. It is also possible to point out a clear differentiation between variables of a vulnerability-reinforcing nature, such as trust in artificial intelligence or perception of personalization, and limiting factors, such as awareness of algorithms or a critical approach to marketing messages. Thanks to the presented visualization, it is therefore possible to confirm the conclusions that resulted from Table 1. At the same time, the relational nature of the analysed relationships and their mutual proportions were emphasized in a more transparent way.

It should be noted that Figure 1 has primarily an illustrative and organizational character, allowing for a synthetic visualization of the relationships presented in Table 1. However, its analytical value is limited, as it does not provide additional insights beyond the numerical data already included in the table. Therefore, the figure serves a complementary role, supporting the interpretation of the results rather than constituting a separate analytical tool.

4. Discussion

On the basis of the conducted research, several conclusions can be drawn that concern the mechanisms shaping the susceptibility of consumers to manipulations such as Dark AI Patterns in the e-commerce environment. Based on the results of the research, it can be indicated that factors related to the perception of technology play a key role. In particular, it is trust in artificial intelligence systems and the perception of personalization of messages. Positive relationships indicate that the higher the level of acceptance and belief in the accuracy of algorithms, the greater the tendency to succumb to the stimuli generated by them. An analogous direction of dependency can be observed in the case of the intensity of the use of AI recommendations, confirming the significant role of the frequency of contact with technology in shaping user reactions.

At the same time, the importance of protective factors can be pointed out. Awareness of algorithms and a critical approach to marketing messages reflect the opposite of vulnerability to manipulation. Therefore, they can be considered as key mechanisms that limit the impact of algorithmic forms of influence. The increase in cognitive competence and reflectivity of users is closely related to the reduction in the level of vulnerability, indicating the importance of knowledge and the ability to interpret digital messages in the shopping environment. These dependencies highlight the role of consumer education in the aspect of the growing presence of technologies that operate on artificial intelligence algorithms.

In addition, the results of the research suggest the co-occurrence of susceptibility to manipulation with behavioral reactions, such as purchasing impulsiveness and feelings of buying pressure. Positive relationships between these variables confirm that susceptibility to algorithmic influence is inscribed in the broader context of consumer behavior. Emotions and situational decision-making stimuli play an important role in such a process. These dependencies suggest that manipulation mechanisms are linked to the general style of purchasing decisions and take on a complex and multidimensional character.

The results obtained in the analyzed article are consistent with the findings of other researchers. This is especially evident in relation to the importance of trust and personalization in the e-commerce environment. A positive relationship was found between trust in AI and susceptibility to manipulation, which corresponds to findings indicating that trust is one of the determinants of user behavior in e-commerce and their propensity to make purchasing decisions (Beatty et al., 2011). On the other hand, the positive relationship between the perception of personalization and susceptibility to algorithmic influence has been confirmed in studies indicating that personalization strategies increase the effectiveness of marketing influence and influence consumer purchasing decisions (Widyatmoko, 2025). Therefore, the results obtained in this study are part of a broader stream of research indicating that mechanisms that increase the alignment of the message and the credibility of the platform can simultaneously strengthen the vulnerability of users to digital impact.

At the same time, the obtained results are consistent with studies on digital persuasion and manipulation mechanisms in e-commerce, which indicate that the use of dark patterns and algorithmic solutions may significantly influence consumer behavior, including increasing impulsiveness and perceived decision pressure (Singh, 2025, 2024, 2026). The positive relationship identified between the intensity of AI-based recommendation use and susceptibility to manipulation also corresponds with research emphasizing the growing role of automated and adaptive systems in shaping consumer decisions (Spasovski, Jönsson, 2025; Kitkowska, 2025). In turn, the negative relationships observed in relation to algorithm awareness and a critical attitude toward marketing messages confirm the protective role of cognitive factors, as indicated in studies on user perception and resistance to manipulation (Avolicino et al., 2022; Silva et al., 2026). The results are also in line with research on manipulation in review and reputation systems, which demonstrate their significant impact on purchasing decisions in e-commerce environments (Wang et al., 2023, 2024; Xu et al., 2015).

It should be emphasized that the relationships identified in this study are correlational in nature and do not imply causality. Due to the cross-sectional design of the research, the observed associations between variables such as trust in AI and susceptibility to manipulation should be interpreted with caution. Therefore, the results indicate co-occurrence rather than cause-and-effect relationships, and any directional interpretations require further verification using longitudinal or experimental research approaches.

5. Conclusions

Based on the results obtained, recommendations can be formulated for enterprises operating in the e-commerce environment. These refer to the responsible use of AI-based tools. In particular, it seems reasonable to limit the use of excessively intensive stimuli, which are based on personalization and mechanisms that strengthen trust in AI systems in a way that may lead to unconscious influence on consumer decisions. It is advisable to design transparent solutions so that users can identify which content is recommendatory and which results from algorithmic activities. This approach can help in the process of building relationships that are based on credibility rather than short-term manipulative effectiveness.

Among the important directions of research, we can point to strengthening users' awareness of the functioning of algorithms and ways of generating shopping content. Implementing solutions that increase the transparency of recommendation systems, such as explanations regarding product selection or the ability to verify the sources of recommendations, will reduce susceptibility to manipulation. On the other hand, the introduction of interfaces that promote reflective purchasing decisions, for example by enabling easy comparison of offers or

introducing mechanisms that delay the completion of the purchase, promotes more informed consumer choices.

In addition, in the process of designing sales systems, it is reasonable to take into account issues related to purchasing impulsiveness and felt decision-making pressure. On the basis of the conducted research, it can be concluded that these factors are closely related to susceptibility to algorithmic influence. This means that strengthening them can lead to exacerbated undesirable behavioral effects. Therefore, it is recommended to use solutions that minimize time pressure and limit the excess of stimuli that stimulate quick decisions. In the long run, this approach leads to more balanced customer relationships. It also strengthens their trust in e-commerce platforms.

The conducted research is subject to certain limitations. They should be taken into account when interpreting the results obtained. The choice of the survey method meant that the data is based on respondents' declarations, and this fact may be associated with the risk of distortion. They are the result of subjective assessment of one's own behaviour, the effect of self-presentation or limited awareness of the influence of algorithmic mechanisms. It should also be added that the study took on a cross-sectional character, making it impossible to capture changes over time, as well as making it difficult to determine cause-and-effect relationships between the analyzed variables. The limitations also include the presence of the structure of the research sample. Despite the diversity, it did not fully reflect the population of all e-commerce users. And this limited the possibility of generalizing the results. In addition, the analysis was based on generalized psychological constructions, it did not take into account the situational context of purchasing decisions or actual consumer behavior, which in turn could be a significant complement to the results obtained.

In future research, it seems reasonable to deepen the analysis of the mechanisms determining the susceptibility of consumers to manipulations such as Dark AI Patterns. In particular, it would be interesting to take into account psychological variables that are related to the regulation of emotions, decision-making style and cognitive resilience. It is also worth considering extending the scope of research to include a longitudinal approach. It would make it possible to observe changes over time and identify the long-term effects of exposure to algorithmic forms of influence. It would also be interesting to use experimental methods. Such an approach would allow for a more precise determination of cause-and-effect relationships. It would also make it possible to compare the effectiveness of different types of manipulation in different purchasing contexts. In addition, differences between consumer groups, including cultural and demographic conditions, could be taken into account. The future direction of research could also be the analysis of the impact of legal regulations and ethical standards on the way AI-based systems are designed in the e-commerce environment.

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PARADOXES OF PROJECTIFICATION. CASE STUDY OF POLISH NONPROFIT ORGANIZATIONS

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Purpose: This study analyzes paradoxical tensions in project management within non-profit organizations (NPOs), addressing a significant gap in the literature by examining the impact of projectification on the balance between strategic, operational, and mission-driven objectives.
Design/methodology/approach: A survey was conducted among 385 Polish nonprofit organizations, including foundations and associations. This study employs a theoretical framework grounded in paradox theory to examine the interplay among projectification, funding, and mission alignment.
Findings: Four key paradoxes were identified. The identity paradox concerns the tension between mission and project objectives. The temporality paradox is defined as the incongruity between short-term funding cycles and long-term organizational sustainability. The flexibility and structure paradox is the tension between standard project procedures and the need for adaptive, flexible actions. The learning paradox is a phenomenon in which innovation and learning are constrained by donor pressure for accountability.
Social implications: The findings offer practical guidance to nonprofit leaders and policymakers who aim to balance project delivery, mission, and funding sustainability.
Originality/value: This study presents a novel application of paradox theory to project-based nonprofit organizations, underscoring the tensions that have received insufficient attention in project management literature. A comparative approach enables differentiation between project-oriented and non-project-oriented nonprofit organizations.
Keywords: Projectification, Paradox theory, Funding, Nonprofit organizations, Project management.
Category of the paper: Research paper, case study.

1. Introduction

In recent years, a substantial shift has been observed in how nonprofit organizations (NPOs) execute their missions, provide assistance, and engage in development activities. These organizations have assumed a predominant role in contemporary responses to significant challenges, overseeing and financing projects and serving as the primary drivers of many development initiatives. Consequently, projectification as an organizational, managerial, social,

and cultural phenomenon applies to these organizations. A survey of the Polish nonprofit sector found a growing share of projects in its operational and strategic activities. The projectification of these entities has emerged as a model for inter-organizational cooperation, with paradox theory serving as an important framework for their study in the context of contemporary grand challenges (Jarzabkowski, Bednarek, Chalkias, Cacciatori, 2018; Ika, Munro, 2022). These social organizations, mainly the foundation and association types, are compelled to respond to these challenges. A close examination of the scholarly discourse on projectification reveals a series of contradictions. Researchers' interest in projectification points to its positive and negative consequences at different levels of the organization (Aguilar Velasco, Wald, 2022). Scholars have postulated that projectification is unavoidable (Huemann, 2022; Nieto-Rodriguez, 2021). Conversely, they identified paradoxes that could serve as catalysts for projectification or deprojectification (Jacobson, Jałocha, 2025). This phenomenon is accompanied by a series of organizational tensions and contradictions, rendering paradoxes a tangible and unavoidable experience for any organization (Carmine, De Marchi, 2023). A recent nationwide survey of the Polish nonprofit sector confirmed significant projectification (Małecka-Dobrogowska, 2025). A survey was conducted among non-profit organizations, the results of which indicated that those engaged in mass project activities faced a distinct paradox regarding the dilemmas posed by the imperatives to acknowledge the preeminence of project objectives, organizational mission, temporal funding, and sustainability. Furthermore, a variety of organizational and inter-organizational tensions were identified, both within NPOs that did not incorporate projects into their activities and within the collaboration of the NPO sector with business and public partners in addressing grand challenges. Projectification is associated with professionalization; however, it is also a search for a balance between the mission-driven, civic, and often idealistic nature of these entities' activities. However, allowing projectification to continue in organizations and society, despite the tensions and contradictions encapsulated in the "unpacked" paradox formula, might prevent the effective realization of project goals and organizational objectives (Naderpajouh, Matinheikki, Keeys, Aldrich, Linkov, 2023). This is particularly true for organizations in which projectification is the main development scenario for maintaining project-based external funding sources. This study explored three research questions:

1) What contradictions and tensions, framed in the context of paradox theory, can be identified and applied to the projectification of the nonprofit sector?
2) What types of contradictions and tensions, captured as paradoxes in the form of content clusters, emerge from the survey of Polish nonprofit organizations?
3) How do these paradoxes affect governance, sustainability, and mission alignment?

A narrative literature review was conducted to address the three research questions, and the results of an umbrella review of systematic reviews related to paradoxes in project management, projectification, and project studies were analyzed. Systematic reviews were selected based on their relevance to and direct connection with the theory of paradoxes in

project management (the so-called umbrella review). This approach was intended to minimize selection bias and ensure the review's comprehensiveness. Therefore, paradox theory and the tensions and contradictions surrounding project management were considered, with particular attention paid to the potential applicability of these approaches to the paradoxes identified in nonprofit sector projects. The following article was developed with the following three objectives. The objective of this study was to apply the paradoxes identified in the literature within new projectification contexts and search for references to the specifics of nonprofit organizations. The realization of this objective enables the formulation of recommendations for identifying paradoxical tensions inherent in routine organizational activities. Second, the study identified four clusters of meanings obtained from a survey of Polish nonprofit entities. These clusters are related to the paradoxes identified in the extant literature. Third, the author considers how paradoxical tension can be resolved. This was achieved by presenting potential scenarios for "unpacking" paradoxes and applying a zoomed-in and zoomed-out perspective (Jarzabkowski et al., 2018). This study aims to address the existing gap in the analysis of projectification from the perspective of nonprofit organizations.

2. Literature review

2.1. Paradox and tension

The following section addresses the concepts of paradox and tension. In this discussion, a paradox is understood as a system of inextricably linked yet contradictory elements that, in management practice, force a binary choice (Schad et al., 2017). This phenomenon, described by Smith and Lewis (2011) as the coexistence of interactive opposites that persist over time, allows for the identification of ‘hidden’ tensions within complex organizational systems. Analyzing and resolving paradoxes and internal and inter-organizational tensions are imperative for achieving project goals (Andriopoulos, Lewis, 2010) and for the optimal functioning of the entire organization (Wiewiora et al., 2022). The identification and analysis of paradoxes in complex inter-organizational contexts can reveal "hidden" paradoxes — those that become dormant, overlooked, or ignored within parts of the system (Smith et al., 2011).

According to Jarzabkowski et al., this poses an additional research challenge by demonstrating the nature of paradoxes among different entities, places, and times. Consequently, the analysis of paradoxes in managed organizations requires a zoomed-in-zoom-out approach (Jarzabkowski et al., 2018). The aforementioned process entails two primary stages: first, the process of zooming in, which entails the analysis of specific details and local contexts; and second, the process of zooming out, which entails the analysis of contradictions from a further inter-organizational perspective, with particular attention directed towards

hidden, nested tensions and their complex interconnections (Schad, Bansal, 2018). To capture the specific nature of Polish NGOs, a 'zoomed-in-zoom-out' approach was applied. It allowed for the simultaneous analysis of local operational contexts (zooming in) and broader, inter-organizational contradictions arising from funding cycles (zooming out), which is essential for analyzing the paradox of 'permanent' temporality. To analyze the collected research material in the context of applying paradox theory to the results of this study of the nonprofit sector in Poland, a narrative review of the literature was conducted, with a primary focus on systematic reviews (2015-2025) available in the Google Scholar database indexing both trade and academic publications – which is crucial for the interdisciplinary nature of project management in the nonprofit sector. The search included phrases such as: 'paradox management', 'projectification NGO', 'systematic literature review project paradox', and 'tensions in non-profit organizations'. The following table presents the context in which the paradoxes emerge.

Table 1.
Summary of the key articles concerning paradox and tensions within the project and NPO context

Study Focus	**Items**		
	key paradox theory context	**analysis approach**	**author**
Intangible assets and performance tensions in nonprofit	Tensions between financial constraints and social value in the context of intellectual capital and performance management.	Systematic, PRISMA-guided literature review	Buonomo, Benevene, Barbieri, Cortini, 2020
Paradox theory in corporate sustainability	Detective, sensemaking, and responsive uses of paradox theory.	Systematic Literature Review	Carmine, De Marchi, 2022
Paradoxes and tensions in inter-organizational relationships	Knowledge sharing vs. protection, unity vs. diversity, flexibility vs. rigidity, **autonomy vs. accountability, exploration vs. exploitation**, cooperation vs. competition, economic vs. social logic, short-term vs. long-term orientation.	Systematic Literature Review	Fortes, Agostini, Wegner, Nosella, 2023
Stakeholder-resource tensions	Stakeholder and communication management tensions within the projectification context.	Systematic Literature Review	Gomes, Sousa, Tereso, 2023
Projectification tensions and implications	Identified tensions as a factor in projectification.	Systematic Literature Review, Bibliometric Review, Multi-level Analysis Review	Voros Fregolente, Neto, Ribeiro, Salerno, Nakano, de Carvalho, 2022
Public sector projectification and paradoxes	Flexibility vs. control, personal vs. organizational priorities, short-term vs. long-term orientation.	Systematic Literature Review	Jakobsen, 2022
Paradoxes in megaprojects	Stakeholder, flexibility, temporality, structure, learning, decision making, identity.	Systematic Literature Review	Wiewiora, Desouza, 2022
Performance-mission tensions	Paradoxes highlight the complex interplay between business and social logics in social enterprises.	Systematic Literature Review	Weller, Ran, 2020

Cont. table 1.

Paradoxes at the intersection of innovation and strategic management	Learning paradox, organizing paradox, performing paradox, innovation paradox.	Systematic Literature Review	Schulte, 2022
Business and NGOs' commercial cooperation	Commercial–social paradox.	Case study	Sharma, Bansal, 2017

Source: own elaboration based on narrative systematic literature reviews (2015-2025).

The results of narrative literature reviews of project management in the context of paradox theory (Wiewiora et al., 2022, p. 247), paradoxes and tensions on projectification (Fortes, Agostini, Wegner, and Nosella, 2023), and deprojectification (Jaccobson et al., 2025) primarily indicate the non-linear, frequently absurd nature of paradox. A more thorough examination reveals an apparent dichotomy between financial constraints and social value, which addresses the general context of NPO project management (Buonomo et al., 2020). As Jacobsen (2022) and Fortes et al. (2023) discuss, the concepts of flexibility and control underscore the need to establish a balance between donor accountability and adaptability to community needs. The structure and flexibility paradoxes also present tension. These tensions emerge from the collision of two distinct yet interrelated project needs: the necessity to address specialized project demands and the concomitant need for organizational autonomy, a phenomenon often referred to as the structure paradox. These tensions have the potential to result in long-term imbalances and conflicts between organizational priorities and mission, on the one hand, and project objectives, on the other. These imbalances and conflicts have been previously identified in the context of the identity paradox (Wiewiora et al., 2022) and tensions between short- and long-term orientations (Jacobsen, 2022). The latter is the temporality paradox, identified by Wiewiora and Desousa (2022). Schulte (2022) initiated a discussion of the identification of paradoxical tensions and the learning paradox at the project level and beyond (Wiewiora et al., 2022).

This study sought to identify paradoxes in the findings of empirical research from Poland, comprising larger samples and employing mixed-method analysis, underscoring the validity of the gap identified at the outset of this study. In light of the findings of a quantitative study on the projectification of nonprofit organizations in Poland, which revealed notable differences in the attributes associated with this phenomenon, as perceived by organizations that engage in projectification compared to those that do not, it was decided to employ a paradoxical lens to analyze these differences.

2.2. Projectification of nonprofit sector organizations

The contemporary paradigm of nonprofit sector development is based on the process of projectification, which has transformed projects from incidental tools into the dominant mechanism for implementing organizational missions. This change, stimulated largely by European Union public policies, has made project management an operational standard

necessary for obtaining funding and ensuring the continuity of statutory activities. In the context of Polish NGOs, this systemic transformation forces organizations to constantly balance the temporary nature of project structures with the permanence of social goals. The evolution of public policies, whether promulgated by the European Union or by regional- or local-level actors, has led to a paradigm shift in which projects have ceased to be the exception and their management, by and of projects, has become a mechanism for implementing the statutory and mission activities of the nonprofit sector. A substantial number of organizations, including nonprofit entities, particularly in the European Union, operate under a project-based funding model (Jakobsen, 2022; Jacobsson et al., 2025, p. 6; Löfström, 2025; Małecka-Dobrogowska, 2025). In contemporary society, projects have emerged as a common means of achieving these objectives. There is an increasing tendency to view all aspects of life and society through a project-oriented lens. Projectification in the nonprofit sector subjects organizations to considerable pressure and a multitude of expectations. Paradoxically, this approach aligns with the well-known maxim "think globally, act locally", as articulated by Geddes (1915), which is particularly relevant to nonprofit organizations. This elucidates the paradox's inherent nature, operating under the assumption of contradictory yet simultaneously inseparable elements — a hallmark of the paradox that manifests in the collision and opposition of global and local perspectives. The notion of projectification as a prevailing management strategy for nonprofit organizations is invoked in the context of discourses concerning a projectified society or global trends in the impact of projectification on economic and social development manifested in the ever-growing share of project work (Radujković, Mišić, 2019; Schoper, Ingason, 2019; Wald, Ingason, Fridgeirsson, 2025). A review of the extant literature reveals a growing body of research on economies, societies, and specific organizations that demonstrates the social and economic dimensions of this phenomenon (Voros Fregolente et al., 2022). The aforementioned theoretical considerations regarding the nature of paradox and projectification serve as a framework for assessing the paradoxical tensions identified in a survey of nonprofit organizations in Poland. This study is part of a broader research initiative that assesses the scale of projectification and its impact, with a view to future research. A paradox lens was used to analyze the results of this assignment.

3. Methods

The present proposal is the result of a 2021-2022 survey of 385 Polish nonprofit organizations, selected through purposive sampling from a national database of non-profit organizations. The respondent profile was dominated by senior management (presidents, board members) and project coordinators, which facilitated the capture of the strategic dimension of projectification. The general objective of this study is to ascertain the extent and attributes of

projectification in the nonprofit sector. This includes the projectification rate, defined as the percentage of time spent on projects relative to total working time (Schoper, Wald, Ingason, Fridgeirsson, 2018; Wald et al., 2025). A specific component of the survey was administered to identify differences between organizations that implement projects and those that do not. The 287 qualitative responses were subjected to thematic analysis, yielding four clusters of meaning (content hubs). These clusters were then analyzed in response to the paradoxes identified in the extant literature. The results of a survey administered as part of the projectification research study, which sought to characterize the dichotomies identified in the proceedings of nonprofit organizations, primarily considered the mission-driven and nonprofit nature of these entities. Conversely, the findings reveal a series of contradictions and tensions inherent in the management of project-based organizations, as well as those that do not prioritize projects as a prerequisite for achieving their mission and statutory objectives. Examining projectification paradoxes led to the selection of conventions for qualitative research and to an action research based on a grounded theory approach.

The results of interpreting the data collected in the questionnaire survey from the open-ended questions—the so-called elicited texts—provided answers to both this question and the accompanying questionnaire-articulated opinions, thoughts, feelings, and evaluations. The open-ended nature of the question about differences between organizations that implement projects and those that do not in the survey questionnaire, coupled with its anonymous administration, elicited information from respondents that would not have been possible with conventional face-to-face survey methods. Among 287 valid responses from 385 respondents, it is noteworthy that they had experience with projectification and considered the open-ended questions in the quantitative survey significant. This finding aligns with assumptions about respondents' engagement, as grounded theory would predict.

The content of the evoked texts was prepared for analysis using NVivo's Computer-Assisted Qualitative Data Analysis Software (CAQDAS), a qualitative analysis software. A significant aspect of the analysis focused on the distinctions between organizations engaged in project-based initiatives and those that are not. A set of 385 entries was obtained for the open-ended questions. These entries were then filtered to remove missing statements, repetitive answers, "yes" or "don't know" responses, and "hard to say/difficult to determine" responses. The remaining responses (287) were consolidated into four overarching thematic clusters. These clusters were then ranked according to keywords. The technique employed for the analysis of the qualitative data obtained enabled a quantitative analysis of the content of the statements, as well as a qualitative presentation in the form of arbitrarily identified paradoxical meaning clusters.

4. Results and discussion

4.1. Identity paradox in the content cluster: mission versus projectification "must-haves"

Nonprofit organizations (NPOs) regard projects as integral components of their identity. Projectification, as perceived by representatives of surveyed organizations, is characterized as "an inherent feature of the nonprofit sector, supplanting missionality with managerial efficiency". This finding suggests a unification of project objectives that extends beyond the organization's scope. The phrase "projectification" as a ‘must-have’ alludes to the identity paradox, as indicated by the following statements by sector representatives: “An organization engaged in numerous projects tends to prioritize the objectives of these projects over the realization of its mission”. It is important to note that the objectives of a project and the mission of an organization are not always aligned. An organization that places its emphasis solely on projects tends to prioritize the needs identified within those projects, thereby limiting its ability to develop and evolve. These objectives are short-term and do not facilitate growth. This reveals the main paradoxical tension. The primacy of the projectification approach is further substantiated by the following statement: ”I think every activity in an organization is a project. Those who are unaware of this fact operate under different systems, the nature of which remains unclear”. It is evident that there is congruence between “the organizational mission and the objectives of the project, as indicated by the presence of an equal sign between these two elements.” The magnitude and consequence of projectification in NPOs are articulated by one respondent's rhetorical inquiry: ‘Are there still organizations that do not project their activities?’ The present moment is characterized by the absence of NGOs that do not engage in project implementation to some extent. This phenomenon can be attributed to the "inherent nature of NGOs, which is predicated on the execution of projects as a fundamental element of their mission". In the opinion of NPOs responding to the survey, it is noteworthy that “no organization exists that does not engage in project implementation”. The placement of the project above the organization's mission directly reveals the contradiction at the heart of this paradox. "Project thinking is at the heart of community functioning, and the utilization of external programs and funding is a natural occurrence". As indicated in the sector's official statements, "an organization that is implementing projects must adapt its goals, financing policy, and type of activities to the requirements of the project". An unanswered issue is the comment made by one respondent: "An organization that does not implement projects is an organization doomed to self-destruction. It is only a matter of time".

In light of these statements, nonprofit organizations (NPOs) are compelled to strike a balance between their core mission and the constraints and opportunities presented by project-based management and funding. This phenomenon directly alludes to the identity paradox (Wiewiora et al., 2022, p. 248), which delineates the contradiction between a project and its

organizational identity. Indeed, this paradox frequently manifests as the integration of project identity and value identity behaviors aligned with the social mission of nonprofit organizations (Wiewiora et al., 2022, p. 248; Fortes et al., 2023). This paradox, predicated on the organization's mission and essential projects, can be extrapolated to reveal interorganizational and even sector-wide relationships. The aforementioned dichotomy manifests as a contradiction between project objectives and the organization's mission objectives, as well as the inherently mission-driven nature of the nonprofit sector. The identification paradox underscores robust project identity within the previously referenced content cluster, encompassing the relinquishment of organizational identity. This paradox identifies numerous tensions within the projectified organization (Voros Fregolente et al., 2022), manifesting as levels of chaos or conflicts of interest. Furthermore, the statements made by representatives of the Polish nonprofit sector, as identified within the content cluster, allude to the intricacies of the identification paradox. This paradox, as posited by Sharma and Bansal (2017), underscores a dichotomy in which nonprofit entities must choose between aligning their identified local needs with those of an external donor or prioritizing their sector's mission activities over commercial objectives. The clustering of statements from Polish nonprofits also alludes to the identity paradox through mismatches and tensions between project goals and the organization's mission. According to the participants' statements, confirmed by Wiewiora and Desoyuza, it is "a conscious action in favor of the project, the project goals, while neglecting the strategic organizational directions and even abandoning the priority of organizational capacity-building opportunities" (Wiewiora et al., 2022, p. 244). The identity paradox in the nonprofit sector is a well-documented dilemma between mission and project priority. This analysis focused on a subset of statements from the projectification scenario prioritized over the organization's mission. This results in projectification becoming an integral part of the organization's identity and is a key source of financial stability

4.2. Temporality paradox in content cluster: The project's short-term funding vs. long-term management and engagement

The proposed cluster of statements below refers to the temporality paradox identified in the literature, in which project funding cycles focus on short-term deliverables that may conflict with long-term social impact goals (Wiewiora et al., 2022, pp. 242, 248). The temporality paradox has been identified as a phenomenon that highlights the dichotomy between short-term and long-term focus in relationships (Jakobsen, 2022). From the perspective of nonprofit representatives, the paradoxical differences between projectified and non-projectified actors in the nonprofit sector can be summarized in three concepts: "operating from time to time without projects", "actionary", and "with projects - continuity of support and funding". This aspect is also noted in the development opportunities of the organizations, concerning differences between project-based organizations in the employment of the team, as expressed in the following opinion: "The distinction and tension lie in the assumption of employment and the

subsequent generation of revenue". This is further compounded by factors such as "the extent of operational activity, income generation, and the capacity to employ personnel". The projectified NPO establishes "a permanent team, accompanied by the assurance of a stable budget, further enhancing the organization's stability". The paradoxically "apparent" stability of the project organization's functioning is indirectly reflected in statements about the "constancy" of the project teams. This assertion has been reiterated on multiple occasions when comparing project-based and non-project-based organizations. It has been demonstrated that "projects can employ staff for which there is no funding outside of the project". Furthermore, "projects offer greater stability and certainty of continuity of employment in a project position, as well as stability of funding during its realization". In contrast, when querying the distinctions between projectified and non-projectified nonprofits, organizations observe tensions concerning a mechanism to diversify their funding sources and undertake proper activities: "Stabilization. It is imperative to acknowledge that projects do not inherently ensure stability. The entity responsible for project implementation functions in a project-oriented manner", that is to say, "in the absence of a project, there is no operational capacity"; "the entity that implements projects frequently benefits from public funding, while the entity that does not implement projects predominantly engages in business or operates on a share-based, often voluntary basis"; and "entities that do not implement projects are more likely to offer paid services to beneficiaries." An organization's strategic orientation is "a business-oriented focus, concentrating on individuals who are at risk of exclusion. (...) Projects are only for a while, and economic activities are permanent".

The tension between the two approaches was considered in the context of the results of this study on nonprofit organizations. The first focuses on short-term or immediate project objectives, whereas the second focuses on long-term project outcomes and future preparation. This tension was noted by Wiewiora and Desouza as a temporality paradox (2022, p. 242). Furthermore, Samset and Volden emphasize the necessity of distinguishing between "tactical performance, which is the question of delivering the project outputs as planned, and strategic performance, which is the worth or utility of the project as seen in a long-term perspective" (2016, p. 300). In both projectified and non-projectified organizations, the necessity to achieve performance emerges, potentially manifesting at the level of "immediate" project goals. This performance often contrasts with the long-term assessment of the vision and mission of nonprofit organizations. Considering this background, the identified responses revealed the paradoxical temporary nature of this group. Non-projectified organizations are often perceived as indicative of stagnation and a lack of challenges. These factors are associated with project objectives, organizational structure, and the implementation and financing of project activities and teams. In this collection of contributions, it is also noteworthy to highlight the paradox of short-term funding, which, in the case of nonprofit organizations, is still paradoxically synonymous with financial stability. By nature, projects require short-term funding. However, the paradox involves creating short-term project forms that are limited by resources, time,

and budgets. These forms are then multiplied and converted into a permanent form of activity for project organizations. Concurrently, the responses obtained from this group demonstrate that the temporality paradox manifests in instances of excessive projectification. According to the surveyed NPOs, this phenomenon can manifest as a deviation from their mission and autonomy, thereby highlighting the contradiction and tension between short-term project goals, precarious employment, and the organization's long-term mission.

4.3. Flexibility and structure paradox in the content cluster: standards versus flexibility and operational independence

Paradoxes arise in content clusters when standards, flexibility, and operational independence are considered. Organizations that implement projects from the perspective of survey participants are distinguished by their possession of both a clearly defined objective and a meticulously formulated action plan to accompany these goals. Those who do not implement projects "focus on the mission, and the payoff is satisfaction." An organization that implements projects is distinguished by its "effectiveness in achieving its goals, expanding the organization's group of beneficiaries", stability, "horizon for achieving goals, and "management style". An organization that implements projects is distinguished by "faster achievement of planned goals, greater dynamism and diversity, and more frequent rotation (variable project teams)". According to the respondents, "project-based team management is employed in such organizations". Operating within a "black box structure" means that "all individuals are capable of delegating tasks according to their function in the project, irrespective of their function in the organization". Those who undertake project implementation "must demonstrate determination and a willingness to make personal sacrifices in terms of their time". The most salient paradoxical tensions arise from the tension between structured frameworks and flexibility. Based on the assumption that project implementation demands structured frameworks, while NGOs often require operational flexibility, the third identified cluster concerns the flexibility paradox (DeFillippi, Sydow, 2016; Wiewiora et al., 2022) and relates to the structure paradox described by Desouza (2022). According to the respondents, the projectified nonprofit organization exhibits characteristics of a "black box", a kind of recorder that acts purposefully and works in teams, following structurally embodied procedures resulting from the project and project management. The respondents' positions were that non-project organizations were contradictory. The respondents assert that these organizations are the only ones capable of operating in a mission-oriented, ideological, and organizationally flexible manner, underpinned by operational flexibility. Standardization, which binds the described projectification of the nonprofit sector, is part of the structural paradox. Organizations are distinguished by an identified goal and a plan of action, in accordance with established practices and strict procedures. The absence of funding and project implementation is characterized by openness and a lack of formal constraints. This state of opposition and paradoxical tension is at odds with conventional structures and processes associated with

project implementation and funding. Organizations that do not subscribe to the projectification scenario and instead operate without external support prioritize fulfilling their mission, deriving satisfaction from the process's focus on it, and the payoff is satisfaction. The identified standardization versus flexibility and ideational independence are relevant to the flexibility and structure paradox, which confirms two of the following contradictions: (1) flexibility versus control and (2) flexibility versus standardization (Wiewiora et al., 2022, p. 241). Concurrently, the tension between the imperative for the adaptable execution of social and mission-oriented initiatives and the standardization inherent in project-based management gives rise to the paradox identified by Fortes et al. (2023). This paradox underscores the inherent contradiction between flexibility and rigidity in organizational frameworks. As posited by Wiewiora and Desouza (2022), contradictory elements (paradoxical constructs) must coexist in order to address distinct challenges.

4.4. Learning paradox in content cluster: development through projects as opposed to routine and patterns

The fourth point concerns a paradox in learning and knowledge creation: the tension between project-based development and adherence to routine or established everyday patterns. NGOs need autonomy to create, but they must also adhere to donor-driven accountability measures, overshadowing grassroots and participatory approaches. The implementation of projects has been demonstrated to foster action, offer organizations the opportunity for self-realization and innovation, and employ creative approaches to achieving development goals. According to respondents, organizations that implement projects choose "development opportunities (institutional as well as human resources)" using external projects and funds". It fosters personal growth, strengthens resilience, and challenges participants to achieve defined objectives". "The organization implementing the projects is focused on development". An NPO with the project scenario is seen as "A broader perspective, new experiences, obtaining financial resources, building coalitions, and partnerships". Projectification means the creation of "interesting products of the organization that can be further developed, access to new knowledge and experience of project partners, and involvement of organization members in projects". Further differences identified by survey respondents include "development potential", "develops", and "implementing projects according to a plan", which improve the quality of work and facilitate it, unlike non-project work. "An organization implementing projects is generally more dynamic, flexible, ready for change, and thus more innovative than an organization that operates on an operational basis". Implementing projects means "specialized management and employees having more developed soft and hard skills". Employees working on projects in the organization are "more creative and versatile". Projectified NPO has "a richer and more interesting offer for its customers and can develop in many respects". On the other hand, respondents are conscious that "project-based organizations incur significant costs in the form of excessive bureaucracy, formalization,

and dehumanization". The implementation of projects is also associated with the negative consequences of control and the need to adapt the organization to the requirements of the external donor. The achievement of project objectives is also contingent upon "top-down supervision", a method of exercising control over the organization that may not be universally accepted, given the ideological independence of certain organizations. These constraints create tensions manifest "in the professionalization of project-based organizations, leading to the imposition of a 'iron cage' that restricts the realization of organizational goals in favor of project goals, as perceived by donors". Conversely, organizations that do not engage in projectification may opt for alternative scenarios for their development, which frequently results in "organizational and staff stagnation since the missionary and less formal character of NPO". According to the respondents, "organizations that do not implement projects are either content operating on public tasks, or they do not set themselves significant challenges". In such cases, "the voluntary work of the members or volunteers must be sufficient". Those who do not implement projects are "more stagnant in the reality surrounding the organization." The absence of projects within an organization can result in a limited number of opportunities for self-realization, innovation, and creativity. This segment of the discourse, which pertains to the comparative analysis of organizations that have implemented projects and those that have not initiated projects, can be encapsulated by the following statement, which was made by a representative of one of the organizations: "In my opinion, an organization implementing projects is characterized by a higher level of professionalization as opposed to the one described. Thanks to projects "NPOs have improved their competences in organizational management", and "realizing projects brings 'life' into the organization—it builds commitment and identification with the organization". Moreover, "working in a project-based organization is geared towards the development of the organization, to develop cooperation with the local environment and respond to its needs, and to allow the organization to be promoted. The implementation of projects provides an opportunity to develop the organization's knowledge and integrate an expert approach or grassroots approach to the social environment's needs".

The transformation of an organization into a project-oriented entity is accompanied by its metamorphosis into an expert organization, a process that generates novel knowledge (Bakker, Cambré, Korlaar, Raab, 2011). Two accounts of this paradox can be found in the literature. The first account compares learning with performance, and the second compares exploration with exploitation (Wiewiora et al., 2022; Andriopoulos, Lewis, 2009). As posited by Bakker et al. (2011) and subsequently referenced by Wiewiora-Desouza (2022), the dichotomy between learning and performance encapsulates the discordances inherent in the generation, dissemination, and utilization of knowledge within and beyond the project's confines. This paradox is also related to project experiences, including their formalization, which spreads in projectified institutions beyond the formal project structure. In the context of the learning paradox, Wiewiora and Desouza (2022) emphasized the financial cost of learning, which

requires allocating time and resources. They also discuss the tension arising from nonprofit organizations' tendency to prioritize project delivery over local community engagement. This tension can result in the “expert” decision to either block underdeveloped, grassroots solutions that are locally satisfying or to promote learning and the expertise of solutions, potentially leading to delays and budget overruns in project delivery. Furthermore, according to Wiewiora and Desouza, the exploration versus exploitation aspect of this paradox is ‘the tension between creating new opportunities to exploit emerging opportunities and reusing existing capabilities and routines to deal with stable and predictable aspects of the project' (Wiewiora et al., 2022, p. 243), which remains a dilemma for further research.

5. Conclusions

The phenomenon of projectification, which has intensified in the Polish nonprofit sector over the past three decades of evolution, following Poland's accession to the European Union, reveals several tensions and paradoxes. Projectification not only redefines management practices but also changes how the mission is carried out, affects the structure of employment, and influences relationships with stakeholders. Identifying and analyzing paradoxes in organizations' project activities is an attempt to answer questions about the long-term consequences of these activities and their compatibility with the idea of sustainable social development. The phenomenon of projectification in nonprofit organizations, especially in the Polish context, is an important field of research that reveals deep and multidimensional tensions between project logic and organizational missions. This study confirms the existence of structural paradoxes that manifest in four areas: identity, temporality, flexibility versus structure, and the learning paradox tension between autonomy and dependence. These theoretical implications arise from applying paradox theory as an analytical framework for studying organizational tensions. Paradoxes such as the identification paradox (conflict between mission and project logic), temporariness (instability resulting from short-term funding sources and permanent functioning of the organization based on temporary structures), learning, flexibility, and structural paradox (dependence on external donors despite apparent autonomy) are inherent elements of project-based NPOs’ functioning. Their presence indicates the need to integrate project management research with organizational and social reflections.

The main conclusions of this study confirm the relevance of the paradox theory in the analysis of project management in the nonprofit sector. Projectification appears not only as a management tool but also as a social and cultural phenomenon that can redefine relationships within organizations and their connections to their environments. This requires new reflection on strategic management models that consider the tension between the temporary nature of project activities and the need for continuity and consistency in missions. These practical

implications suggest the need to implement remedial strategies that support tension management rather than its elimination. Such strategies include: (1) evaluating projects not only in terms of effectiveness but also in terms of their compatibility with the organization's mission; (2) diversifying funding sources, including integrating projects with paid activities and fundraising; (3) building stable employment structures around the core team; and (4) ensuring inter-project space for reflection and strengthening relationships with the environment. Projects should be a means, not an end in themselves—an instrument supporting the mission — and should not be replaced. They should include the need to implement mechanisms for monitoring project compliance with the organization's mission. Organizations should strive to diversify their funding sources and activities to reduce their dependence on public projects. Professionalization of staff should be supported by stable, core employment rather than project-based employment. It is also necessary to plan for "inter-project space" as a moment for reflection and relationship building with stakeholders.

The limitations of the study steam from the subjective nature of the data. The analysis is based on subjective elicited texts and respondents' opinions and emotions, and the conclusions are based on statements made by representatives of the organizations. This may limit the possibility of generalizing the results. Therefore, data triangulation and in-depth qualitative research are necessary. The homogeneity of the empirical sources and the subjective nature of respondents' statements also pose limitations. The participants were mainly representatives of organizations actively implementing projects, which may have influenced their perceptions of the phenomenon and limited the representativeness of the sample. There is also a lack of comparative data from organizations that have not implemented the project model, which makes it difficult to fully capture structural and cultural differences. A further limitation of this study is that it does not include financial data, such as revenues and employment forms, for individual organizations. This limits the possibility of substantiating the theses quantitatively on the scale of instability in project organizations.

Further research should focus on (1) an in-depth analysis of the impact of projectification on the quality of the relations between beneficiaries and the local community, (2) an evaluation of the effectiveness of paradox management strategies in the long term, and (3) cross-sectoral and cross-cultural comparisons. It is recommended that future research endeavours incorporate a qualitative perspective alongside an economic analysis of nonprofit sector entities. It is also worth exploring the potential of deprojectification as a conscious organizational choice and identifying the conditions under which projectification ceases to be an effective development tool. In addition, they should focus on analyzing the long-term effects of projectification, the diversity of NPO adaptation strategies, and international comparisons. It is also important to empirically test the effectiveness of recommended paradox management strategies.

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MARKETING CONCEPT REVISITED. FROM OPERATIONAL MARKETING TO INTEGRATED MARKETING MANAGEMENT

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Purpose: The aim of the article is to identify the most important premises and circumstances concerning the transformation of the marketing concept from operational marketing functions and tasks towards the integrated marketing management process.
Design/methodology/approach: The article presents the "road" from marketing functions and tasks related to the operational marketing level towards the integrated marketing management process. A literature review and an identification approach were used.
Findings: Marketing is a very significant tool for building the firm success, firm competitive advantage, firm competitive position as well as firm market success. The contemporary marketing concept is a crucial tool in transformation from operational marketing functions and tasks toward the integrated marketing management process.
Practical implications: The marketing concept is of a great importance both in business practice and firm management. To effectively and efficiently implement the marketing concept in contemporary business management, it is necessary to define the premises and circumstances for the transformation from operational marketing functions and tasks toward the integrated marketing management process.
Originality/value: The most important characteristics concerning the marketing management scope and process were presented. The article is addressed both to researchers as well as managers and other business practitioners.
Keywords: marketing, marketing concept, marketing management.
Category of the paper: Conceptual paper.

1. Introduction

The role of marketing in broadly defined business as well as in firm management is still growing. Marketing, and especially marketing concept is a very significant tool for building the firm success, firm competitive advantage, firm competitive position as well as firm market success.

In the process of firm success and firm competitive advantage building, the concept of marketing is particularly important. This concept represents a decision-making model that encompasses the following components: (1) strategic analysis, (2) marketing goals, (3) marketing strategies, and (4) marketing tools.

In recent years there has been a growing importance of the managerial and strategic aspects of marketing, concerning the perception of marketing as a factor strongly influencing the effectiveness and efficiency of business management as well as the shaping, forming and development of business models (Matwiejczuk, 2006; Mruk, Pilarczyk, Szulce, 2007; Kotler, Keller, 2022). The contemporary concept of marketing is a crucial tool in the process of transformation from operational marketing functions and tasks toward the integrated marketing management process (Rosa, Perenc, Ostrowska, 2016; Matwiejczuk, 2025).

The aim of the article is to identify the most important premises and circumstances concerning the transformation of the marketing concept from operational marketing functions and tasks towards the integrated marketing management process. The article presents in particular: (1) the most significant marketing functions and tasks related to the operational marketing level, (2) strategic marketing functions which are the basis for the marketing concept development and (3) the scope and the structure of the integrated marketing management process.

2. Operational marketing – the most significant marketing functions and tasks

Marketing was initially one of the most general functions of a firm. However, even then, it was a highly diversified firm activity. It encompassed many specific functions that defined relatively homogeneous types (subsets) of the marketing activities of a firm (Niestrój, 1996).

Effective and efficient implementation of the marketing concept within the market activities of the firms involves, among other things, performing a number of diverse functions and tasks aimed at meeting the needs and wants of customers.

Marketing functions of a firm may be defined as a set of actions and activities undertaken in the process of marketing activities to ensure that the firm market offer (products and services offer) meets customer expectations (Pindakiewicz, 1995).

Marketing functions stem from specific principles (rules) adopted for the effective and efficient implementation of the marketing concept in a firm (Kramer, 2004). While marketing functions constitute a set of the firm actions and activities, specific marketing tasks constitute individual actions and/or activities leading to the achievement of the marketing goals. The general hierarchy and structure of the firm marketing functions and tasks presents table 1.

Table 1.
General hierarchy and structure of the firm marketing functions and tasks

Criteria for marketing functions and tasks hierarchy and structure	**Marketing functions**	**Marketing tasks**
Marketing functions concerning market information collecting	Analysis of the global environment of a firm	– Continuous tracking (monitoring) of the processes and activities occurring in the environment: a) macroeconomic, b) demographic, c) natural, d) technological, e) political, f) cultural, g) legal.
	Customer preferences research	– Identification of the customer needs and wants, as well as prediction of their future development. – Identification of the opportunities to create and maintain long-term relationships with customers. – Data collection and analysis allowing the market segmentation, target market selection as well as product and service market positioning. – Determining the sensitivity and potential reaction of customers for the use of various marketing tools.
	Analysis of the firm capacities compared to the capacities of the other firms / competitors	– Collecting information concerning the competitors' strategies, their future plans and intentions. – Collecting information concerning the processes and activities conducted by intermediaries (suppliers, wholesalers, retailers, etc.). – Assessing the market position as well as competitive advantage (its sources, types, size, sustainability). – Assessing the resources as well as the capabilities concerning resources use in relation to competitors. – Assessing the possibility of using benchmarking.

ont. table 1.

Marketing functions concerning goods turnover	Support of the purchase and sales processes (transactions)	– Supporting the processes of transferring goods from the manufacturer to the customer (supporting physical distribution). – Supporting the processes of transferring raw materials and materials from suppliers to the manufacturer (supporting physical procurement). – Analysis and formation of the flow of goods (supply and distribution channels).
	Integration of marketing activities with logistics activities	– Development of the customer service assumptions (standards) and their implementation. – Integration of marketing-mix and logistics-mix components. – Implementation of the "7R" logistics principle.
Marketing functions concerning business management	Marketing as a management concept comprising planning, organizing, implementing and controlling of the processes and activities	– Strategic analysis, diagnosis, and forecast of the marketing business situations. – Strategic marketing goals identification. – Marketing strategies identification and development. – Operational marketing goals identification. – Marketing-mix selection. – Marketing organization of within the firm. – Marketing process and activities implementation and controlling.
Marketing functions concerning social area	Firm cooperation with the firm environment	– Cooperation between the firm and its customers. – Cooperation between the firm and other firms (competitors, collaborators, market partners). – Cooperation between the firm and intermediaries. – Cooperation between the firm and the other entities in the global environment. – Offering safe, ethical, and useful goods, services, and ideas.
	Forming and shaping the interpersonal relations within the firm	– Collaboration among marketing department employees. – Collaboration between marketing department employees and the other departments employees as well as the firm top management employees.
Marketing functions concerning scientific area	Building marketing theory based on pragmatic experiences	– Tasks in the field of the "transformation" of the practical experiences and their outcomes into the marketing theory.

Source: Matwiejczuk, 2006, pp. 7-8.

Individual and specific marketing functions and tasks primarily support the firm market day-by-day operations. These functions and tasks often are the organizational routines that pertain to the execution of ongoing processes and activities.

At the same time, some of the above-mentioned marketing functions and tasks are of the particular importance in the process of forming and shaping the marketing concept, which is the basis for the development of the strategic aspects of marketing and, as a result, the integrated marketing management concept and process.

3. Strategic marketing functions as the basis for the marketing concept development

Taking into account the considerations and comments presented in the previous chapter, two groups of marketing functions play a key (strategic) role within the process of the marketing concept and – as a result – integrated marketing management development (Matwiejczuk, 2006):

1) Marketing functions and tasks concerning business management.
2) Marketing functions and tasks concerning goods turnover.

Marketing functions and tasks concerning business management are associated with the permanent development and enrichment of the marketing's achievements, reflected in its increasing importance as a management function. Therefore, the contemporary marketing at the strategic level is perceived as a market-oriented management concept (Przybyłowski, Hartley, Kerin, Rudelius, 1998; Matwiejczuk, 2006; Czubała, Niestrój, Pabian, 2020).

In turn, marketing functions and tasks concerning goods turnover are one of the most important platforms of the integration between marketing as market-oriented management and logistics as flow-oriented management. Such an integration is reflected in the concept of the integrated marketing-logistics management, within which a special role is assigned to so-called marketing logistics (Matwiejczuk, 2006; Blaik, Bruska, Kauf, Matwiejczuk, 2013).

Marketing concept – in general – is a decision-making model comprising four levels (Becker, 1983; Sławińska, Urbanowska-Sojkin, 1997): (1) strategic analysis, (2) marketing goals, (3) marketing strategies, and (4) marketing tools (figure 1).



Figure 1. The marketing concept.

Source: Matwiejczuk, 2006, p. 3.

The concept of marketing has had a large number of studies, concerning the classic approach to marketing, which include first of all marketing-mix concept and components (Kotler, 1994; Przybyłowski, Hartley, Kerin, Rudelius, 1998; Lambin, 2001; Kotler, Armstrong, Saunders, Wong, 2002; Matwiejczuk, 2025). In several recent years one may notice an increasing significance of the strategic aspects of the marketing concept, concerning the perception of marketing as a factor strongly affecting business management performance as well as the formation and development of business models (Hutt, Speh, 1997; Garbarski, Rutkowski, Wrzosek, 1998; Matwiejczuk, 2006; Kotler, Keller, 2022).

A properly and comprehensively defined marketing concept, encompassing marketing goals integrated with the entire firm goals, marketing strategies being the integral part of the entire firm strategy and the marketing-mix components within the structure of the entire firm management tools, constitutes the basis for forming, shaping and developing the integrated marketing management of a firm.

4. From marketing concept towards the integrated marketing management process

Considering the forming, shaping and development of the marketing concept, the terms "marketing" and "marketing management" are often used interchangeably. Distinguishing between these two terms is primarily cognitive and didactical (Altkorn, 1995; Niestrój, 1996).

In this context, the term "marketing" encompasses all general knowledge about the principles, methods, and techniques of decision-making as well as actions and activities within the area of a firm relations with its actual and potential customers. Considering the subject as well as tools of marketing activities, within "marketing theory" the following areas can be distinguished (Altkorn, 1995; Niestrój, 1996):

1) Consumer behavior theory.
2) Marketing research.
3) Market segmentation and targeting.
4) Product and assortment formation and development.
5) Price policy.
6) Distribution.
7) Promotion.

In turn, the term "marketing management" requires the ordering of the individual issues according to the criteria of scope and sequence of the processes and activities that make up the formation and development of the overall concept of the firm market activities and its implementation in appropriately formed organizational structures and with appropriate use of the management and control systems (Altkorn, 1995; Niestrój, 1996).

The scope of the marketing management process presents the figure 2.

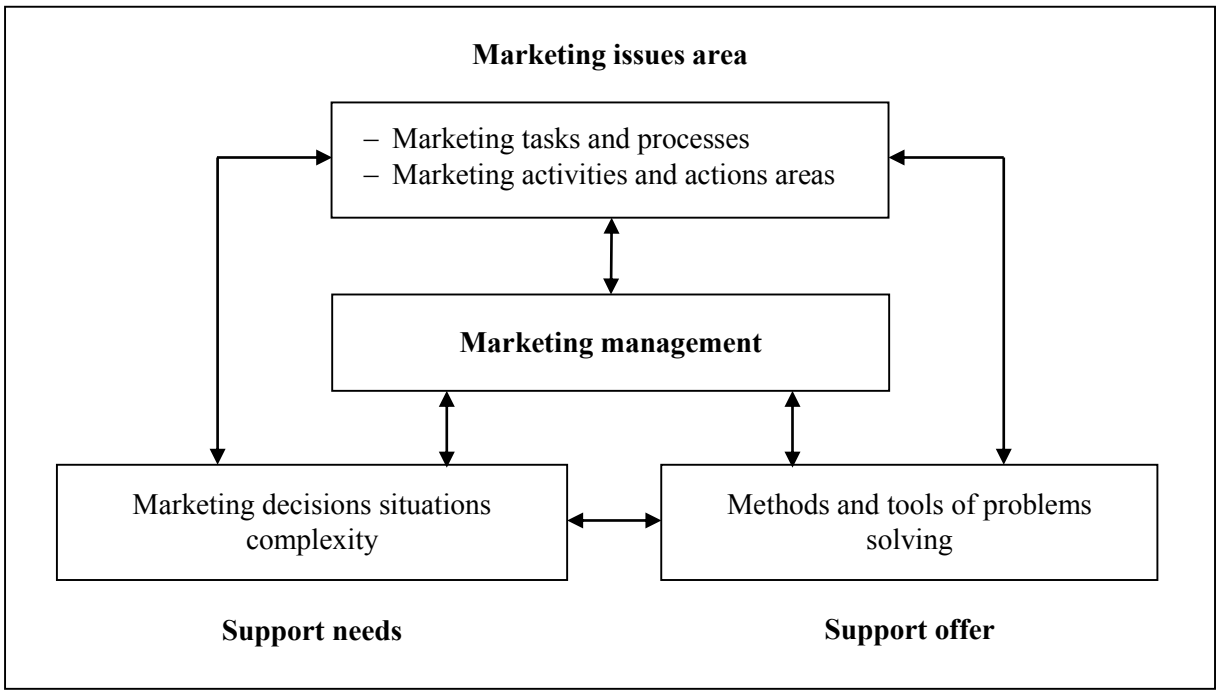

Figure 2. The scope of the marketing management process.

Source: Based on Matwiejczuk, 2006, pp. 9-10.

The starting point in defining (forming and shaping) the scope of the marketing management process is the identification and characterization of the marketing issues area. These problems concern, in particular: (1) marketing tasks and processes, and (2) marketing activities and actions areas.

In turn, the complexity of marketing decision-making situations refers to two basic dimensions of the decisions made: (1) the strategic dimension and (2) the operational dimension.

The strategic dimension concerns in particular:

1) Strategic analysis, diagnosis and forecasting of the firm's marketing situations, related to both its current and future market position.
2) Defining strategic marketing goals and their systemic integration into the structure of the entire firm's goals.
3) Shaping (forming) and developing marketing strategies, integrated both with the entire strategy of the firm as well as the product-market strategies of individual business units.

Operational decisions and actions expand upon and further detail strategic decisions and actions. These are particularly related to the processes and activities implemented within the marketing- mix, i.e., the tools (instruments) encompassing: (1) product, (2) price, (3) place (distribution), and (4) promotion, enabling the firm to actively influence the market through the development and implementation of the marketing programs.

The scope of the marketing management process describes how the marketing concept is transformed into the integrated marketing management process. This process encompasses the subsequent steps that determine the sequence of marketing activities (processes and actions) implemented by the firm, based on the assumptions of the marketing concept (figure 3).

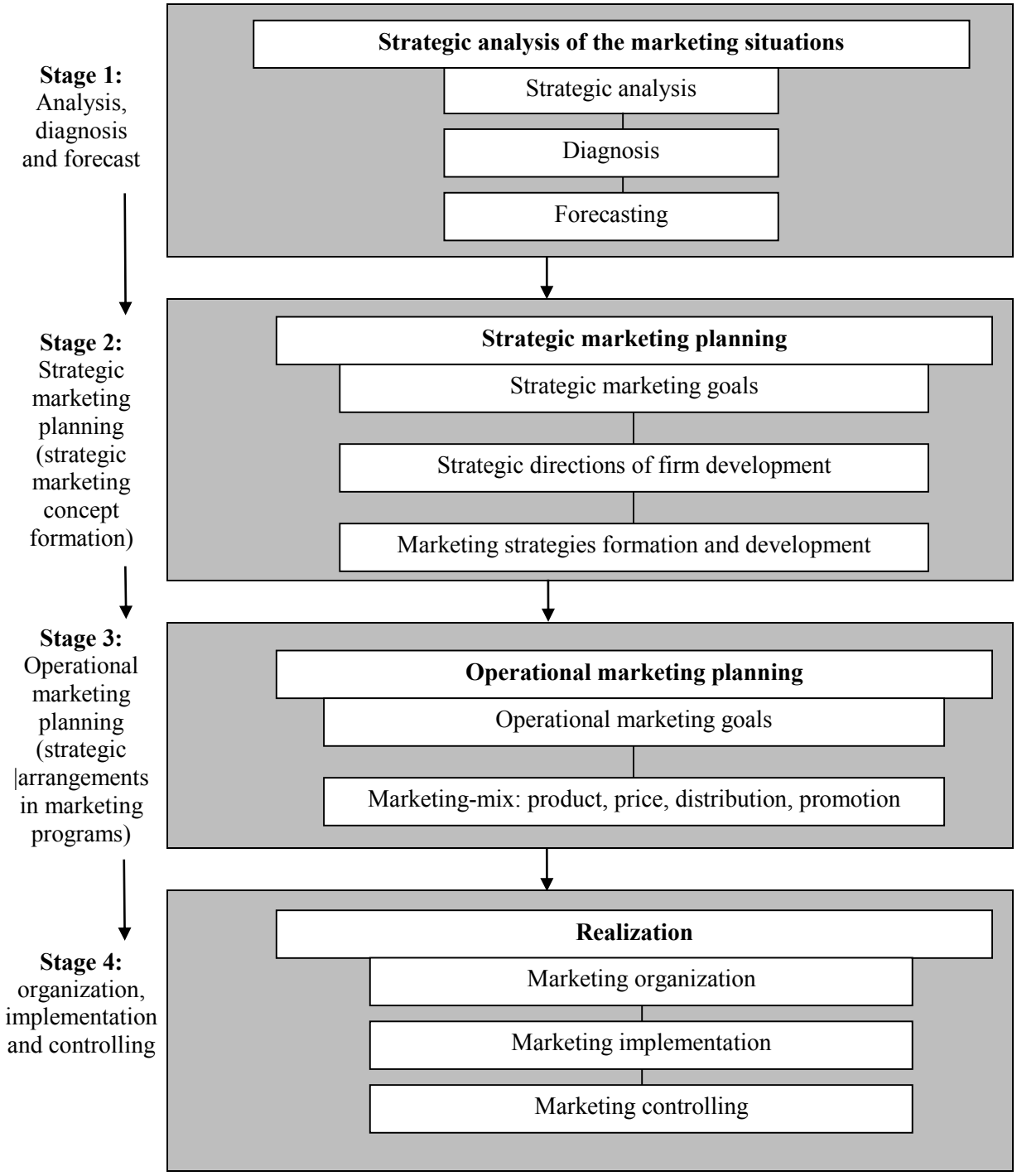

Figure 3. The integrated marketing management process.

Source: Own work.

The first stage of the integrated marketing management process, i.e. the strategic analysis of marketing situations, actually performs both analytical and diagnostic functions as well as prognostic ones.

Considering the scope of the strategic analysis, it covers the following areas (Niestrój, 1996; Romanowska, 2004; Matwiejczuk, 2006):

1) Analysis of the firm, including analysis of the tangible, intangible, financial and human resources, as well as analysis of the firm capabilities, competences and knowledge.
2) Market analysis (including analysis of customer needs, preferences, expectations and behavior), competition analysis, as well as analysis of suppliers (supply / purchase) and trade intermediaries and sellers (distribution / sales / marketing).
3) Analysis of the environment, including in particular the macroeconomic, demographic, natural, technological, political, cultural and legal environment.

The second stage of the integrated marketing management process, i.e., strategic marketing planning, is primarily related to forming and developing the strategic marketing concept within the firm. Strategic marketing planning encompasses a set of activities (processes and actions) leading to the development of the strategic concept for the firm marketing activities, including in particular: (1) defining strategic marketing goals, (2) forming strategic directions for the firm development, and (3) formulating and developing of marketing strategies (Niestrój, 1996; Lambin, 2001).

The third stage of the integrated marketing management process, i.e. operational marketing planning, is primarily concerned with the specification of strategic arrangements in marketing plans and programs. The starting point of operational marketing planning is the specification of the previously adopted strategic assumptions and goals. In particular, such a specification involves specifying the marketing goals that the firm intends to achieve within its market activities. This requires the decomposition of the strategic goals into the operational objectives, also referred to as partial or short-term objectives (Niestrój, 1996; Lambin, 2001). Operational objectives determine the final composition of the marketing-mix components comprising product, price, place (distribution), and promotion, constituting a set of tools enabling the firm to actively affect and influence the market.

Finally, the fourth stage of the integrated marketing management process, i.e. the realization phase, includes three main components:

1) Marketing organization.
2) Marketing implementation.
3) Marketing controlling.

The integrated marketing management process allows not only for the effective and efficient implementation of the marketing concept in the firm market activities, but also for achieving several strategic and operational marketing goals related to building the firm success, building and maintaining the firm competitive advantage, as well as achieving and maintaining the firm intended market and competitive position.

5. Conclusion

As it was presented in this article, the role of marketing both in business as well as in firm management is growing since many last days. Marketing, and especially marketing concept which comprises strategic analysis, marketing goals, marketing strategies, and marketing tools, plays a crucial role in building firm success, its competitive advantage, competitive position as well as its market success.

The aim of the article was to identify the most important premises and circumstances concerning the transformation of the marketing concept from operational marketing functions and tasks towards the integrated marketing management process. The most important stages within this transformation comprise the identification of: (1) the most significant marketing functions and tasks related to the operational marketing level, (2) strategic marketing functions which are the basis for the marketing concept development and (3) the scope and the structure of the integrated marketing management process.

The most significant directions for further research include, first of all, an increasingly deeper embedding of marketing, especially the concept of marketing, within the market orientation, as well as a stronger connection between strategic aspects of marketing and broadly understood strategic business management.

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FROM REACTIVE TO CALCULATED QUITS: ADAPTING THE UNFOLDING MODEL OF VOLUNTARY TURNOVER

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Purpose: This study assesses the adequacy of the unfolding model of voluntary turnover (UMVT) in the Polish context to propose a revised version. Addressing the wide variation in classification rates reported in previous empirical tests (12.1-92.6%), it adapts the model to the evolving conditions of the contemporary labor market.
Design/methodology/approach: A retrospective quantitative design was employed using an instrument adapted from Lee et al. (1999). Data were collected via computer-assisted personal interviewing, yielding high data quality and a response rate of 68.1%. Respondents were classified into decision paths using an algorithmic procedure based on the presence or absence of key model constructs.
Findings: The study revealed that the original UMVT had limited explanatory power of 18.1%, whereas the adapted model successfully classified 87.5% of cases. Results indicate that voluntary turnover decisions are predominantly calculated, as all resignations were preceded by job search, evaluation of alternatives, and a job offer. Additionally, specific paths were identified where employees decided to quit despite reporting high job satisfaction.
Research limitations: The study's generalizability is limited by its focus on a purposively selected, homogeneous occupational group (call center employees) within a single large organization in Poland. Additionally, the retrospective research design may introduce a risk of recall bias among respondents.
Practical implications: Retention strategies should target the extended pre-decision deliberation phase. Since high job satisfaction alone does not prevent planned turnover, organizations must monitor external labor market conditions, provide internal career development opportunities, and introduce tenure-based incentives. Furthermore, managers should be trained to proactively identify work-related shocks and initiate early retention dialogues.
Originality/value: As the first empirical test of the UMVT in the Polish context, this study contributes to turnover theory by highlighting a transition from reactive, shock-driven processes characterized by minimal mental deliberation to proactive decisions grounded in planning and active career management.
Keywords: Voluntary turnover, Unfolding model of voluntary turnover, Decision paths, Shocks, Job satisfaction.
Category of the paper: Research paper.

1. Introduction

Voluntary employee turnover remains one of the most persistent and costly challenges in contemporary human resource management. Its consequences extend far beyond the direct financial costs associated with recruitment, selection, and onboarding, encompassing losses in organizational human and social capital (Cascio, 2000). Excessive turnover disrupts work processes, erodes organizational knowledge, and weakens team cohesion, thereby adversely affecting organizational effectiveness and service quality (Abelson, Baysinger, 1984; Hancock et al., 2013). In the aftermath of the COVID-19 pandemic, the scale of voluntary resignations intensified, a phenomenon widely referred to as the "Great Resignation", which has renewed scholarly interest in the mechanisms underlying employee turnover (Formica, Sfodera, 2022; Serenko, 2023).

Research aimed at identifying the decision-making processes leading to voluntary job resignation has been undertaken by numerous scholars since the second half of the twentieth century (Hom et al., 2017). These efforts gave rise to several influential models of employee turnover rooted in the job dissatisfaction paradigm, conceptualizing the decision to quit as a relatively rational and sequential process typically initiated by declining job satisfaction and followed by the search for alternatives and ultimately leaving the organization (Hom et al., 2020).

A significant contribution to the development of employee turnover theory was made by Lee and Mitchell (1994), who proposed the unfolding model of voluntary turnover (UMVT), challenging the assumption that job dissatisfaction constitutes a necessary precondition for leaving an organization. The model emphasized the role of sudden events (shocks) and the reliance on pre-existing plans of action (scripts) in the decision-making process, and introduced the notion of multiple distinct decision paths leading to quitting, including those that may occur independently of job satisfaction levels.

The UMVT has been empirically tested in the United States among accountants (Lee et al., 1999), military officers (Holt et al., 2007), and IT professionals (Niederman et al., 2007), as well as in the United Kingdom among nurses (Morrell et al., 2008) and construction professionals (Jones et al., 2010). The findings of these studies revealed considerable variation in the effectiveness of classifying turnover cases into the model's decision paths, with classification rates ranging from 12.1% (Niederman et al., 2007) to 92.6% (Lee et al., 1999). Importantly, more recent empirical investigations have tended to report lower levels of model fit and have identified additional decision-making processes extending beyond the model's original structure.

Although the newly identified decision paths were interpreted as specific to particular occupational groups, a comparative analysis of prior empirical tests of the model suggests an alternative interpretation. The decision-making processes observed in more recent studies

(Holt et al., 2007; Niederman et al., 2007; Jones et al., 2010)—irrespective of the profession examined—demonstrated notable similarities, indicating that their occurrence may reflect broader technological, social, and economic transformations rather than merely the unique characteristics of specific occupations. From this perspective, the additional decision paths may be understood as manifestations of the adaptation of turnover mechanisms to changing organizational and labor market conditions.

The inconsistencies in prior empirical findings, combined with shifting labor market dynamics and the growing scale of voluntary resignations, underscore the need for further investigation into the decision-making processes underlying employee turnover. A particularly important yet underexplored research context concerns the countries of Central Europe. To the best of the author's knowledge, no empirical studies in Poland have to date tested the assumptions of the unfolding model. Addressing this research gap, the aim of this study is to assess the adequacy of the UMVT within a selected occupational group and, on this basis, to propose a revised version of the model that accounts for contemporary labor market conditions.

2. Theoretical background

2.1. Classical approaches to employee turnover

Scholarly interest in voluntary employee turnover dates back to the second half of the twentieth century. One of the earliest formal conceptualizations was March and Simon's (1958) decision to participate model, grounded in the theory of organizational equilibrium. The authors identified two key mechanisms underlying turnover decisions: perceived desirability of movement and perceived ease of movement. Even at this early stage, the model emphasized the importance of both psychological factors, such as job satisfaction, and labor market conditions.

Subsequent approaches further developed this line of reasoning by emphasizing job satisfaction as the primary predictor of employee turnover. Price's (1977) model of turnover proposed that dissatisfaction leads to turnover primarily under conditions of high perceived opportunity. Opportunity was defined as the availability of alternative roles in the environment, including not only alternative employment but also withdrawal from the labor market and engagement in non-work activities. In turn, Mobley's (1977) process model described a sequence of stages in the decision-making process leading from dissatisfaction to actual turnover, including, among others, dissatisfaction, thoughts of quitting, evaluation and search for alternatives, intention to quit, and ultimately turnover. The extended version of the model proposed by Mobley et al. (1979) additionally incorporated individual, organizational, and labor market factors, integrating earlier perspectives into a more comprehensive framework

for explaining the turnover process. Steers and Mowday (1981) proposed a model integrating, among other elements, job expectations and values, individual and organizational characteristics, job performance, affective attitudes, non-work influences, and turnover intention. A common feature of these conceptualizations was the linear structure of the process and the dominant role attributed to job satisfaction as the primary antecedent of turnover.

2.2. An alternative approach: The unfolding model of voluntary turnover

Empirical tests of classical turnover models have confirmed the relationship between job satisfaction and turnover intention (Hom, Griffeth, 1991; Hom et al., 1992). However, they also indicated that job satisfaction does not fully explain actual voluntary turnover. The association between turnover intention and actual leaving was found to be moderate, suggesting that decisions to quit are not always a straightforward consequence of accumulating dissatisfaction and do not necessarily follow a linear progression (Blau, 1993). These limitations prompted the search for alternative theoretical approaches that would account for the role of initiating events and the heterogeneity of decision-making processes. In this context, Lee and Mitchell (1994) proposed the UMVT, introducing—among other constructs—the concept of a shock initiating the turnover process and the enactment of a pre-existing plan of action, known as a script.

The UMVT is grounded in image theory, originally formulated by Beach (1993) and subsequently refined in later publications (Beach, Connolly, 2005; Beach, Mitchell, 2014). In contrast to normative decision-making models based on utility maximization, image theory assumes that individuals make decisions primarily by evaluating the compatibility of a contemplated action with their internal images of values, goals, and action plans. A central mechanism of the theory is the compatibility test, through which alternatives that conflict with these images are eliminated without the need for extensive cost–benefit analysis. This perspective made it possible to interpret decisions to leave an organization not only as a consequence of accumulating dissatisfaction, but also as a response to events that violate an individual's core images.

The assumption of the UMVT is that multiple distinct decision paths may lead to voluntary turnover. These paths differ, among others, in the role attributed to job satisfaction, the significance of shocks, the presence or absence of alternative employment opportunities, as well as the speed and degree of deliberation involved in the decision-making process. The model thus enables the explanation of both turnover preceded by prolonged consideration of available options and decisions made relatively quickly in response to specific organizational or non-work events.

In the original version of the model, Lee and Mitchell (1994) identified four distinct decision paths leading to voluntary turnover. Three of these paths (Paths 1-3) are initiated by a shock, defined as a specific event that captures attention and prompts reflection on continued employment. A shock may be personal or organizational in nature and may carry a positive,

neutral, or negative valence; it may also be expected or unexpected. Its significance lies not in directly determining turnover, but in triggering the decision-making process.

Path 1 assumes that following the occurrence of a shock, an almost automatic decision is made on the basis of a previously formed script. The decision is reached without in-depth analysis of the situation and without searching for alternatives, as the individual has previously adopted the principle that employment should be terminated under particular circumstances. Path 2 is also triggered by a shock; however, instead of activating a script, the event results in a perceived incompatibility with the individual's values, goals, or strategies (image violation). Consequently, the individual decides to quit without searching for or evaluating alternative employment opportunities. Path 3 is likewise initiated by a shock that produces image violations; however, in this instance, this sequence leads to dissatisfaction, triggering the search for and evaluation of alternative employment opportunities. Path 4 reflects the classical dissatisfaction paradigm, as the process begins with gradually increasing job dissatisfaction. This path may take two variants: dissatisfaction may lead to the consideration, search, and evaluation of alternative employment opportunities prior to making a final decision (4B), or the decision to quit may be made without prior search for alternatives (4A).

2.3. Empirical tests and model extensions

The first empirical test, involving nurses (Lee et al., 1996), employed retrospective interviews to classify turnover cases. While findings confirmed the occurrence of the previously proposed decision paths, including shock-initiated processes, the qualitative analysis revealed conceptual ambiguities and difficulties in classifying certain cases. Consequently, the next stage of development involved a quantitative replication among accountants (Lee et al., 1999), which refined the operationalization of key constructs—shock, engaged script, image violation, satisfaction, search and/or evaluation of alternatives, likely offer—and introduced a formalized classification procedure.

Empirical tests of the UMVT reveal varying classification rates across occupational groups, indicating that decision-making processes may extend beyond its original structure. While high rates were achieved for accountants (92.6%; Lee et al., 1999) and UK nurses (77.0%; Morrell et al., 2008), the model showed moderate fit for military officers (47.3%; Holt et al., 2007) and limited applicability for IT (12.1%; Niederman et al., 2007) and construction professionals (19.2%; Jones et al., 2010).

In the study of IT professionals, additional Paths 1a, 1b, and 4c were proposed (Niederman et al., 2007). All three involved the enactment of a script centered on searching for and evaluating alternatives and holding a job offer prior to turnover, differing in the configuration of shock, image violation, and job satisfaction. Path 1a assumed a negative shock accompanied by image violation and low job satisfaction; Path 1b involved a positive shock with sustained job satisfaction and no image violation; and Path 4c reflected gradually increasing dissatisfaction accompanied by image violation in the absence of a shock.

In the study of construction professionals, the presence of Paths 1a, 1b, and 4c was confirmed, and additional Paths PP6 and PP7 were proposed (Jones et al., 2010). Both involved the occurrence of a shock, the enactment of a script, the search and evaluation of alternatives, and the likely offer. However, they differed in the configuration of image violation and job satisfaction: of image violation and job satisfaction: in Path PP6, low job satisfaction occurred without image violation, whereas in PP7 image violation was present despite sustained job satisfaction. In the study of military officers (Holt et al., 2007), new decision paths were also identified, and the need to modify the model was emphasized, highlighting the limited adequacy of its original structure under conditions of strong institutional constraints.

In all of the empirical studies cited above that tested the UMVT, the questionnaire and classification procedures developed by Lee et al. (1999) were employed, which enable direct comparison of the reported results. Nevertheless, some studies sought to identify decision paths using alternative methodological approaches. These included the use of different sets of survey questions (Donnelly, Quirin, 2006; Shipp et al., 2014), as well as data derived from exit interviews (Kulik et al., 2012).

3. Hypotheses development

This study assesses the adequacy of the UMVT within a selected occupational group in Poland and, on this basis, proposes potential modifications to the model. It is assumed that the key constructs of the decision-making process—shock, engaged script, image violation, satisfaction, search and/or evaluation of alternatives, likely offer, and the varying temporal dynamics of individual paths—constitute essential components of voluntary turnover decisions.

Previous empirical tests of the model have yielded highly differentiated classification rates across the five original decision paths ranging from 12.1% (Niederman et al., 2007) to 92.6% (Lee et al., 1999), with lower levels of fit more frequently observed in more recent studies. This pattern may suggest that dynamic technological, social, and economic transformations have altered the structure of decision-making processes leading to voluntary turnover. Accordingly, Hypothesis 1 is proposed:

H1: The original UMVT provides a limited explanation of the decision-making processes underlying contemporary voluntary turnover among call center employees in Poland.

Although the UMVT identifies five primary decision-making processes, its theoretical structure allows for the distinction of a greater number of paths. Empirical studies have confirmed the occurrence of additional, recurring paths, including, among others, 1a, 1b, 4c, 5a, and 5b. Based on the analysis of prior empirical tests of the model, Hypothesis 2 was formulated as follows:

H2: Two original Paths 3 and 4b, combined with three Paths 1a, 1b, and 4c identified by Niederman et al., provide a more comprehensive explanation of the turnover decision-making processes among Polish call center employees than the five original paths.

Contemporary career concepts – such as the boundaryless (Sullivan, Arthur, 2006), protean (Hall, 2004), intelligent (Arthur et al., 1995), and spiral career (Brousseau et al., 1996) – emphasize individual responsibility for professional development and deliberate interorganizational mobility. Leaving an organization may therefore constitute an element of a planned career scenario, even in the presence of sustained high job satisfaction. Accordingly, Hypothesis 3 was formulated as follows:

H3: Among call center employees, decision paths exist that comprise job search and/or evaluation of alternatives and a job offer, occurring along with high job satisfaction.

Concurrently, economic conditions in Poland – including relatively low wage levels, limited household savings, and a high share of household debt (Statistics Poland, 2020a) – may encourage employees to decide to change employers only after obtaining an alternative job offer. Consequently, a limited occurrence can be expected of decision paths characterized by a minimal or moderate scope of deliberation and the absence of a job offer in hand, such as Paths 1, 2, and 4a. On this basis, Hypothesis 4 was formulated as follows:

H4: The three original UMVT Paths 1, 2, and 4a occur sporadically or not at all among call center employees.

4. Methods

4.1. Sample selection and research context

The selection of the study population was purposive and conducted in two stages: first, the organization was chosen, followed by the occupational group. The study was conducted in a large organization particularly exposed to excessive voluntary turnover and within a homogeneous occupational group that had not previously been used to verify the assumptions of the UMVT, characterized by both high voluntary turnover and strategic importance to the organization.

The enterprise selection criteria were established based on data from Statistics Poland, using a dynamic analysis covering the years 2010-2019 and a static analysis for 2019, focusing on employee-initiated terminations and the unemployment rate. The analysis revealed more than a twofold increase in employee-initiated terminations during the examined period (Statistics Poland, 2011-2020). Concurrently, their share of total terminations increased from 9-10% in 2010-2013 to 15% in 2018-2019, accompanied by a decline in the proportion of employer-initiated terminations (Statistics Poland, 2011-2020).

A very strong negative correlation (r = -0.97) was identified between the registered unemployment rate and the employee-initiated termination rate (Statistics Poland, 2011-2020). This indicates that the intensity of voluntary turnover increases as labor market conditions improve. This relationship is consistent with the literature, which suggests that the relative ease of obtaining alternative employment enhances employees' propensity to leave (Ehrenberg, Smith, 2012), and that the unemployment rate is considered one of the most robust single predictors of employee turnover (March, Simon, 1958). Consequently, the selection of the research site was restricted to voivodeships characterized by relatively low unemployment rates (below 5.5%).

An analysis of variation in employee-initiated termination rates across sections of the Polish Classification of Activities (PKD, 2007), corresponding to NACE Rev. 2, in 2019 revealed significant differences between types of economic activity (ranging from 0.8% to 7.1%). The highest values were recorded in the following sections: Information and Communication (7.1%), Financial and Insurance Activities (5.2%), Professional, Scientific and Technical Activities (5.1%), and Accommodation and Food Service Activities (4.9%). Moreover, the intensity of employee-initiated terminations was markedly higher in the private sector than in the public sector (Statistics Poland, 2011-2020).

Based on the conducted analysis, it was determined that the study would cover a private sector enterprise whose main activity falls within one of the four PKD sections characterized by the highest employee-initiated termination rates and which is located in a voivodeship with an unemployment rate below 5.5%. In the second stage, the selection of the occupational group was based on two criteria: its classification as a shortage occupation in the given location, verified based on the Occupational Barometer 2020 (Regional Labor Office in Krakow, 2019), and its strategic importance to the enterprise.

4.2. Research instrument and classification rules

The research instrument was developed based on the questionnaire used in the first quantitative empirical test of the UMVT (Lee et al., 1999). The study employed a version adapted to the Polish context, while preserving the logic of the decision-process classification proposed by Lee et al. (1999). Certain items of the questionnaire were modified to reflect the specific conditions of the Polish labor market, enhance measurement precision, incorporate the results of the pilot study, and accommodate a different data collection technique.

Given the retrospective nature of the study, screening questions were applied. Individuals who declared that they did not accurately recall the circumstances and reasons for quitting their job were excluded from the study to minimize post hoc attribution bias and memory distortions (Huber, Power, 1985; Miller et al., 1997).

The classification of respondents into specific decision paths was conducted algorithmically, based on the criteria defined by Lee et al. (1999). The procedure involved binary coding of the presence (1) or absence (0) of key model constructs: shock, engaged script,

image violation, satisfaction, search and/or evaluation of alternatives, and likely offer. For example, the occurrence of a shock was identified based on an affirmative response regarding a specific event that triggered thoughts of quitting, its description in an open-ended question, or confirmation of having received an unexpected job offer. Depending on the configuration of these constructs, cases were classified into particular decision processes (both original and empirically identified in the course of the study). This approach ensured the comparability of the findings with earlier tests of the model while simultaneously enhancing measurement validity within the studied context.

4.3. Data collection procedure

The study employed computer-assisted personal interviewing (CAPI), whereas earlier empirical tests of the UMVT relied primarily on self-administered modes, such as mail or online surveys. This choice was motivated by concerns about data quality. Compared with self-administered techniques, interviewer-administered CAPI offers greater control over the measurement process, including the ability to resolve queries and clarify ambiguities during the interview, achieve higher response and completion rates, and allow the interviewer to identify imprecise or internally inconsistent answers (Groves et al., 2009).

Research procedures adhered to ethical standards for research involving human participants. Formal approval was granted by the participating organization's management, and the data collection process complied with GDPR regulations. Prior to the interview, all participants were informed about the study's purpose and assured of full anonymity and confidentiality. Participation was voluntary, and respondents provided informed consent by agreeing to take part in the computer-assisted interview.

Ultimately, a response rate of 68.1% was achieved, which constitutes a notable methodological strength compared with the reference studies, which reported substantially lower rates ranging from 10.6% (Niederman et al., 2007) to 38.9% (Holt et al., 2007). This high level was largely attributable to the data collection mode employed and to managerial support for the study, evidenced by, for instance, permission to conduct interviews during working hours and provision of dedicated space for interviews.

5. Results

5.1. Characteristics of the research group

The study was conducted in a commercial bank with its Operations Center located in Łódź. The organization met the pre-established selection criteria regarding ownership sector (private sector), type of economic activity (Financial and Insurance Activities), and location in

a voivodeship with a relatively low unemployment rate (Łódź Voivodeship – 5.4% in December 2019; Statistics Poland, 2020b).

The homogeneous occupational group consisted of call center employees, a sample not previously used in empirical verifications of the model. According to the Occupational Barometer 2020, telephone and electronic customer service clerks were classified as a shortage occupation in the Łódź Voivodeship in 2019 (Regional Labor Office in Krakow, 2019). The study participants consisted of current employees who had voluntarily resigned from their previous employment within the last four years.

A total of 160 employees from an internal call center participated in the study, representing primarily the debt collection department (62.5%) and the customer service department (35.0%). The sample was predominantly female (86.3%). The largest age group comprised participants aged 31-35 (44.4%), followed by those aged 36-40 (28.8%) and 26-30 (25.6%). All participants held a university degree. The average tenure in the organization prior to voluntary turnover was 3.71 years.

5.2. Testing the UMVT and its adaptation

The results indicate that the structural components of the UMVT are present in the decision-making processes of the studied group. Specifically, 43.1% of respondents experienced a shock, 76.9% engaged a script, 86.9% reported image violation, and 90.6% indicated low job satisfaction. Notably, all participants reported searching and/or evaluating alternatives and possessing a job offer.

Classification of respondents into the five original decision paths of Lee and Mitchell's model revealed that 18.1% of cases were assigned to Path 3 (7.5%) and Path 4b (10.6%), whereas Paths 1, 2, and 4a were not observed. This outcome simultaneously supports Hypotheses 1 and 4. However, including the additional paths identified in subsequent studies (1a, 1b, 4c) significantly improved the model's classification accuracy. A total of 87.5% of respondents were assigned to Paths 3, 4b, 1a, 1b, and 4c, which supports Hypothesis 2.

In the studied sample, Paths 1b and PP7 were identified, in which the decision to quit was made despite sustained high job satisfaction, accompanied by search and/or evaluation of alternatives and having a job offer in hand. This finding supports Hypothesis 3. Consequently, the results justify modifying the UMVT. The proposed adaptation includes Paths 1a, 1b, 3, 4b, and 4c—specifically, the decision processes that achieved significant empirical share and exceeded the adopted classification threshold ($\geq 5\%$). Figure 1 illustrates the adapted model.

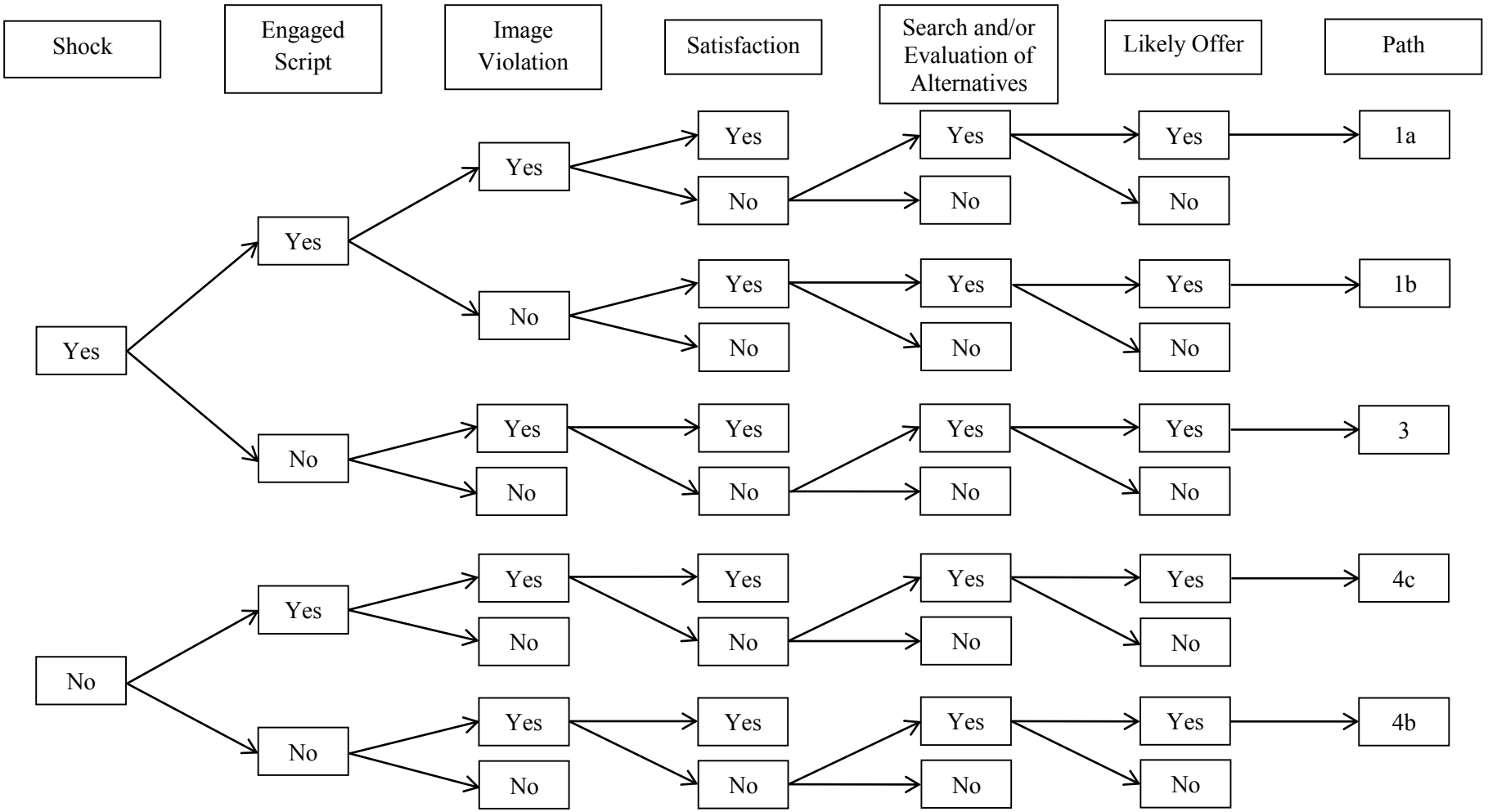

Figure 1. Adaptation of the unfolding model of voluntary turnover to the current conditions of the Polish labor market.

Source(s): Adapted from Lee et al. (1999) and author's own research.

To contextualize the findings, the classification rates observed among call center employees were compared with results from prior empirical tests of the UMVT, covering both its original and adapted forms. In the present study, the classification rate for the five original paths was 18.1%, whereas it increased to 87.5% for the adapted version. Applying the adapted model structure to previous datasets yielded similarly substantial improvements: for Holt et al. (2007), the rate rose from 47.3% to 78.6%; for Niederman et al. (2007), from 12.1% to 79.8%; and for Jones et al. (2010), from 19.2% to 76.9%, as shown in Table 1.

Table 1.
Comparison of classification rates for the original and adapted versions of the UMVT across selected empirical studies

Path	Lee et al. (1999)	Holt et al. (2007)	Niederman et al. (2007)	Morrell et al. (2008)	Jones et al. (2010)	Present study
Original version of UMVT						
1	6 (2.6%)	6 (7.0%)	0 (0%)	2 (0.6%)	0 (0%)	0 (0%)
2	7 (3.1%)	1 (1.2%)	0 (0%)	0 (0%)	1 (1.0%)	0 (0%)
3	136 (59.4%)	46 (25.3%)	6 (4.8%)	115 (32.7%)	5 (4.8%)	12 (7.5%)
4a	8 (3.5%)	1 (1.2%)	0 (0%)	1 (0.3%)	0 (0%)	0 (0%)
4b	55 (24.0%)	32 (37.2%)	9 (7.3%)	153 (43.5%)	14 (13.5%)	17 (10.6%)
Classification rate	212 (92.6%)	86 (47.3%)	15 (12.1%)	271 (77.0%)	20 (19.2%)	29 (18.1%)
Adapted version of UMVT						
1a	n.a.	46 (25.3%)	55 (44.4%)	n.a.	42 (40.4%)	30 (18.8%)
1b	n.a.	19 (10.4%)	10 (8.1%)	n.a.	5 (4.8%)	8 (5.0%)
3	136 (59.4%)	46 (25.3%)	6 (4.8%)	115 (32.7%)	5 (4.8%)	12 (7.5%)
4b	55 (24.0%)	32 (37.2%)	9 (7.3%)	153 (43.5%)	14 (13.5%)	17 (10.6%)
4c	n.a.	n.a.	19 (15.3%)	n.a.	14 (13.5%)	73 (45.6%)
Classification rate	191 (83.4%)	143 (78.6%)	99 (79.8%)	268 (76.1%)	80 (76.9%)	140 (87.5%)

Sources: Own elaboration based on Lee et al. (1999); Holt et al. (2007); Niederman et al. (2007); Morrell et al. (2008); Jones et al. (2010), and the present study.

5.3. Duration of decision paths

The analysis of the duration of voluntary turnover processes revealed that the mean length of the overall process was 7.2 months. The first period (deliberation), covering the time from the first thoughts of quitting to the decision to leave, lasted on average 5.3 months, whereas the second period (implementation)—from the decision to leave to actual quitting—lasted 1.9 months. Differences in process duration were also observed across decision paths. The longest mean duration was found for Path PP7 (8.3 months), while the shortest was observed for Path 3b (5.6 months). These results indicate that voluntary turnover is a gradual

process, characterized by a significantly longer period of deliberation compared to implementation.

6. Discussion

The path classification results observed in this research are most comparable to those reported by Niederman et al. (2007). In both studies, the classification rate for the five original paths of the UMVT was low (18.1% and 12.1%, respectively), with respondents assigned to only two decision processes—Paths 3 and 4b (7.5% vs. 10.6% and 4.8% vs. 7.3%, respectively). Concurrently, in both the present study and the analysis by Niederman et al. (2007), Paths 1a and 4c were dominant (18.8% vs. 45.6% and 44.4% vs. 15.3%, respectively).

The study of call center employees is distinguished from previous research by the universal presence of search and/or evaluation and job offer constructs across all identified decision paths. This pattern may be attributed to the lower level of affluence in Polish society compared with the United States and the United Kingdom, where this type of research has predominantly been conducted to date. Employees may be less able to afford frictional unemployment; consequently, quitting decisions tend to be more calculated and are typically preceded by securing an alternative employment option. Unlike the rapid, automatic decision-making typical of Path 1, the patterns observed in this study point to an extended deliberation process where individuals minimize economic risk. The results reveal a fundamental transition from reactive, shock-driven processes to proactive decisions grounded in planning and active career management.

The adapted version of the model, comprising Paths 1a, 1b, 3, 4b, and 4c, yields substantially higher classification rates not only in the present study (87.5% instead of 18.1%) but also when applied to data reported by Holt et al. (2007), Niederman et al. (2007), and Jones et al. (2010). This indicates that the proposed adaptation demonstrates greater empirical stability across different occupational groups and varying labor market conditions.

In interpreting the findings, it is also beneficial to draw on the stream of research on job embeddedness, which emphasizes the employee's enmeshment in the organization as a factor that constrains their propensity to leave. Recent empirical studies indicate a significant negative relationship between embeddedness and turnover intention, while simultaneously highlighting the context-dependent nature of this association (e.g., Sahoo et al., 2024; Kiazad et al., 2024). However, Peltokorpi and Allen (2024) suggest that even strong on-the-job embeddedness does not preclude turnover decisions when employees identify attractive external alternatives. The present findings align with these insights: in the analysed sample, even respondents reporting high job satisfaction (Paths 1b and PP7) engaged in job search behaviors and decided to change employment upon securing a favourable offer. This implies that organizational

embeddedness and high job satisfaction do not eliminate planned career mobility; instead, they serve as a stable foundation from which employees proactively manage their careers when superior alternatives arise.

It is worth emphasizing that the UMVT remains the subject of ongoing analyses and theoretical development. Evaluating the model, Kim (2025) points to its enduring value as a framework for explaining voluntary turnover processes, while also underscoring the need for empirical tests across diverse occupational contexts. In parallel, research is refining our understanding of the shock mechanism, suggesting that quitting decisions may result not only from directly experiencing an event but also from anticipating it (Liu et al., 2025). Moreover, recent work has sought to integrate the UMVT with other theoretical perspectives, including a temporal approach to job embeddedness (Tipirneni, 2024), indicating that the UMVT is not a closed concept but continues to evolve in response to changing labor-market conditions and emerging research questions.

6.1. Practical implications

The results have significant implications for human resource management practice. The average duration of the voluntary turnover process (7.2 months) offers organizations a real opportunity to implement retention strategies. However, its internal structure is critical: the deliberation period (averaging 5.3 months) is significantly longer than the implementation period (1.9 months). Consequently, retention management efforts should focus on the pre-decision period, as the scope for effective organizational intervention appears limited thereafter.

The findings confirm that turnover decisions are not determined solely by job dissatisfaction, as assumed by most classical models. Instead, the process may be initiated by a shock or result from the enactment of a preexisting script. In some cases, the decision to quit was made despite high job satisfaction (Paths 1b and PP7), indicating the growing importance of planned career mobility. Contemporary turnover scripts encompass both transitions to organizations offering superior working and pay conditions and leaving after a predetermined period, representing a planned stage in an individual's career.

From a managerial perspective, this implies that reducing turnover cannot rely solely on increasing job satisfaction. Monitoring external factors becomes essential, particularly the unemployment rate and employment conditions offered by competitors. At the same time, greater emphasis should be placed on creating internal career development opportunities and tenure-based incentives (e.g., seniority bonuses) that may offer an alternative to enacting a turnover script. Targeted actions are particularly relevant for employees who report high job satisfaction yet actively monitor the labor market or are pursuing a planned career stage.

Moreover, the significant proportion of shock-initiated processes (43%) suggests the need to develop organizational mechanisms for the early identification of events, particularly work-related ones, such as organizational changes, missed promotions, or modifications to job responsibilities. Enhancing managerial awareness in recognizing such situations and

developing skills in conducting retention dialogues at the early stage of the turnover decision-making process may increase the chances of effective intervention before the resignation is formalized.

6.2. Limitations and future research

Due to certain methodological limitations, the results should be interpreted with caution. The study was conducted on a purposively selected, homogeneous occupational group employed within a single large organization in Poland, which limits the generalizability of the findings to other professions and countries. Additionally, the retrospective nature of the study may have entailed a risk of recall bias among respondents.

Future research should examine whether the proposed adapted version of the model retains its greater explanatory power in other occupational groups, particularly within roles of strategic importance to organizations. A further promising avenue is the in-depth identification of the specific scripts employees enact, as well as the scope and frequency of labor market monitoring preceding the emergence of thoughts about quitting. In this context, particular attention should be paid to the impact of AI advancement and task automation, which may reshape job content and generate new, as yet undocumented turnover scripts.

7. Summary

The study aimed to assess the adequacy of the UMVT within a selected occupational group in the Polish context and to modify the model where necessary. The findings indicate that leaving an organization results from diverse decision-making processes based on distinct configurations of the following constructs: shock, engaged script, image violation, satisfaction, search and/or evaluation of alternatives, and a likely offer. While the UMVT remains a fundamentally useful analytical framework with empirically supported core constructs, its original five-path version demonstrates limited explanatory power among the studied call center employees (18.1%).

Consequently, the first empirical test of the UMVT in Poland and a comparative analysis of prior related studies enabled the successful adaptation of its original version to the current situation in the labor market. The revised model, comprising Paths 1a, 1b, 3, 4b, and 4c, allows for the classification of the vast majority of cases (87.5%) and better reflects the actual course of voluntary turnover processes. Ultimately, this updated framework contributes to the turnover literature by highlighting a shift toward planned and controlled career mobility, while simultaneously providing a practical tool to support modern employee retention management practices.

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URBAN MOBILITY UNDER PRESSURE: A CRITICAL LOOK AT PUBLIC TRANSPORT IN NAIROBI'S METROPOLITAN AREA

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Purpose: This paper explores the critical challenges impeding the development of public transport services in the Nairobi Metropolitan Area. It aims to assess the current infrastructure, evaluate the role of governance, identify financial limitations, and propose sustainable transport strategies informed by global best practices.
Design/methodology/approach: The study employed a mixed-methods research design. Qualitative data were collected from comparative case studies of cities such as Bogota, and Shenzhen. Quantitative data were gathered via structured questionnaires distributed to commuters, transport operators, and regulatory authorities. Secondary sources included government reports, peer-reviewed literature, and environmental assessments.
Findings: The research reveals systemic weaknesses in Nairobi's transport system: poor roads and rail infrastructure, limited investment, informal and unregulated operations, and widespread corruption. These factors hinder service efficiency, sustainability, and safety. The findings highlight the urgent need for policy reforms, integrated infrastructure development, and public-private collaborations.
Originality/value: This study provides a comprehensive and localized analysis of the Nairobi metropolitan area public transport service sector, combining global insights with ground-level realities. It adds value by proposing practical, context-specific solutions for improving urban mobility in rapidly growing African cities.
Keywords: metropolitan, infrastructure, transport, population, urban, economy.
Category of the paper: Research paper.

1. Introduction

Public transport services are a cornerstone of urban mobility and development.. The demand for effective, dependable, and inclusive transport services is critical in rapidly urbanizing regions like the Nairobi Metropolitan Area. Nairobi, Kenya's capital and East Africa's largest metropolis, experiences significant strain on its public transport services and infrastructure due to rapid population growth, urban sprawl, and governance challenges. According to

Macrotrends, Nairobi's population exceeded 5.5 million in 2024 and is projected to reach 10 million by 2030.

Nairobi - Historical Population Data		
Year	Population	Growth Rate
2025	5,767,000	4.08%
2024	5,541,000	4.06%
2023	5,325,000	4.02%
2022	5,119,000	4.00%
2021	4,922,000	3.95%
2020	4,735,000	3.93%
2019	4,556,000	3.88%
2018	4,386,000	3.88%
2017	4,222,000	3.86%
2016	4,065,000	3.86%
2015	3,914,000	3.87%

Figure 1. Population growth in Nairobi over the years.

Source: Macrotrends database.

This trend of population growth in major cities is a phenomenon worldwide, and there is a need for a futuristic plan.

It is worth noting that a large proportion of this population is youthful and unemployed. The sample data indicates that 50% of respondents are unemployed, including both students and non-students.

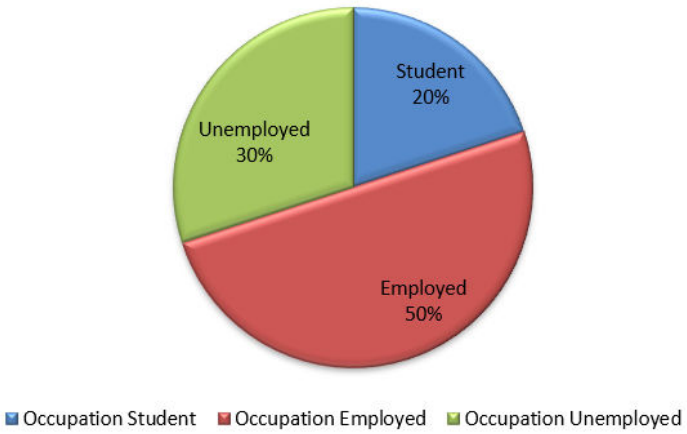

Figure 2. Occupation of people living within the Nairobi metropolitan area.

Source: Own study.

Notably, the unemployed place additional pressure on public amenities in the city without contributing to their sustainability and present a significant burden on the economy. The rapid population growth in this metropolis underscores the need for commensurate and sustained investment in transport systems. Challenges arising from poorly developed transport services and inadequate infrastructure often lead to acute traffic congestion, negative economic impacts,

and environmental degradation. The Nairobi Metropolitan Area, like other major metropolises around the world, requires modern, well-developed public transport services. Such improvements make it easier for residents to commute, thereby increasing socio-economic activity and reducing environmental impacts. A report by the Centers for Disease Control and Prevention (CDC) highlights that properly designed transport policies are critical in promoting public health by reducing traffic congestion, minimizing air pollution, and ensuring accessibility for its residents (CDC, 2024).

Similarly, according to Heaps, Abramsohn, and Skillen (2021), expanding public transport systems translates to a significantly enhanced public health and promoting social equity. These benefits include reducing traffic crashes, lowering pollution levels, encouraging physical activities, and improving access to essential services such as medical care, employment opportunities, nutritious food, and social connections.

Even though efforts have been made to improve public transportation in Nairobi metropolitan area, there are still many problems hindering development. This paper seeks to address systemic inefficiencies and proposes ideas for a more dependable, inclusive, and sustainable public transport system.

2. Literature review

Mobility is an essential element of social, economic, and individual life. Since the earliest societies, human existence has been inextricably linked to the need to move. Initially, people moved to find food and shelter, and to protect themselves from threats. As civilization developed over time, mobility became a key element of trade, communication, and general cultural exchange between communities. Today, mobility is an intrinsic part of people's lives as it enables access to work, education, healthcare, recreation, and many other areas.

In the context of urban transport, mobility describes the potential and actual movement of people and goods within a city. Potentially, it expresses the accessibility and reachability of a variety of destinations where different human needs can be met. From this perspective, mobility is an individual concept resulting from the spatial distribution of an area and the location of places for socializing, working, and other activities. This potential mobility is limited by factors such as time, budget, and the transport network's available means of transport. In practice, however, mobility is described by measures such as distance travelled per person in kilometers, travelled by different modes of transport, vehicles on a given stretch of road in each period, and transport workload (Mężyk, 2019).

The satisfaction of human mobility needs may be realized primarily through either collective or individual modes of transport. Collective transport refers to regular, scheduled services that are organized at the request of local governmental transport authorities and may operate within a single municipality or across multiple municipalities, based on inter-municipal agreements (Kiba-Janiak, Cheba, 2011). In contrast, individual transport is characterized by its non-scheduled nature, lack of regularity, and the predominance of private initiative and control (Kiba-Janiak, Cheba, 2011).

In scholarly discourse, collective transport is commonly equated with public or urban transport systems, whereas individual transport is typically associated with private means of mobility (Cichosz, 2014). Moreover, Cichosz (2014) identifies a third, intermediate category—group transport—which, although less prevalent, includes modalities such as taxis and carpooling.

The principal distinctions between the two primary transport categories—individual and collective—are summarized in Table 1.

Table 1.
Differences between individual and collective transport

Description	Collective transport	Individual transport
Source of funding	Dually: cities and users of this kind of transport	Users of this type of transport means
Regularity of transportation	High regularity of transportation	Lack or rare regularity of transportation
Transport conditions	Many people using one means of transport	A small number of people using the same means of transport
Costs	Low cost of movement for one passenger	Excessive costs of movement
Privacy	Lack of privacy	High privacy
House -to-house movement (flexibility of movement)	Moving along designated and fixed routes	You can reach any place

Source: Kramarz, Dohn, Przybylska, Jonek-Kowalska, 2022, p. 173; Kiba-Janiak, Cheba, 2011.

The previously indicated basic divisions of passenger transport in the city can be complemented by a classification indicating the following: surface transport (the most popular form of transport, e.g., bus, trolleybus, motorbike, urban railway), underground transport (underground railway), aboveground transport (monorail) and water transport (e.g. water tram) (Janczewski, 2020).

However, the applicability and effectiveness of these transport modes vary significantly across cities, particularly in developing regions. Urban mobility in many African cities is characterized by fragmented transport networks, heavy reliance on informal transport, and inadequate infrastructure (World Bank, 2022). In the Nairobi Metropolitan Area, rapid unplanned urbanization has created significant challenges for public transport systems. Aligula et al. (2005) highlight that Nairobi's transport system suffers from congestion, weak institutional coordination, and limited investment in mass transit solutions.

Studies also show that successful reforms in cities such as Bogotá and Shenzhen demonstrate how integrated transport policies, Bus Rapid Transit (BRT) systems, and electrification of public transport fleets can significantly improve mobility efficiency and environmental sustainability. However, despite these examples, Nairobi continues to face systemic challenges related to governance, financing, and infrastructure development. Therefore, further research is required to understand the specific structural barriers affecting the development of public transport in the Nairobi metropolitan area.

3. Methodology Research

This study adopts a mixed-methods research approach combining both qualitative and quantitative techniques to examine the challenges affecting public transport development in the Nairobi metropolitan area. The mixed-methods approach allows for the integration of statistical data with contextual insights from key stakeholders within the transport sector. Quantitative data were collected through structured questionnaires administered to commuters and transport services operators, while qualitative data were obtained through interviews with relevant stakeholders and comparative case studies of selected cities.

The subsections below describe the research design, data collection procedures, sampling strategy, and methods of data analysis applied in the study.

3.1. Research Design

The research adopts a mixed-methods research design that integrates both qualitative and quantitative techniques to develop a comprehensive understanding of the public transport challenges facing the Nairobi metropolitan area. The use of multiple data sources helped strengthen the reliability of the research. This approach is particularly appropriate for complex urban mobility studies, where both empirical measurements and institutional perspectives are required to explain transport system dynamics.

More so, this research design is both descriptive and analytical in nature. The descriptive component focuses on identifying the current state of transport infrastructure, operational efficiency, and commuter experiences. The analytical part investigates underlying governance and socio-economic factors influencing the development of public transport services in the metropolis.

3.2. Quantitative Data Collection

Quantitative data were collected through structured questionnaires distributed to 60 respondents within the Nairobi metropolitan area. The respondents included daily commuters, matatu operators, and representatives of transport authorities. The questionnaire

consisted primarily of closed-ended questions designed to capture commuter experiences and perceptions of the public transport system.

The survey addressed several key variables, including:

- occupation of respondents,
- transport mode distribution,
- infrastructure quality,
- perceived causes of congestion,
- exposure to bribery within the transport sector,
- approximate travel time of commuters,

Responses to these variables were analyzed using descriptive statistical methods to identify patterns in commuter behavior and perceptions, and to evaluate the key challenges influencing public transport usage and the effectiveness of existing mobility infrastructure in the Nairobi metropolitan area.

3.3. Qualitative Data Collection

Qualitative data were collected through document analysis of existing texts, including policy documents, reports, and relevant literature. This helped to examine underlying governance, financial, and institutional factors influencing public transport development. The qualitative component provided deeper insights into the systemic problems that cannot be fully captured through quantitative surveys alone.

3.4. Comparative Case Study Analysis

In providing additional context and identifying potential solutions, the study incorporated comparative case studies. It analyzes two international cities: Bogotá (Colombia) and Shenzhen (China). These cities were selected due to their globally recognized success in implementing innovative public transport systems. Firstly, Bogotá's Bus Rapid Transit (BRT) system demonstrates how high-capacity bus corridors can improve urban mobility and reduce congestion. Secondly, Shenzhen, through its large-scale electrification of public transport buses, represents a global example of sustainable mobility. These case studies provide useful insights and policy lessons that may apply to Nairobi metropolitan areas' transport development strategy.

3.5. Sampling Strategy

A purposive sampling method was used to select respondents who have direct experience with Nairobi's public transport system. This sampling strategy ensured that participants possessed relevant knowledge about Nairobi's transport sector. The selected participants included commuters who regularly use public transport services, operators involved in matatu operations, and stakeholders responsible for transport regulation and planning.

3.6. Data Analysis

Quantitative survey data were analyzed using descriptive statistical methods, including percentages and frequency distributions. These methods helped identify patterns in commuter perceptions and transport service performance.

Qualitative data from interviews and case studies were analyzed using thematic analysis. This involved identifying recurring themes related to governance challenges, infrastructure deficiencies, and financial constraints affecting public transport development.

3.7. Research Limitations

Despite the strengths of the mixed-methods approach, it is important to note that there can be limitations that should be acknowledged. For example, the sample size of respondents may limit the generalization of the results to the entire Nairobi metropolitan population. However, the integration of qualitative interviews and secondary data sources available helped enhance the robustness of the findings and provided valuable insights into the transport system that is currently in existence.

4. Existing transport services and infrastructure in Kenya

4.1. Mobility services available

Historically, transport in Kenya played a key role in socio-economic development, with early infrastructure shaped by colonial influence. In the 19th century, mobility was limited, relying on donkeys and horse carriages. These early routes influenced the current road network. With Nairobi's designation as the capital of British East Africa, formal transport infrastructure began to develop, including passenger buses such as Kenya Bus Services and rail tracks by Kenya Railways Corporation linking Nairobi to Mombasa, Kisumu, and Nakuru.

In the 1960s, the emergence of matatus—privately owned vans—introduced affordable, though initially illegal, public transport (Sclar, Alexander, 2007). Despite initial opposition, matatus were legalized in the 1980s and currently they dominate Nairobi's public transport service system. About 1 million people rely on matatus to commute daily (Salon, Gulyani, 2019). They operate alongside buses under SACCOs, as per Nairobi’s city by-laws. Even though matatu operations are licensed, there is still an extensive unlicensed informal network in the metropolis.

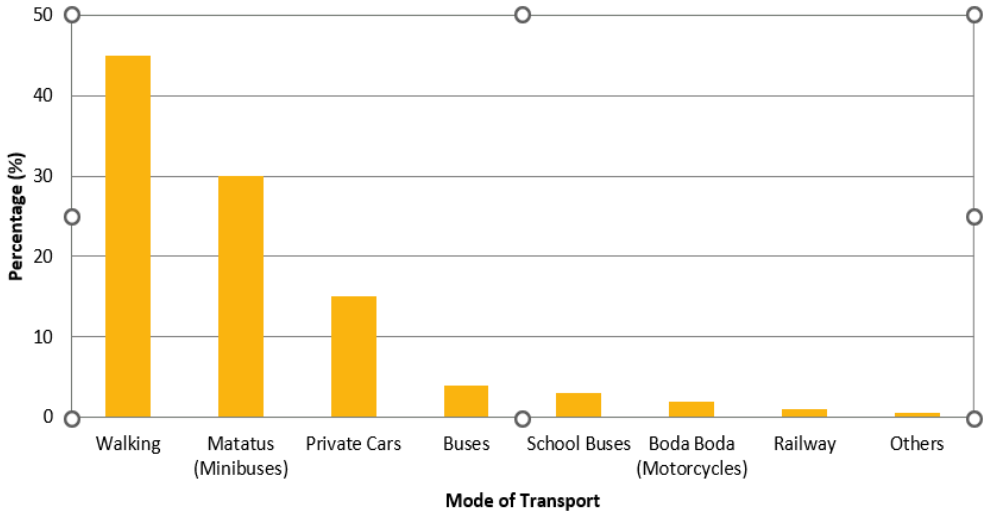

Figure 3. The distribution of the use of major means of transport in the Nairobi metropolitan area. Source: Own study.

Research findings show mobility within the metropolis is highly dependent on walking and the use of matatus (minibuses). Visibly, the limited use of formal public transport options, such as buses and rail, points to inadequate investment and poor integration of mass transit systems. Additionally, the low reliance on private vehicles suggests economic constraints among residents.

4.2. Infrastructure present

Key infrastructure components include major roads that link Nairobi city to other urban centers and other roads link the CBD to its outskirts. Listed below are examples of major highways and bypasses, commuter terminals, railway networks parking zones and non-motorized infrastructure present:

Nairobi Expressway: A 27-km elevated toll highway linking CBD to Jomo Kenyatta International Airport, easing congestion, and reducing travel time to 20 minutes (South China Morning Post, 2022). It was completed in 2022 under a public-private partnership between the Kenyan government and China Roads and Bridges Corporation, costing approximately €487 million.

Thika Superhighway: Eight-lane highway connecting Nairobi CBD to Thika Town, enhancing access to Kiambu and Mount Kenya region (Kenya Roads Board, 2020).

Outer Ring Road: Links Eastlands to Thika Road and Mombasa Road, recently expanded (World Bank, 2019).

Southern Bypass: From Mombasa Road to Kikuyu via Langata, relieving inner-city congestion (Kenya Roads Board, 2020).

Northern Bypass: From Ruaka to Ruiru via Limuru and Thika Roads.

Eastern Bypass: Connects Embakasi to Ruiru, easing traffic in densely populated areas.

Western Bypass: 32-km highway linking Kikuyu to Ruaka, designed to divert traffic from CBD.

Bus Stations: Key terminals include Kencom, Odeon, Railways, Country Bus, Muthurwa, Afya Centre, Ambassadors, and Tea Room. Railway and Country Bus stations serve both local and long-distance routes. These hubs are crucial to the city's transport network, with modernization efforts needed to support a growing population. According to a study by Wangui (2017), matatus provide the biggest portion of public transport services in Nairobi, with key stations such as Kencom and Railways acting as the central nodes for these services. Similarly, a report by García (2022) highlights that bus stations are essential to city commuter transport. These findings underscore the need to modernize and expand the capacity of these stations to meet the growing urban population.

Nairobi Commuter Rail: Kenya Railways Corporation has revitalized existing colonial-era rail lines, using second-hand diesel trains from Spain's SFM to enhance urban mobility. Rail remains a preferred option along available routes due to cost and time savings (Simpson, Barry, 1994).

Non-Motorized Transport Infrastructure: Sidewalks and pedestrian footbridges support walking, which accounts for 47% of transport modal share. Bicycle lanes are being included in urban plans, though implementation remains limited.

Parking Facilities: Nairobi offers both public and private parking in malls, offices, and near public spaces like hospitals and markets. Designated zones for taxis also exist within the CBD.

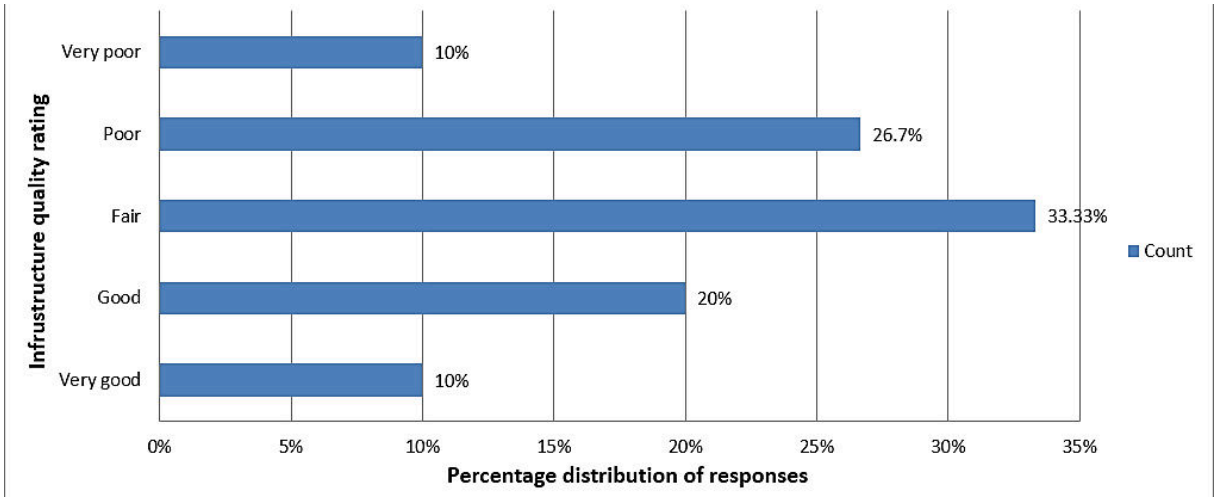

Figure 4. Resident's sentiments on the quality of infrastructure present in Nairobi.

Source: Own study.

The predominance of fair (33.33%) and poor (26.7%) ratings by the research findings indicates that existing infrastructure is insufficient to support dependable, safe, and efficient transport systems. This distribution suggests that a significant proportion of users experience persistent challenges in mobility, including delays, discomfort, and limited accessibility. It also reflects the poor quality of public transport delivery.

5. Challenges in public transport services development

The development of public transport in Nairobi faces critical challenges that compromise its efficiency and reliability. The challenges in the development of public transport services focus on systemic, operational, and societal barriers that hinder efficiency and reliability. These challenges include overcrowding due to high commuter volumes, unregulated matatu operations, and weak enforcement of traffic laws. Additionally, there is political interference, corruption, and resistance to change by commuters and operators that significantly impact the implementation of reforms.

5.1. Social challenges

Congestion and Overcrowding

The Nairobi metropolitan area is documented to host approximately 15,000 vehicles daily operating on approximately fifty routes, with 14-seater matatus comprising 80% of the total (Africa Snow, 2024). Matatus operators often compete for passengers, leading to erratic driving behaviors such as frequent stops and acceleration, causing a smooth traffic flow to be disrupted. Additionally, the rise in the number of private vehicle owners has increased traffic congestion, while outdated transport policies and insufficient road networks fail to keep pace with the city's rapid growth.

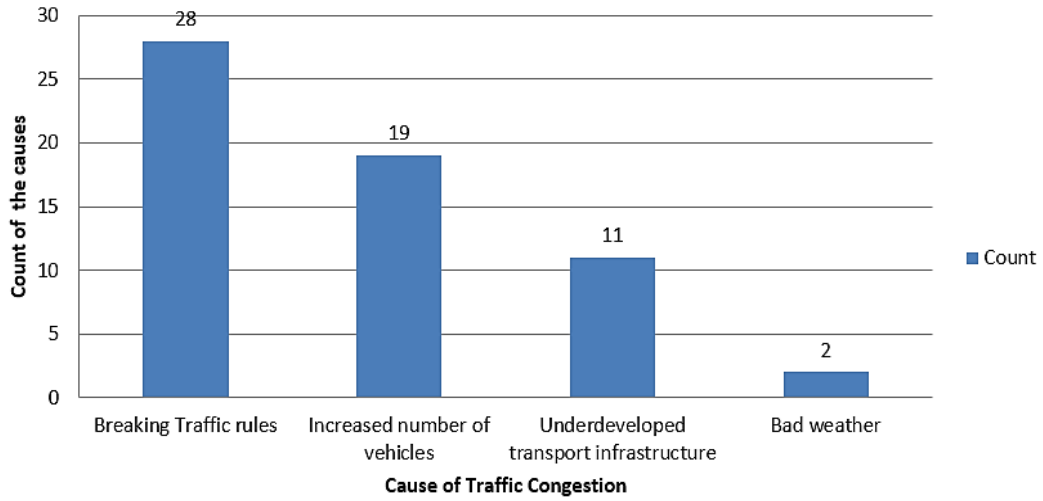

Figure 5. A representation of the causes of traffic congestion in the Nairobi metropolitan area. Source: Own study.

Research findings indicate that traffic congestion in the Nairobi metropolitan area is largely driven by both behavioral and systemic factors. In particular, the prevalence of traffic rule violations as a major contributing factor, coupled with other challenges, exacerbates congestion and imposes a significant burden on commuters and residents.

Resistance to Change

Resistance to change by commuters and operators often results in opposition to the public transport initiative proposed by city management. Examples include opposition to relocating bus stations from the city center to facilities such as the Nairobi Green Park Terminal, which has led to riots and resistance. In this case transport operators resisted changes that restrict their access to the city center, whereas traders argue that such relocations harm their businesses. Commuters' express concerns about being dropped off at locations far from their destinations, which adds to opposition efforts. Many matatus are outdated, lacking modern safety and comfort features, and are operated under loosely regulated Savings and Credit Cooperative Organizations (SACCOs).

Informal transport service networks

According to Kinyanjui (2023), a substantial number of the matatus, buses, and termini are operated illegally. The report revealed that while 272 SACCOs were officially registered in Nairobi, an additional 420 unregistered SACCOs were operating illegally. This lack of regulatory oversight has allowed matatus to operate on unauthorized routes, contributing to disorder in the public transport sector. These services depict how Nairobi's public transport sector is highly informal, despite government attempts at regulating it and despite various attempts at organizing the actors into formal unions. Many matatu routes are infiltrated and controlled by the illegal gangs (Rasmussen,2012). These illegal operations contribute significantly to the disruption of traffic flow and pose significant safety risks to passengers and other road users.

Political Involvement

Nairobi being the capital of Kenya means that the metropolitan region is a crucial focal point of political activities. Firstly, politicians often avoid implementing reforms in the transport sector if such reforms conflict with the interests of matatu sector members, as they prioritize securing votes. Secondly, members of different ethnicities always clash and fight over routes and stages that lead to full-blown skirmishes, especially during elections. Efforts to relocate hawkers from streets often becomes difficult because of the political sensitivity associated with such moves (Oduor, 2024). Hawkers form a huge voting block that can be considered by any political aspirant within the metropolitan area. Therefore, political considerations, including winning the support of hawkers and the influence of organized groups, often complicate enforcement actions. According to (Mutai,2023) such politics contributes significantly to the obstacles faced by authorities in managing street vending activities within the city.

Bribery

Bribery extends to all transport stakeholders, including traffic police officers, drivers, and commuters. This results in poor law enforcement and compromised road safety. SACCOs, drivers, and conductors often pay advance bribes to regulatory officers to avoid arrest or fines, highlighting significant integrity issues within the sector. As shown in Figure 6 below, the likelihood of bribery occurring within the transport system is high, with up to 90% of respondents reporting that they have witnessed bribery taking place.

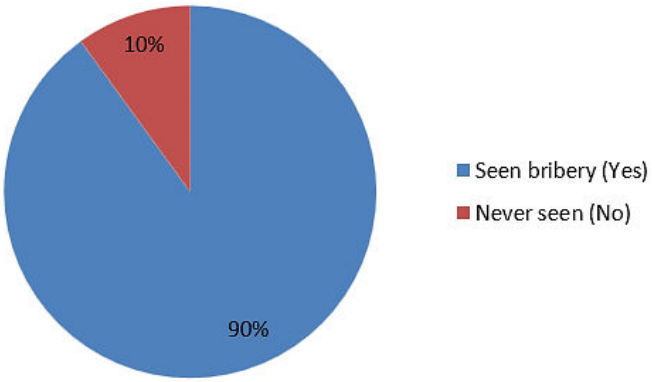

Figure 6. Bribery in the public transport services sector as witnessed by commuters.
Source: Own study.

The findings reveal that bribery is widely prevalent in the public transport sector, with a significant 90% of respondents reporting having witnessed such practices. From the responses given, it can be inferred that there are deep systemic governance and regulatory challenges in the Nairobi metropolitan area.

5.2. Infrastructure inadequacies

Inadequate infrastructure puts immense pressure on existing ones, hindering gradual progress towards a sustainable transportation system. According to a 2023 report by the Kenya Urban Roads Authority (KURA), shown in Table 2 below, of the 3982 kilometers of urban roads, 2385 kilometers are officially gazetted, while 1597 kilometers are classified but still awaiting gazettement. However, conditions on these roads vary significantly, with 34% (1334 kilometers) considered in good condition, 43% (1704 kilometers) in fair condition, and 24% (943 kilometers) in poor condition. The report shows 1956 kilometers of urban road network remain unpaved, representing half of the total distance. This substantial proportion of unpaved and poorly maintained roads in urban centers increases the congestion and inefficiencies that already plague the transport system (KURA, 2023).

As a matter of urgency, the government needs to improve the 24%—equivalent to 943 km—of urban road networks that are currently in poor condition. Additionally, 49% of unpaved roads need to be upgraded to paved roads, as unpaved surfaces are often severely affected by weather conditions such as heavy rains.

Table 2.
Condition of Roads in Kenya's urban centers

Road Surface Type	Condition			Total (Kms)	Proportion (%)
	Good (Kms)	Fair (Kms)	Poor (Kms)		
Paved	858.21	839.9	327.81	**2025.92**	51%
Unpaved	475.80	865.00	615.28	**1956.08**	49%
Total	**1334.01**	**1704.9**	**943.09**	**3982.00**	**100%**
Proportion (%)	**34%**	**43%**	**24%**	**100%**	

Source: Kenya Urban Roads Authority's 2023 report.

The expansive Nairobi metropolitan area is faced with inadequate terminal facilities for buses and matatus. This further leads to the ineffectiveness of the transportation system that affects commuters. Most terminals are overcrowded with commuters, small-scale vendors, homeless people, etc. These terminals in most cases usually lack basic amenities such as waiting bays, proper lighting, and sanitation facilities.

Rail transport remains an underutilized infrastructure in the Nairobi Metropolitan Area. An efficient rail network could provide a sustainable solution to mass transit. However, according to Kenya Railways (2024), poorly maintained railway lines and inadequate stations continue to hinder the effectiveness of the commuter rail service, which also suffers from a shortage of passenger coaches and freight wagons. The railway network covers only a limited area, mainly because no new railway lines have been developed since Kenya's independence in 1963. The Nairobi Commuter Rail Service operates on tracks originally built during the British colonial era. Lack of expansion and connectivity restricts the rail system's potential as a viable mass transit solution, forcing many commuters to rely heavily on road transport.

Lastly, there is a lack of adequate non-motorized transport (NMT) infrastructure in Nairobi. Many streets in the city center and satellite towns do not have proper sidewalks. Where sidewalks do exist, they are often occupied by street vendors and hawkers, forcing pedestrians to share space with vehicles and significantly increasing the risk of accidents.

5.3. Financial Constraints

Several factors cause financial constraints in the development of public transport services in the Nairobi metropolitan area. Below are a few major causes:

5.3.1. Insufficient Budgetary Allocations

One of the key challenges facing public transport development in Nairobi is chronic underfunding by the government. Budget allocations are often inadequate to initiate, implement, or complete critical projects. Large-scale transport infrastructure like the Bus Rapid Transit (BRT) system requires substantial investment, yet it has struggled due to minimal government financial commitment. Nairobi's ambitious plans are regularly stalled or delayed

because city management cannot meet contractor payments or afford comprehensive project execution.

5.3.2. Corruption

Funds allocated for transport systems development are often misappropriated. Embezzlement and kickbacks between contractors and ministry officials are usually common. Contractors sometimes pay bribes to win tenders, inflate project costs, or abandon projects midway once money has been siphoned. Delays in the disbursement of funds, combined with governance challenges, usually force the suspension and abandonment of the projects. Bribery remains a pervasive daily phenomenon in Kenya's public transport sector. An example is the illegal payments made by public transport operators to traffic police or municipal officers to evade arrest for breaking the law or failing to pay required licenses. This system of bribery drains potential revenue and deters reforms. As a result, trust in institutions erodes, and the effectiveness of public service delivery is compromised.

5.3.3. Weak Public-Private Partnership (PPP) Frameworks

While PPP models have shown great success globally, Nairobi has struggled to attract private-sector involvement in transport infrastructure. This is due to:

- Unclear policy frameworks.
- Lack of investor protections.
- High perceived risks.
- Widespread corruption and political interference.

Private investors hesitate to engage in long-term transport projects where returns are uncertain, and the legal environment lacks predictability. The failure to streamline PPP laws and provide incentives for private sector involvement has significantly slowed the city's infrastructure development. Without reforms in governance and enforcement, PPPs remain underutilized as a tool to bridge funding gaps.

6. Implications and consequences

The availability of a seamless transport service system in cities is paramount to its development. However, poor development of transport services always results in frequent malfunctioning leading to adverse consequences. The implications affect not only the commuters but also the country's economy, environment, and sustainability of the sector. Urban mobility in Nairobi's metropolitan area is severely affected by multi-faceted persistent challenges. Examples include heavy traffic congestion and environmental pollution, which manifests itself as excessive noise, smoke, and dust. Additionally, limited route networks constrain accessibility for commuters (Aligula et al., 2005). These mobility issues are further

compounded by ineffective management practices, inadequate safety measures, and widespread insecurity within the public transport system. The implications are therefore major issues that must be addressed.

6.1. Urban sustainability

Urban sustainability in transport services refers to the sector's ability to meet the needs of commuters, function efficiently, and expand commensurately with the growing population without external interventions. To ensure this there is always a need for both infrastructural development and transport service improvements. According to Wang et al. (2018), transportation infrastructure significantly affects sustainable development, which in turn affects various environmental and economic factors. This highlights the government's need for the constant development of transport infrastructure. When infrastructure and services face development challenges, the sustainability of public transport system is critically compromised (Tucho, 2022). The results of an unsustainable transport service in Nairobi are:

1. Operational Inefficiency.
2. Increased Dependence on Informal Transport.

Operational Inefficiency

Insufficient investment in transport infrastructure leads to poor revenue generation, high operational costs, and inefficient service delivery. The dependence on outdated matatu fleets and poorly maintained roads increases maintenance expenses, which puts operators and commuters at risk. Furthermore, cash-based fare collection systems result in revenue leakages, limiting funds available for infrastructure upgrades and service improvements (Wang et al., 2018). The lack of strategic investments in public transport further hinders the system's ability to sustain itself financially, leading to continued inefficiencies (Tucho, 2022).

Increased Dependence on Informal Transport

Poor infrastructure development in the Nairobi metropolitan area forces commuters to rely on informal transport means of mobility such as unregistered matatus and boda-boda motorbikes, which are not only unsafe but also unreliable. The absence of an integrated transport network, which connects buses, commuter rail, and nonmotorized transport (NMT) routes, reduces efficiency, and magnifies congestion. Studies on urban transport challenges highlight that an overreliance on informal transport discourages structured private-sector investments, further complicating urban mobility planning and sustainability (Tucho, 2022). Without proper integration and long-term planning, Nairobi's transport system risks remaining fragmented, inefficient, and environmentally unsustainable.

6.2. Socio-economic implications

Due to the inadequate development of the commuter infrastructure, Nairobi faces an uphill task in addressing its economic and social challenges. Congestion in the metropolitan area usually makes the commute time longer than expected. During rush hours, for example, while going to work, a journey that would take less than 30 minutes often exceeds over 2 hours. A third of the productive time is wasted on the road and this situation is unfortunately repetitive for daily commuters. A report by The Standard, a local newspaper (2024) indicated that Nairobi lost Ksh 58 million daily (about $ 448 thousand) in the estimated time wasted in traffic jams. Such losses have a significant influence on the economy, affecting job creation, employee paycheck management, and expansion of businesses. Furthermore, due to unethical drivers' behavior of flaunting traffic rules by speeding up and overlapping, Nairobi's transport sector is often plagued with accidents. This costs the economy not only a healthy workforce, but injured patients are a burden to the health system.

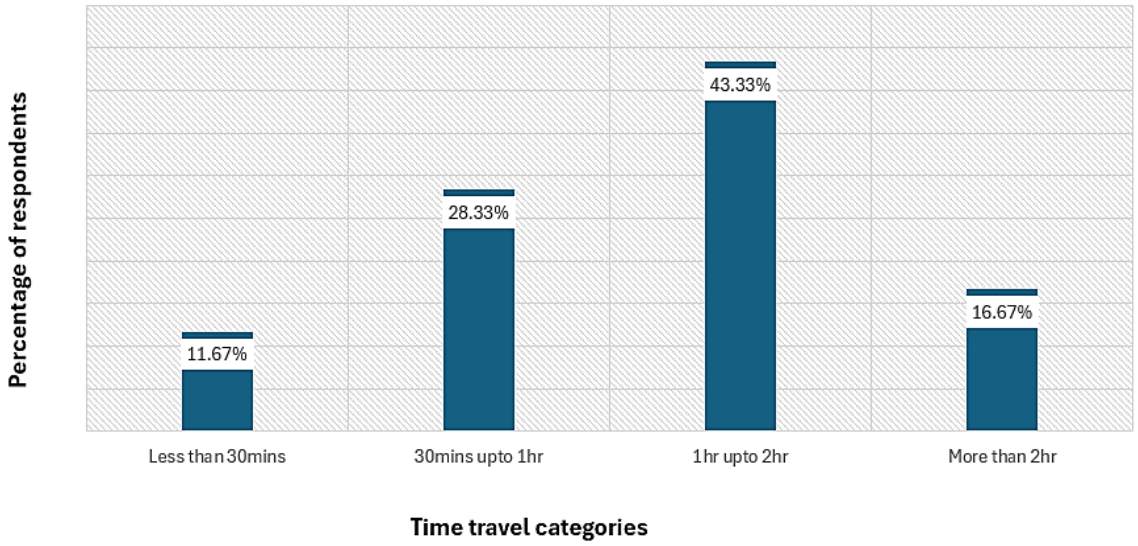

Figure 7. Commuter responses on the average time taken to travel from one area to another in Nairobi. Source: Own study.

Figure 7 above indicates that 43.33% of respondents spend between one and two hours traveling from one point to another. This reflects notable inefficiencies within Nairobi's transport system. This pattern clearly highlights the effects of congestion and infrastructural limitations, which contribute to prolonged travel times. As a result, commuters experience persistent mobility challenges, including delays and reduced travel reliability.

6.3. Environmental implications

The transport sector is a major contributor to environmental pollution not only in Kenya but also globally. Several forms of pollution are caused by this sector of the environment. These forms of pollution are intertwined, and in addition to the unwillingness to improve it can only increase. These forms of pollution are as follows:

- Air Pollution.
- Noise Pollution.
- Water and Land Pollution.
- Encroachment of Green Spaces.

6.3.1. Air Pollution

According to Statista, road transport is one of the largest producers of greenhouse gas (GHG) emitters. By 2021, road transport contributed to a total of 12% of these gases, making it the second largest contributor to global emissions after coal power. Furthermore, the study elaborates that the primary source of transportation emissions is light-duty vehicles, such as passenger cars (Statista Research Department, 2024). In Kenya, high vehicle emissions from old and poorly maintained public transport vehicles contribute significantly to air pollution.

The increase in the number of vehicles and the reliance on petrol-fueled matatus and buses in the public transport sector in Nairobi serves to only amplify the release of greenhouse gases. The high concentration of air pollutants, particularly particulate matter, is attributed to the large number of vehicles on the roads, deteriorating road conditions, and poor vehicle maintenance. The study highlights that these factors contribute significantly to air pollution, exacerbating its impact on public health and the environment (Wanjiku, 2023).

Traffic congestion further increases the environmental impact because vehicles idling in traffic emit pollutants longer. Air pollution is equally concerning, with dust from unpaved or deteriorated roads in Nairobi city and satellite towns adding to the pollution by particulate matter. During the dry seasons, fine dust is airborne and contributes to poor air quality. According to IQAir, the main contributors to PM2.5 pollution in Nairobi include vehicle emissions. Many vehicles, motorcycles, and trucks are older models, and emit higher levels of pollutants due to less efficient combustion processes (IQAIR,2025). Long-term exposure to PM2.5 there is an increase in the risk of people developing respiratory conditions such as asthma and bronchitis. The risk only increases further among vulnerable groups such as children and the elderly. (Kinney et al., 2011). In 2012, according to a report by the World Health Organization (WHO), air pollution-related diseases were responsible for approximately seven million premature deaths worldwide (World Health Organization, 2014).

6.3.2. Noise pollution

Due to traffic congestion, overcrowded bus stations, and narrow streets, drivers frequently honk while conductors shout to attract the attention of potential passengers. In addition, old vehicles, particularly buses and matatus, often play loud music and have revving engines, further contributing to noise pollution. This significantly disrupts urban life in the Nairobi Metropolitan Area, leading to increased levels of stress among residents.

6.3.3. Water and Land Pollution

Oil leaks and the improper disposal of vehicle maintenance waste significantly contribute to contamination of water bodies in the Nairobi Metropolitan Area, posing severe risks to aquatic ecosystems and public health. Many garages that serve matatus are located along riverbanks, where oils, paints, and other hazardous materials are often washed into the rivers during maintenance activities. These practices, combined with inadequate waste management systems, exacerbate pollution levels. The absence of stringent law enforcement allows such environmentally harmful practices to persist unchecked, further degrading water quality and threatening biodiversity. Notable examples are the Nairobi and Ngong rivers, which were once vital ecological resources but have become heavily polluted due to the careless disposal of toxic substances.

6.3.4. Encroachment of green spaces

The expansion of informal transport infrastructure often results in the encroachment of green spaces and public lands, leading to significant environmental consequences. Such encroachments reduce urban biodiversity and limit the natural absorption capacity of pollutants, exacerbating air and water pollution.

7. Recommendations

To address Nairobi's transport challenges, several solutions and interventions are recommended:

- Nairobi Metropolitan can construct a BRT system that will enhance fast and reliable transit services to its mass population. Example of a city that has implemented BRT systems is Bogota, Columbia. This city has shown that BRT systems can change the dynamics of commuter transport in populated cities. According to the Energy Sector Management Assistance Program (ESMAP) (2009), Bogotá's TransMilenio system has significantly reduced travel times by 32% overall and improved accessibility for millions of commuters, accident rates by 92%, fuel savings by 47%, and emission reduction by 40%.
- Due to global shifts to modern electric buses, Nairobi can take this early advantage and be among the first cities to gradually transition to electric buses from Matatus. However, there is a need to invest in clean energy infrastructure, such as charging stations. Cities like Shenzhen, China, have become global pioneers in adopting green transport solutions by transitioning to an entirely electric bus fleet. According to a case study by the International Energy Agency (IEA) authored by Berlin, Zhang, and Chen (2020), by 2017, Shenzhen was the first city in the world to successfully electrify approximately

17,000 of its buses. This transition has led to a significant reduction in greenhouse gas emissions.

- With the knowledge of Smart city solutions for mass transit, Nairobi can easily develop integrated mobility systems between different modes of transport. This can also be supported by the advancement of technology in mobile applications thereby taking advantage of unified ticketing systems and real-time information platforms.
- To easily decongest the city center, the management can introduce congestion fees in the city center. This will serve a dual purpose: reducing traffic in the city by discouraging private cars into the CBD and the city authority will earn revenue.
- There is a need for the expansion or construction of a well-organized bus and matatu termini with designated parking and boarding areas in the city and its satellite towns.
- Roads and streets should be expanded to eliminate bottlenecks that cause traffic congestion and vehicle interlocking.
- Solutions can also come from the implementation of technology-driven enforcement of traffic laws and route allocation to curb illegal operations and corruption.

Therefore, Nairobi city authorities should consider expanding non-motorized infrastructure. This will reduce overreliance on public transportation and alleviate strain on the transport system. An example is Copenhagen, Denmark, which is renowned for its extensive cycling infrastructure and pedestrian-friendly urban design. The city has achieved remarkable success, with 49% of all trips to work or school made by bicycle—up from 35% a decade ago. This progress is attributed to sustained municipal investment, with the city allocating more than €40 per capita annually to develop and maintain its cycling infrastructure (Thoem, n.d.).

8. Conclusions

According to a report by the United Nations, 55% of the world's population resides in urban areas, a figure projected to rise to 68% by 2050 (UN, 2018). This rapid urbanization is expected to place increasing pressure on public transport systems, as is already evident in the Nairobi Metropolitan area. The findings of this research study demonstrate that Nairobi's commuter transport system is facing serious challenges. The challenges are a result of a combination of issues, namely, infrastructural limitations, behavioral patterns, and systemic inefficiencies. All these contribute to congestion, extended travel times, and reduced service reliability.

The fact that a significant proportion of commuters experience prolonged travel durations or delays reflects the broader impact of congestion and inadequate infrastructure on daily mobility. These conditions not only affect individual commuters through time wastage and increased costs but also have wider implications for national productivity. As such,

the challenges facing Nairobi's transport system are comparable to those experienced in many other developing nations' cities.

It is therefore of critical importance to have a coordinated policy intervention focused on upgrading transport infrastructure, strengthening institutional capacity, and expanding integrated mass transit systems to meet growing urban demand. Drawing from global best practices and grounded in local research, the study emphasizes the importance of strategic reforms, sustained investment, and strong political commitment in transforming Nairobi's transport sector. A multi-stakeholder approach involving international partners, government agencies, private sector actors, and local communities is essential for ensuring the effective implementation and long-term sustainability of transport initiatives.

An improved public transport system has the potential to enhance commuter experience while supporting broader socio-economic development and generating positive externalities. Notably, a well-functioning transport sector contributes to improved public health by reducing stress, limiting exposure to pollution, and lowering the incidence of road-related accidents, thereby fostering a healthier and more productive population. Furthermore, given that the transport sector is a major contributor to environmental pollution, the development of efficient and sustainable transport systems significantly reduces emissions and promotes environmental sustainability. Globally, as cities strive to optimize transport systems' performance, the overall burden of environmental pollution can be significantly reduced.

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DEVELOPMENT OF THE SOCIAL BOND MARKET IN THE EUROPEAN UNION IN YEARS 2020-2024: ANALYSIS OF TRENDS AND PROSPECTS

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Purpose: The study aims to analyze the concentration, dynamics and structural characteristics of the social bond market in European Union countries between 2020 and 2025, focusing on the number and value of issuances, issuer type and geographic distribution.
Design/methodology/approach: The research combined qualitative and quantitative methods. A critical review of literature on sustainable finance and social bonds was first conducted. Empirical analysis was based on data derived from the Environmental Finance Data (EFD) database. It assessed market concentration and analysed issuance dynamics and sectoral distribution. The study also employed the synthesis method.
Findings: The analysis shows that the EU social bond market was highly concentrated both in terms of issuance value and number of issuers. France consistently held a dominant position, while Germany, the Netherlands, Italy and Spain played secondary but significant roles. Two distinct phases were identified: growth in issuance values from 2020 to 2022, followed by a decline from 2023 to 2025. Issuances were primarily led by public sector entities (agencies), with financial institutions contributing a high number of issuances.
Research limitations/implications: The short temporal horizon of the analysis, resulting from the gradual development of the social bonds market in the European Union.
Practical implications: Findings provide insights for policymakers, market regulators and financial participants regarding development trends, issuer behavior and the contribution of social bonds to financing social needs.
Originality/value: This research is among the first to provide a detailed analysis of the EU social bond market over 2020-2025, highlighting geographic and sectoral concentration, market dynamics and challenges, thus contributing to the literature on sustainable finance and ESG debt instruments.
Keywords: social bonds, sustainable finance, sustainable debt instruments.
Category of the paper: Research paper.

1. Introduction

In the face of growing civilizational challenges and regardless of the level of economic development achieved, countries are confronted with significant social challenges. Consequently, the importance of financial instruments that combine investment objectives with positive social impact is increasing. The response to these global issues is the development of sustainable finance, within which social bonds (SIBs) occupy a prominent position.

The issuance of social bonds primarily aims to finance projects that strengthen social cohesion, social capital and well-being, reduce exclusion and problematic behaviors and enhance societal resilience in times of crisis. Consequently, this instrument combines financial objectives with clearly measurable social impact. Social bond issuances are primarily directed at financing specific infrastructure and social service projects (housing, education, healthcare, inclusion) and strategically, at achieving ESG/SDG objectives, fulfilling CSR commitments and enhancing issuer credibility. A crucial aspect is linking the issuance to clearly defined, measurable social goals, coupled with transparent reporting to ensure tangible social impact. Velez-Valencia et al. (2026) argue that SIB investors are guided primarily by organizational learning, generating social impact and strategic alignment with core business objectives, rather than financial gains. They highlight that SIBs offer a pathway to achieving corporate social responsibility (CSR) and environmental, social and governance (ESG) objectives by aligning private investments with public goals. Based on signaling theory, they demonstrate how SIBs serve as credible signals of institutional commitment to sustainable development, identifying the role of SIBs in promoting public-private partnerships through signaling and investor approaches to environmental and social challenges in emerging economies. Indriastuty (2025) asserts that social bond issuance, oriented beyond mere profit, is implemented through projects expected to produce positive social outcomes, helping issuers address social inequalities according to the concept of socio-economic well-being. He notes that, to achieve economic equality - particularly in programs aimed at accelerating access to housing - social bonds can serve as a capital market instrument, providing an alternative to traditional housing finance.

Social bonds are a form of thematic instrument in the capital market, whose proceeds are used to finance or refinance economic activities of a social nature. Zaheeruddin (2022) highlights that SIBs are among the newest financial market instruments, grounded in sustainable finance principles. Funds raised through social bond issuances are allocated to projects with positive social impact. These outcomes relate to affordable infrastructure or low-cost essential services. Affordable infrastructure may include low-cost public transportation, reasonably priced electricity, safe and sufficient water supply and improved sanitation services. Low-cost essential services encompass housing, healthcare, education and food security. His research indicates that the majority of social issues addressed by social bond proceeds include improving conditions in crisis-affected regions (e.g., COVID-19 and other crises),

subsidized housing, maintaining and creating jobs, supporting farmers, education, poverty alleviation, robust infrastructure and innovation, climate action, animal welfare and promoting peace and justice.

Despite the growing interest in the social bond market, there is still a lack of in-depth analyses regarding the market structure of these bonds in European Union countries and their implications for allocative efficiency, cost of capital and investment risk profile. Previous studies have mainly focused on: the lack of regulation in this segment of sustainable finance, the need to refine definitions, reporting standards and enforcement mechanisms to reduce the risk of "social washing" and genuinely support social objectives (Lenzi, 2020); differences between SIBs and other thematic bonds (Barembruch, 2024); or the characteristics of issuance objectives (Sidorenko, 2023). Meanwhile, the degree of concentration in the social bond market in the European Union is a significant parameter for its assessment, which has so far been insufficiently explored and represents an important research gap.

The aim of this article is to assess the development of the social bond market in European Union countries in 2020-2025 across the following dimensions: 1) value-based (the total value of social bond issuances), 2) quantity-based (the number of social bond issuers) and 3) geographical (the issuing country). The analysis period covers full calendar years and issuances denominated in EUR.

The study tests the following hypotheses:

H1: From 2020 to 2025, social bond issuances in EU countries were characterized by a high level of concentration in terms of both issuance value and number of issuers.

H2: From 2020 to 2025, the value of social bond issuances increased.

H3: From 2020 to 2025, the concentration of social bond issuers was primarily in the financial sector.

H4: Between 2020 and 2025, France served as the leading market in terms of issuance value compared to other EU countries.

The results of the analysis demonstrated a high concentration of the social bond market in the EU, both in terms of value and the number of issuers, with a clear dominance of a single country. It was shown that the largest issuers of social bonds by issuance value were France and Germany. From a sectoral perspective, the findings confirmed that issuer concentration was highest in the financial sector.

The conducted study has practical value for both public policymakers and financial market participants. The results of the social bond market concentration analysis are particularly useful for regulators and supervisory institutions, as they support the design of policies conducive to the development of financing for social needs. They also provide knowledge for issuers considering entering the SIB market. From the investors' perspective, the study offers information on the degree of concentration, which may influence risk assessment, pricing efficiency and portfolio diversification opportunities. The assessment of this market responds

to the growing demand within the academic community for in-depth research on alternative sources of financing for social needs.

The further structure of this article is as follows: literature review, research method, research results, discussion and conclusions.

2. Literature review

For over a decade, awareness of environmental and social challenges aligned with sustainable development strategies has been growing among all participants in the economic environment. These challenges create a demand for capital whose expected value exceeds the capacity of public financing. It is therefore evident that a substantial scale of investment in this area over the long term must be financed through private sector funds obtained in the financial market.

A key tool enabling the financing of pro-social activities is social bonds, which are used to fund projects aimed at achieving both positive social and financial outcomes (Sereleas, Stutt, 2003). They support sustainable development goals by improving social outcomes in policy areas that are underserved by conventional public service (Scheyvens, Banks, Hughes, 2016). The European Commission defines social bonds as engagements, typically by private investors, financing social services provided by a service provider implementing a social program, in exchange for a commitment from the public sector to repay the principal and a rate of return if the program achieves pre-defined social objectives (Puszer, 2019). This definition highlights the mechanism of social impact bonds (SIBs), which are often equated with social bonds in the literature. However, clear differences exist between them. Social bonds are debt securities issued by governments or corporations to raise capital, the proceeds of which are used to finance social projects (Węgrzyn, Molenda, 2024). They belong to the category of thematic bonds, which also includes green bonds, blue bonds and sustainable bonds, whose funds are used in accordance with ESG criteria.

Unlike traditional bonds, social bonds are characterized by the explicit definition of pro-social objectives in the terms of issuance, providing investors with assurance that funds will be used for the designated purposes. This is particularly important because, in the informational documents of traditional bond issuances, specifying the purpose of the issuance is not mandatory. Issuers are also required to demonstrate a specific and measurable impact and to report regularly on the allocation of funds and the achieved social impact (Barembruch, 2024). Social bonds provide several benefits:

- enhancing the issuer's reputation and positioning them as an innovative entity committed to ESG objectives,
- attracting investors interested not only in financial returns but also in positive social impact,
- facilitating the financing of investment projects that may face difficulties in obtaining traditional capital (Barembruch, 2024).

The literature also emphasizes "soft" success factors for social bond issuance, including strong alignment with the issuer's ESG/CSR strategy and the desire to signal commitment to SDGs (Becker et al., 2025), as well as high information transparency and reliable outcome data, which are essential for attracting institutional investors and mitigating reputational risk (Wang et al., 2025).

Multiple stakeholders are engaged in SIBs, each with different motivations for participation. All participants pursue their social objectives while aligning expectations to achieve social outcomes that generate sufficient savings to provide investors with returns. Social impact investors are motivated by a wide range of factors, often related to making investments consistent with their values, particularly those prioritizing social change and the creation of public value. Therefore, investors are attracted to SIBs for the same reasons they pursue social investments: social and financial benefits. However, SIBs also offer the opportunity to invest in entrepreneurial solutions that investors may not be able to include in other investment portfolios. Institutional investors are partially motivated by the chance to fund entrepreneurial solutions they historically could not support. Foundations investing in SIBs are motivated by the possibility of program-related investments that allow them to recoup funds and allocate them to other projects, as well as the opportunity to enhance reputation. Service providers, typically social enterprises, are motivated to participate because SIBs provide a stable, long-term revenue source, enable them to achieve outcomes, encourage innovation and creativity and allow them to focus on what they do best. Meanwhile, the commissioner (result financer) is often motivated by savings that can be realized in delivering social services, risk reduction if a service fails and societal cost-benefit advantages over the long term if outcomes are successful. SIBs are positioned between achieving financial returns and contributing to community welfare. One further driver is the potential for competitive advantage. For instance, social enterprises, financial intermediaries and advisors view SIBs as a strategy to enter new markets and gain a competitive edge (Care et al., 2020).

Issuing social bonds may provide access to new capital and strengthen the issuer's ESG profile, but it involves high complexity, costs, reputational risk and the potential for "social washing". Nevertheless, social bonds allow financing social projects without immediately burdening the public budget or the issuer's balance sheet. SIBs primarily enable public entities to access larger funds for preventive actions and early interventions in areas at risk of social problems. Furthermore, the public entity pays only for successful projects, allowing for public fund savings by rewarding effective interventions. Service providers are incentivized to

generate measurable value—the better their performance, the higher the remuneration. The underlying idea of social bonds supports continuous evaluation of social programs, identifying which are effective and which should be discontinued. Public entities pay only for interventions that work in practice, enabling more effective support for preventive programs rather than merely addressing social problems (Kraszewski, 2015; Puszer, 2017; Matos, Christopoulos, 2023).

Social bonds also facilitate the creation of innovative instruments and scaling of programs, as pressure on results and private investor engagement can foster innovation, better management and more intensive support for program participants, sometimes translating into improved employment and income outcomes (Hevenstone et al., 2023). They may enhance corporate governance and reporting, as measuring social outcomes strengthens monitoring systems, transparency and attractiveness for ESG investors (Demuynck, Van Dooren, 2024). SIBs enable effective allocation of donor funds, as rigorous program evaluation ensures social impact is achieved more effectively than through typical charitable actions. There is also the potential for the repeated use of investor funds (leverage effect), as funds can finance similar or other projects. Social bond programs contribute to the establishment of a new, systematic and sustainable source of financing for NGOs engaged in social projects (Mulgan et al., 2011).

Social impact bonds (SIBs), in contrast, do not constitute a classical type of bond and are not recognized as financial instruments under legal regulations. They represent a specific form of social financing, whereby funds are raised from investors to provide service providers with capital for delivering social services (A Legal Road Map…, 2014). The structure of SIBs is based on a "payment-by-results" (PbR) agreement between various institutions (Warner, 2013). These agrrements are aimed at achieving defined social outcomes, under which the payer does not compensate the service provider for task completion but for achieving pre-defined results (Ragin, Palandjian, 2013). This mechanism contributes to generating savings in public budgets (Rizello, Kabli, 2020). These agreements are most often civil law contracts, defining the rights and obligations of all parties involved, and as such, they cannot be traded on public or private markets.

The specificity of this mechanism lies in the fact that private investors provide funds for a social project and the return on investment depends on achieving the specified social outcomes. Since achieving social objectives in the short term is challenging, desired results are often realized over a longer period, making the maturity of SIBs longer than that of traditional bonds (Mikołajczak, 2023).

The practical implementation of the "payment-by-results" mechanism requires three key elements:

- payments are made only upon achieving specific, intended outcomes,
- the service provider has the discretion to choose the method of task implementation,
- remuneration is contingent upon independent verification of achieved results by an evaluator (Perrin, 2013).

The SIB issuance process involves several stages. First, the government or local authority identifies social problems to be addressed with private investor financing. The second stage involves the public entity entering into a contract with an intermediary, whose task is to provide funding for the program's operation by attracting social investors. The intermediary must be credible and efficient and program objectives must be achievable to attract market interest. After funds are allocated and social services delivered, an independent evaluator measures program outcomes, which determine payments from the budget (Becchetti, Pisani, Salustri, Semplici, 2021). If the project achieves planned outcomes, investors receive the return of capital plus the premium specified in the issuance terms; otherwise, they face the risk of losing their investment. Payments are made from budgetary savings generated by delivering social services with private capital. In summary, public funds are allocated only to activities with measurable outcomes and the risk of program failure can be transferred to the private sector.

Attention may also be drawn to key structural and regulatory prerequisites of issuance conditions. One of these is the clear and precise definition of the use of proceeds, as funds must be allocated to eligible projects in accordance with the ICMA "Social Projects" standard (e.g., affordable housing, employment, health, education, food, social infrastructure) for clearly defined vulnerable groups (the poor, marginalized, migrants, unemployed) (Park, 2018). Special attention is given to project selection and evaluation criteria, which should be measurable and present quantitative indicators of social impact, while the project selection process must align with the issuer's framework. According to the impact management principle, proceeds should be recorded in a segregated account or internal system ensuring allocation exclusively for social purposes. Reporting and transparency are also prerequisites for issuance credibility, requiring regular reports on fund utilization and achieved social outcomes (Sidorenko et al., 2023).

The social bond financing mechanism can be analyzed in both task-related and financial dimensions (Marchewka-Bartkowiak, Wiśniewski, 2015). The task-related dimension concerns the relationship between the public sector and an intermediary operating on commercial or non-profit principles. The public entity defines the social task and specifies outcomes for a defined social group, acting as the payer committed to remunerating the intermediary once the task is completed and the planned outcomes are achieved. In the financial dimension, public funds cannot be the sole source of financing because the intermediary is remunerated ex post. Using the guarantee provided by the public sector, the intermediary introduces an alternative funding source via social bonds, based on the "payment-by-results" concept. Investors are aware that capital return and bond profitability depend on achieving the intended social outcome.

Private capital for social bonds may come from various sources. Based on investor type, social bonds can be classified as follows (Mulgan et al., 2011):

- Philanthropic SIBs – investors are private donors, foundations, or charitable institutions. These investors accept higher risk than commercial investors and strategically engage in creating public value for a specific social group, allowing public entities to transfer risk and reduce the use of public funds.
- Public sector SIBs – investors may be local authorities providing capital for tasks under central government competence. The central authority contracts for social outcomes and pays upon achievement. This model is relatively easy to design and implement, with fewer investors and lower transaction costs, but requires precise definition of issuance terms and success metrics.
- Commercial SIBs – commercial investors such as banks, investment funds, pension funds, or large corporations. Financial institutions require robust risk assessment and return estimation methodologies to treat the investment as a financial asset.
- Hybrid SIBs – investors from multiple sectors, requiring trust-building between parties with different objectives, perspectives and programs.

The SIB contract structure distributes the risk of achieving social outcomes among the public entity, intermediary and investors. The public entity bears the "payment-for-results" risk, which could be difficult to manage through traditional administrative methods. Intermediary and investor risks are interrelated: the intermediary cannot deliver the social task without investor funding, while investors cannot be certain of capital return and profits if the intended outcomes are not achieved (Marchewka-Bartkowiak, Wiśniewski, 2015).

Despite the aforementioned benefits, the use of social impact bonds also involves risks and weaknesses. Criticism (Pratt, 2013) and warnings (Keohane, Mulheirn, Shorthouse, 2013) regarding their limitations are also noted in the literature. Commonly recognized limitations include (OECD, 2020):

- the risk of losses for private investors in the event of program failure, which creates a need for investors to exert greater influence over service providers,
- social impact bonds cannot be applied where it is impossible to define objectively verifiable measures of social impact,
- impact measures are not always verifiable or reflective of project success,
- difficulties in selecting indicators for project outcome evaluation,
- the necessity of hiring an independent evaluator, which generates additional costs.

A lack of precise definition of social cohesion and uncertainty regarding remedial measures in case of unmet social obligations entails significant "social washing" risk, i.e., the misuse of the "social" label without tangible impact (Lenzi, 2020). The literature also notes high costs and complexity due to multi-party contracts, outcome measurement and oversight generating significant transaction costs that may reduce financial benefits. SIB issuance costs can be categorized into two broad groups: costs similar to those of a traditional issuance and costs

arising from structuring the social intervention as a bond, including transaction costs associated with safeguards against potential contractual risks. Examples include anticipated issuance-related costs, project management and advisory fees, evaluator and validator fees, auditing and legal fees, fiscal service costs, one-time financial advisory fees, stakeholder meeting expenses and maintaining a small contingency reserve for unforeseen project expenditures (Pandey et al., 2018). Care et al. (2020) identify various types of risks, with the most important being:

- Implementation risk – concerning project feasibility, requiring clear pilot data and a well-documented history of social interventions.
- Financial risk – related to investor repayment conditions, ensuring sufficient funds are available if the project succeeds.
- Intermediary risk – risk that the SIB intermediary fails to fulfill obligations, hindering achievement of social and financial objectives.
- Operational risk – risk of program delays during the design phase.
- Political risk – concerning the capacity and willingness of the host government to meet SIB commitments and not obstruct other parties, including delays or renegotiations of legal frameworks.
- Reputational risk – related to potential negative public perception or criticism of the social bond issuer.
- Impact risk – the possibility that expected social outcomes are not achieved.
- Intervention model risk – risk that chosen social service interventions fail to produce the intended outcomes.
- Program failure risk – related to the possibility that the funded social project does not achieve its intended outcomes.
- Evaluation risk – the evaluation may not accurately measure whether outcomes were achieved, due to poor design or implementation.
- Default risk – risk that the ultimate payer (usually government) fails to repay investors if outcomes are achieved.
- Liquidity risk – payments to SIB investors may occur over extended periods.
- Macroeconomic risk – arising from adverse changes in key macro indicators (inflation, exchange rates, interest rates) affecting the project's cash flows necessary to pay investors and lenders.

Social bonds offer real potential for mobilizing capital, fostering innovation and improving outcome measurement. At the same time, they require robust standards, high transparency, careful project selection (preferably simple, measurable interventions) and conscious management of costs and risks. Despite the existing barriers, the potential for developing this form of social task financing at the global level remains indisputable. Poland should therefore actively engage in this market, particularly given the importance of meeting ESG-related obligations, which emphasize the measurable social impact of implemented initiatives rather than merely their execution using public funds.

3. Research method

The research objective adopted in the article determined the selection of the study sample. The study involved the identification of all social bond issuances (Social Bonds) in European Union countries between 2020 and 2025, denominated in euros (EUR). It should be emphasized that during this period there were also social bond issuances conducted in other currencies, which were not the subject of the present study. The empirical verification was conducted based on data obtained from the Environmental Finance Data database (efdata.org). Based on the collected data, an analysis of issuances was conducted, detailing the issuing country, the number of issuance, the issuance value and the issuer type. The article employed the method of in-depth literature review, covering both domestic and international literature, the cause-and-effect analysis method, as well as the synthesis method. The analysis employed chain dynamics indicators and structural indicators. Dynamic analysis, also referred to as horizontal or time analysis, is used to determine the direction, pace, and intensity of changes in individual financial phenomena (financial variables) over a given period. The chain dynamics was calculated using the following formula:

$$d_z = \frac{A_t}{A_{t-1}} - 1 \; dla \; A_{t-1} \neq 0 \tag{1}$$

where:

d_z - chain-based dynamics of the i-th item in the period, expressed as a percentage or fraction,

A_t - value of the i-th item in period t,

A_{t-1} - value of the i-th item in period t-1.

The application of the structural analysis method involves determining the share of specific items within a certain aggregate financial value. The formula for calculating structural indicators is expressed as follows:

$$S_i\% = \frac{A_i}{\mathrm{A}} \cdot 100\% \tag{2}$$

where:

$S_i\%$ - structural indicator for the i-th item, where i = 1, …, expressed as percentage,

A - aggregate value for the i-th item,

A_i - value of the i-th item included in the aggregate value A.

4. Research results

The conducted analysis made it possible to extract the most important information regarding social bond issuers in the years 2020–2025. Table 1 presents a synthetic summary of issuance activity in the social bond market in European Union countries between 2020 and 2024, including both the number of issuers and the total issuance value expressed in million EUR.

Table 1.
The number of issuers and the value in mln EUR of social bond issuances in European Union countries in 2020-2024

Country	Number of issuers	Issuances value in mln EUR
Austria	1	500,00
Belgium	3	9 492,20
Finland	2	1 250,00
France	21	164 384,04
Germany	18	26 745,00
Ireland	2	2 250,00
Italy	13	14 805,49
Luxembourg	1	21,27
Netherlands	3	21 030,00
Poland	1	750,00
Portugal	2	1 300,00
Spain	4	11 750,00
Sweden	2	3 150,00
Total sum	**73**	**257 428,00**

Source: own calculation based on EFD data.

In the analyzed period, a total of 73 social bond issuers were identified and the total value of completed issuances amounted to 257,428.00 million EUR. The collected data also indicate significant variation among the Member States in terms of the scale of utilization of this financial instrument.

The clear market leader was France, which recorded the highest number of issuers (21) and by far the largest issuance value – 164,384.04 million EUR. This indicates that the French market concentrated a significant portion of the total issuance value in the EU, confirming its dominant position in financing social projects through debt instruments. The second country in terms of the number of issuers was Germany (18); however, the issuance value there was relatively lower, amounting to 26,745.00 million EUR. Italy also belongs to the group of countries with a distinctly developed social bond market, with 13 issuers and a total issuance value of 14,805.49 million EUR. The Netherlands held a significant position in terms of issuance value (21,030.00 million EUR), despite having a relatively small number of issuers (3). A similar situation occurred in Belgium, where, with 3 issuers, the total issuance value reached 9,492.20 million EUR. This may indicate market concentration in the hands of a limited number of large entities issuing instruments with high nominal values. In the remaining countries, the market scale was moderate or limited. In Spain, 4 issuers were

active, with a total issuance value of 11,750.00 million EUR. Sweden and Finland had a similar number of issuers (2 each), with the issuance value in Sweden (3,150.00 million EUR) exceeding that in Finland (1,250.00 million EUR). Ireland and Portugal also had 2 issuers each, with issuance values of 2,250.00 million EUR and 1,300.00 million EUR, respectively. Compared to other countries, particularly low issuance activity was observed in Austria, Poland and Luxembourg, where only one issuer was identified in each. However, it is worth noting that the issuance values in these countries were varied: from 21.27 million EUR in Luxembourg, through 500.00 million EUR in Austria, to 750.00 million EUR in Poland.

In summary, the data presented in the table indicate a strong concentration of the social bond market in the EU, both in terms of the number of issuers and the issuance value, with France clearly dominating. At the same time, it is noticeable that in some countries (e.g., the Netherlands, Belgium) high issuance values were generated by a small number of issuers, which may suggest a greater share of large-scale entities or the dominance of public and quasi-public issuances. Conversely, in many countries, this instrument remained a marginal source of financing social activities during the analyzed period.

Figure 1 presents the total value of social bond issuances in European Union countries from 2020 to 2025, as well as the year-on-year dynamics of change. The data allow for an assessment of both the scale of utilization of this financial instrument during the analyzed period and the direction and pace of changes in issuance values.

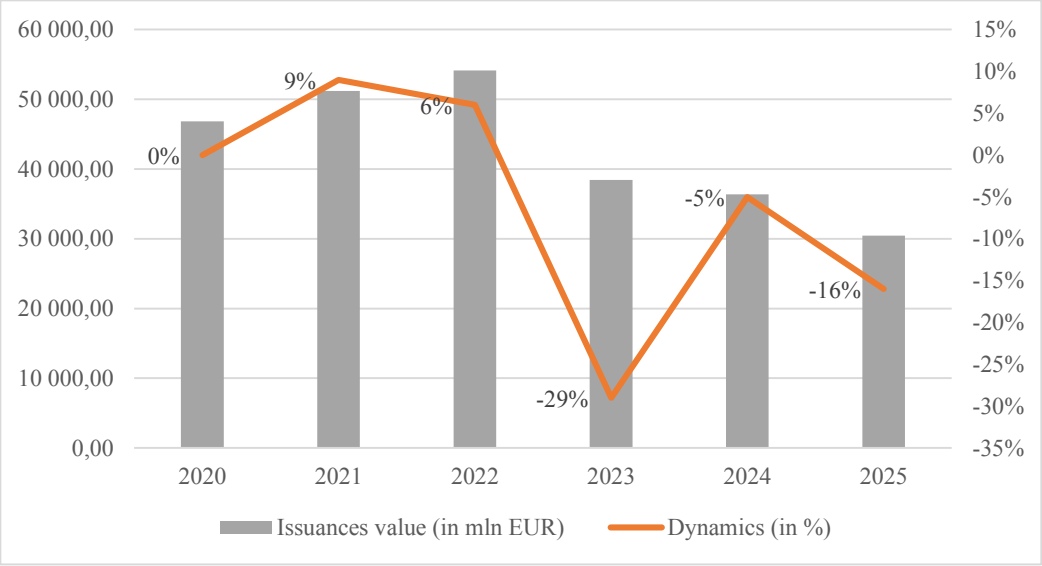

Figure 1. Total value in mln EUR of social bond issuances in European Union countries in 2020-2025 and their year-on-year change dynamics (in %).

Source: own calculation based on EFD data.

In 2020, the value of social bond issuances amounted to 46,840.00 million EUR, serving as a reference point for subsequent years. In 2021, the issuance value increased to 51,183.79 million EUR, representing a 9% growth compared to the previous year. The upward trend continued in 2022, when the issuance value reached 54,125.22 million EUR (an increase of 6% compared to the previous year). This indicates that in the first three years of the analyzed period,

the social bond market in the EU developed steadily, increasing the total capital raised. However, from 2023 onward, a clear reversal of the trend occurred. The issuance value decreased to 38,454.19 million EUR, reflecting a sharp decline of 29% compared to 2022. The following years confirmed the continuation of the downward trend: in 2024, the issuance value fell to 36,364.80 million EUR (a decrease of 5%), while in 2025, the decline deepened to 30,460.00 million EUR, corresponding to a -16% change relative to the previous year.

In summary, the data analysis indicates two clearly distinct phases in the development of the social bond market in the EU. The years 2020–2022 were characterized by moderate but consistent growth in issuance values, whereas the period 2023–2025 saw a sharp correction and a gradual reduction in the scale of issuances. Ultimately, in 2025, the issuance value was significantly lower not only compared to the maximum reached in 2022 but also below the baseline year of 2020, which may indicate a weakening of issuance activity and a decline in the importance of this instrument within the structure of financing social objectives in the EU during the final part of the analyzed period.

Table 2 presents the distribution of social bond issuance values in the European Union from 2020 to 2025, broken down by the countries issuing in each year. The compilation allows for the identification of both market leaders and changes in the geographical structure of issuances over time.

Table 2.
Social bond issuances value in mln EUR in the European Union by country and year (2020-2025)

Year	Country	Issuances value in mln EUR
2020	France	35 070,00
	Netherlands	3 000,00
	Spain	2 500,00
	Germany	2 220,00
	Italy	1 750,00
	Belgium	1 000,00
	Sweden	700,00
	Finland	600,00
Total sum		**46 840,00**
2021	France	35 172,80
	Netherlands	4 000,00
	Germany	3 675,50
	Spain	2 500,00
	Italy	2 155,49
	Sweden	1 250,00
	Portugal	800,00
	Belgium	630,00
	Austria	500,00
	Finland	500,00
Total sum		**51 183,79**

Cont. table 2.

2022	France	36 387,75
	Germany	6 043,20
	Netherlands	4 905,00
	Spain	2 000,00
	Italy	1 600,00
	Belgium	1 468,00
	Ireland	1 000,00
	Sweden	700,00
	Luxembourg	21,27
Total sum		**54 125,22**
2023	France	22 398,49
	Germany	4 355,70
	Netherlands	3 325,00
	Belgium	3 025,00
	Italy	1 650,00
	Spain	1 500,00
	Ireland	750,00
	Poland	750,00
	Sweden	500,00
	Portugal	200,00
Total sum		**38 454,19**
2024	France	15 780,00
	Germany	7 200,60
	Italy	5 050,00
	Netherlands	3 850,00
	Belgium	2 084,20
	Spain	1 750,00
	Ireland	500,00
	Finland	150,00
Total sum		**36 364,80**
2025	France	19 575,00
	Germany	3 250,00
	Italy	2 600,00
	Netherlands	1 950,00
	Spain	1 500,00
	Belgium	1 285,00
	Portugal	300,00
Total sum		**30 460,00**

Source: own calculation based on EFD data.

Throughout the entire analyzed period, France maintained a dominant position, being the largest issuer of social bonds in the European Union each year. Particularly high issuance values were recorded in 2020–2022 (over 35 billion EUR annually), which determined the high level of total issuance value in the European Union during those years. At the same time, in 2023, a significant reduction in France's issuance activity occurred (down to 22.4 billion EUR), deepening in 2024 (15.8 billion EUR), with a partial rebound in 2025 (19.6 billion EUR). This indicates that fluctuations in the EU market were largely a result of changes in issuance volumes in the French market.

The second group comprises countries with a relatively stable issuance presence, yet on a significantly smaller scale. This particularly applies to Germany and the Netherlands, which were active in all years covered by the analysis, with their issuances ranging from several to

several billion EUR annually. In the case of Germany, an increase in significance is visible in 2022-2024 (peaking at 7.2 billion EUR in 2024), followed by a decline in 2025 (3.25 billion EUR). The Netherlands, in turn, achieved its highest issuance values in 2022-2024 (up to 4.9 billion EUR), with a marked decrease in 2025.

The role of Italy also deserves attention, as it has systematically participated in the market since 2020, reaching its highest volume in 2024 (5.05 billion EUR). Spain and Belgium, in turn, represent markets with moderate but recurring activity, with Belgium standing out for a relatively high issuance value in 2023 (3.03 billion EUR), indicating periodic shifts in issuance activity among medium-sized countries.

The remaining countries (including Ireland, Portugal, Finland, Sweden, Poland, Austria and Luxembourg) were characterized by a low scale of issuance and limited continuity of activity, suggesting the marginal significance of these markets in social financing through debt instruments. Their share in the total issuance value of the European Union was supplementary and did not substantially affect the overall issuance volume in the EU.

In summary, the data from the table indicate a highly concentrated character of the social bond market in the European Union, with a clear dominance of France and a significant but secondary role played by Germany, the Netherlands and Italy. At the same time, the decline in issuance values observed in the EU during 2023-2025 should be interpreted as a result of reduced issuances in key countries, without sufficient compensation from the remaining member states.

Table 3 presents the number and value of social bond issuances in the European Union from 2020 to 2024, categorized by issuer type. Percentage shares of social bond issuances by issuance value and issuer type are presented on Figure 2.

Table 3.
Number and value in mln EUR of social bond issuances in the European Union in 2020-2024 by issuer type

Issuer type	Number of issuances	Issuances value in mln EUR
Agency	106	152 945,00
Corporate	17	10 640,00
Financial Institution	217	84 225,80
Municipal	35	9 617,20

Source: own calculation based on EFD data.

Figure 2. Percentage shares of social bond issuances by issuance value (in mln EUR) and issuer type in European Union countries in 2020-2025.

The analysis of the data presented in Table and Figure 2 indicates that between 2020 and 2024, the social bond market in the European Union was strongly dominated by public entities, categorized as agencies. These issuers were responsible for 106 issuances with a total value of EUR 152,945 million, accounting for 59% of the total market value. The value dominance of this segment suggests that social debt instruments were primarily utilized by institutions implementing social policy objectives or quasi-public projects of strategic importance.

At the same time, the financial sector played a significant role in terms of the number of issuances: 217 issuances with a total value of EUR 84,225.8 million, representing 33% of the market value. The concentration of issuances in this segment, despite a relatively lower value share, indicates that financial institutions carried out numerous smaller issuances, acting as capital intermediaries in the financing of social projects.

Corporate and municipal issuances had a limited share both in terms of number and value. Corporate entities carried out 17 issuances worth EUR 10,640 million (4%), while local governments were responsible for 35 issuances totaling EUR 9,617.2 million (4%). The low participation of these types of issuers points to the limited use of social bonds in the private and local sectors, which may result from regulatory or administrative barriers, or the limited availability of projects meeting social utility criteria.

The market structure described above indicates a high value concentration in the hands of public issuers, alongside a relatively dispersed number of issuances in the financial sector. This configuration suggests that the development of the social bond market in the European Union during the analyzed period was driven primarily by public institutions, while the potential of the private and local sectors remained largely underutilized.

The analysis of data on social bond issuances in the European Union from 2020 to 2025 also enabled the identification of the main areas for the use of proceeds. During the examined period, 17 primary categories of the used of proceeds were identified, as listed below:

- Affordable basic infrastructure.
- Affordable housing.
- Clean transportation.
- Covid-19 response.
- Eco-efficient products, production technologies and processes.
- Energy efficiency.
- Employment generation, including through the potential effect of SME financing and microfinance.
- Food security.
- Green buildings.
- Other eligible green categories.
- Other eligible social categories.
- Renewable energy.
- Socioeconomic advancement and empowerment.
- Sustainable management of living natural resources.
- Sustainable water management.
- Terrestrial and aquatic biodiversity conservation.
- Access to essential services.

The analysis indicates that social bonds functioned as a multidimensional instrument for financing projects of both social and environmental character. Initiatives aimed at improving quality of life and access to public services predominated, while simultaneously supporting activities related to environmental protection and sustainable development. These findings confirm that the proceeds were used in a diversified manner, combining the achievement of social objectives with investments in ecological efficiency and natural resource protection. This underscores the growing role of social bonds as a tool supporting sustainable development policy within the European Union.

5. Discussion

In the European Union, the concept of social bonds as instruments for financing social needs first appeared in February 2013 in the document "Social Investments for Growth and Cohesion, including the Implementation of the European Social Fund for 2014-2020". In this document, the European Economic and Social Committee highlighted that "social bonds should be considered as a potential solution, providing incentives for private investors to finance social programs by offering a public-sector return if the programs achieve positive social outcomes. The Commission will support Member States by facilitating the exchange of experiences". It should be emphasized that the EU does not yet have a distinct, comprehensive regulation specifically for social bonds; the market relies on general sustainable finance regulations, private standards, and national-level rules (Lenzi, 2020). Broader EU frameworks for the social economy and impact investing - such as the Social Business Initiative, Social Economy Action Plan, EuSEF, and ECSP - provide an institutional context for social bond issuance but do not define the instrument in detail.

Between 2020 and 2024, the EU social bond market developed within the broader trend of sustainable finance (GSSS: green, social, sustainable), and studies emphasize the rapid growth of social bond issuances, which is strongly dominated by a few countries and segments. In terms of the number of issuers, the EU social bond market is relatively fragmented and dominated by selected countries, primarily France, Germany, and Italy. Regarding issuance value, France exhibits clear dominance. This is corroborated by Węgrzyn and Molenda (2024), who demonstrate that the market was dominated by social bonds issued in France, including both sovereign and corporate bonds. The issuance value of these debt securities in France accounted for approximately 39,4% of global social bond issuance, confirming its leading position within the EU. Similarly, research by Lewandowski and Smoleńska (2023) indicates that the EU social bond market is highly concentrated in a few countries and among major issuers. The highest issuance values were observed between 2020 and 2022, which contributed to elevated issuance levels across the EU. Since 2023, issuance activity in France has decreased,

but it still maintains a leading position. Hajer (2020) emphasizes that Social Impact Bonds (SIBs) are deeply embedded in the international wave of neoliberal reforms in public sector management. His comparative studies suggest that the development of SIBs in France and Germany is more limited than in the United Kingdom or the United States, as strong traditions of solidarity and welfare states are less compatible with the logic of outcome-based contracts and private capital. Consequently, social bonds in France and other EU countries remain rather experimental and contested instruments rather than central pillars of the system. They combine the promise of innovation and new capital sources with real risks, including high costs, difficulties in measuring outcomes, and potential weakening of traditional social solidarity. Future policy decisions will depend on whether EU countries choose to further open social policy to market logic or strengthen classical, budgetary forms of social service financing.

Analysis of the direction and pace of issuance value changes indicates that two distinct phases characterized the EU social bond market between 2020 and 2025. The period 2020-2022 saw an increase in issuance value across the EU, whereas subsequent years were marked by a decline, with the highest value recorded in 2023. These results are not fully consistent with Węgrzyn and Molenda (2024), who, considering global issuance, reported a decrease in social bond issuance value from 2021. In contrast, Okhrimenko and Sytailo (2024) highlight strong growth in issuance, particularly between 2020 and 2022, for all EU sustainable finance instruments, including social bonds. Torricelli and Pellati note that prior to 2020, the social bond market was relatively small, with "sporadic" issuances, and that the breakthrough occurred in 2020, when global social bond issuance increased by approximately 420% compared to 2019, directly linked to the Covid-19 pandemic.

Assessment of social bond issuance by type of issuer between 2020 and 2025 indicates high value concentration among public sector issuers (agencies), with a relatively dispersed number of issuances in the financial sector. Węgrzyn and Molenda (2024) emphasize that among social bonds issued globally between 2012 and 2022, those issued by supranational organizations or national governments dominated (57,7%). Significant issuances, accounting for approximately 17,9% of global issuance value, were conducted by financial organizations, while social bonds issued by non-financial corporations represented 7,9%. Other prominent issuer groups included development banks (7,2%) and local government units (6,2%). It is important to note that significant social bond issuance values are not solely driven by the objective of supporting social goals (primarily the case for government or municipal issuances) but also by efforts to enhance corporate image, particularly among private-sector entities. Lenzi (2020) highlights that commercial and development banks (e.g., UBI Banca) are among the first and most active corporate social bond issuers, often financing grant and loan projects in social entrepreneurship, health, education, or employment. Corporations use social bonds to finance projects with measurable social impact (e.g., social housing, social services), typically under a "use-of-proceeds" structure. Kosztowniak (2023) indicates that the leading issuers of

ESG bonds, including social bonds, in the global economy are financial enterprises (57% of issuance) and non-financial corporations (29%).

6. Conclusions

Social bonds constitute a new category of debt securities designed to finance social needs. Social bonds can be regarded as a systemic and institutional solution that supports cooperation between the public and private sectors, as well as addressing specific social challenges. They also create opportunities for increasing the involvement of private sector entities (e.g., individuals, non-governmental organizations) in the provision of public services or the financing of strategic social projects within the European Union, which becomes particularly important in the context of limited public resources.

The findings of this study contribute to the field of sustainable finance research and demonstrate that the concentration of social bond issuance in European Union countries, considering both total issuance value in EUR and the number of issuers, is heterogeneous. The applied method of synthesis and the assessment of dynamics indicated that between 2020 and 2025 there was a strong market concentration of social bonds in EU countries, both in terms of the number of issuers and the issuance value in EUR. It should be emphasized that regarding the number of issuers, the EU social bond market is relatively fragmented and dominated by selected countries, primarily France, Germany, and Italy. However, considering the issuance value, France exhibits clear dominance, while Germany, the Netherlands, Italy, and Spain also recorded significant issuances.

Consequently, hypothesis H1: From 2020 to 2025, social bond issuances in EU countries were characterized by a high level of concentration in terms of both issuance value and number of issuers - was confirmed, as France maintained a dominant position throughout the study period and was the largest issuer of social bonds in each year. It is worth noting that in France, the market share remained stable, which confirms hypothesis H4: From 2020 to 2025, France served as the leading market in terms of issuance value compared to other EU countries. Notably, the highest issuance values occurred between 2020 and 2022, contributing to elevated levels of social bond issuance across the EU. Since 2023, France's issuance activity has declined, although it still remains the market leader.

Considering the dynamics of change, which reflect the scale, direction, and pace of issuance value changes, it can be observed that between 2020 and 2022, social bond issuance values across the EU increased. In subsequent years, however, there was a decline in issuance value, indicating reduced issuance activity but also highlighting the continued importance of this instrument in financing social needs. The study does not confirm hypothesis H2: From 2020 to 2025, the value of social bond issuances increased.

Examining the structure of social bond issuance by type of issuer reveals that the EU market between 2020 and 2025 was characterized by high value concentration in the hands of public sector issuers (agencies), with a relatively dispersed number of issuances in the financial sector. Based on this, hypothesis H3: From 2020 to 2025, the concentration of social bond issuers was primarily in the financial sector - was only partially confirmed, as the number of issuances was dominated by the financial sector, whereas issuance value was dominated by the public sector.

The study demonstrates that the EU social bond market between 2020 and 2025 exhibited high concentration both in terms of issuance value and number of issuances, with clear dominance by France. The largest number of issuers was observed in France, while the fewest issuers were located in Austria, Luxembourg, and Poland. From a sectoral perspective, the results confirmed that concentration of social bond issuers was highest within the agency sector.

Despite the considerable growth potential of the EU social bond market, the article also highlights potential challenges in this area. Key challenges include high transaction costs related to establishing specific agreements among issuers, investors, and project implementers (due to the absence of widely available standardized agreements). Moreover, the complex mechanisms underlying Social Impact Bonds (SIBs) may limit the potential pool of participants to professional investors only.

The research focused on assessing the development of the social bond market in EU countries from 2020 to 2025 in terms of value, quantity, and geographic distribution. SIBs represent a primary source of financing for a wide range of social needs in the EU. The variation in demand for financing social needs through the financial market is a direct consequence of decreasing public sector funds. The choice of this research subject is supported by both theoretical and practical considerations. Current knowledge regarding social bonds as instruments for financing social needs in the EU remains incomplete. Most studies focus on the mechanism of social bonds, assessments of global or national markets, or issues of "social washing". Few studies analyze the concentration of the social bond market within the EU.

The study of social bonds as a means of financing social needs is significant not only from a cognitive perspective but also for economic practice. The condition and development of this market are relevant to individual and institutional investors, economic entities, and both the EU as a whole and its member states. The results of this study indicate that social bond issuances exhibited uneven growth among EU countries in meeting social needs.

These findings make an important contribution to the literature on sustainable finance and ESG-related debt securities, confirming the growing significance of this market segment. Social bond issuance is increasing globally and within the EU, although its concentration depends on multiple factors, including region, issuer type, quality of information, and regulatory environment. The study is relevant for a wide range of stakeholders interested in social bonds as debt instruments financing social needs, including public finance entities, individual and institutional investors, business practitioners, and students of various disciplines.

At the same time, the study has certain limitations, mainly due to the small sample size and the scope of variables. Future research should consider issuances according to specific social objectives. Despite these limitations, the study confirms that the social bond market in EU countries constitutes an important channel for financing social needs, whose effectiveness largely depends on the type of issuer and the quality of the macroeconomic environment. These results provide a basis for further research on the factors influencing issuers' decisions regarding these debt instruments.

Further exploration is important both theoretically and practically. Future studies should encompass all European countries, with particular attention to the United Kingdom, which not only initiated the social bond market but also shaped its global standard through institutions, regulations, and political promotion. The United Kingdom played a key, exemplary role in the establishment and global development of social bonds (SIBs), while its experience also highlights the main tensions and weaknesses of this model of financing social policy.

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MOBILIZATION OF TACIT KNOWLEDGE: A NEW APPROACH TO INTERNAL AUDITING

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Purpose: The purpose of this paper is to analyze and synthesize existing literature on the role and mobilization of tacit knowledge in internal auditing and to propose a new conceptual perspective on audit practice.
Design/methodology/approach: The main methodology adopted in this study was a systematic literature review (SLR). The purpose of the systematic literature review (SLR) was to address the research questions outlined. The results were compiled and analyzed in the paper. As organizational practices continue to evolve, so does internal auditing transitioning from traditional checklist-based inspections to collaborative, knowledge-driven approaches that integrate human expertise, experience, and judgment. The second research method used in this study was the questionnaire method, which aimed to reflect the actual state of enterprises' approaches to tacit knowledge in internal audits.
Findings: The results of the preliminary study provide grounds for a new approach to management system audits based on literature reports indicating mechanisms to mobilize tacit knowledge that are used in internal control systems.
Research limitations/implications: Although it included empirical research in several companies, the sample size was small, limiting generalizability. The literature review also revealed few studies on tacit knowledge in internal auditing, restricting comparative analysis. Future research should expand empirical investigations and explore the role of digital technologies and AI in mobilizing tacit knowledge and enhancing audit quality and organizational performance.
Originality/value: Highlighting the tacit knowledge in internal audits and company research that has not been discussed in the literature.
Keywords: Tacit knowledge, Knowledge mobilization, Internal auditing, Knowledge management, Organizational learning.
Category of the paper: Literature review.

1. Introduction

Contemporary research indicates that the scope of internal auditing has expanded significantly over recent decades, with internal auditors now engaged not only in traditional compliance and control tasks but also in strategic risk oversight and governance activities. This shift reflects a broader recognition of internal audit's role in enhancing transparency, accountability, and organizational resilience, as well as its contribution to corporate governance frameworks (Hanadoyo, 2024; Mathivha, Nzama-Sithole, 2025). Internal auditors now play a vital role in supporting digital transformation, and advancing sustainability initiatives, making them indispensable strategic partners in today's dynamic business environment (Sutono et al., 2026).

Nowadays stakeholders expect confirmation that management decisions related to risk oversight, information transparency, and control processes are appropriate and adequately monitored (Panda, Leepsa, 2017). In order to meet these objectives, business organizations must establish strong governance mechanisms and formalized guidelines. Effective governance arrangements facilitate the achievement of organizational goals, mitigate risks, and strengthen corporate governance practices (Chowdhury EK, 2021). The Internal Audit Function (IAF) serves as a cornerstone of corporate governance, offering independent evaluations, assisting across organizational processes, and fostering enhancements and innovative practices (Tiron-Tudor et al., 2021). The quality of the IAF is determined by both the competence and independence of internal auditors, as these factors are essential for ensuring effective governance, maintaining regulatory compliance, and supporting reliable decision-making within the organization (Bari et al., 2024).

The limited integration of tacit knowledge within internal audit functions represents a critical challenge that may affect both the effectiveness and efficiency of auditing activities. Tacit knowledge, being personal, context-specific, and difficult to codify, is essential for improving audit quality and supporting informed decision-making. Despite its importance, several factors including lack of formal mechanisms for knowledge capture, reliance on standardized procedures, and insufficient training hinder its effective application within internal audits. Procedural fairness affects managers' willingness to share knowledge, with higher fairness increasing cooperation, particularly with outsourced auditors. Organizational barriers, such as limited independence, restricted access to records, and insufficient cooperation from other departments, further impede knowledge flow. In addition, many audit functions lack effective knowledge management systems, and cultural or motivational obstacles reduce the extraction and sharing of tacit knowledge (Seymore, Robertson, 2020; Abudu, Syed, 2025; Mai, Nguyen, 2022; Supanitchaisiri et al., 2020).

Existing knowledge management practices are generally insufficient to address the complexity of tacit knowledge, and despite the potential of advanced approaches including cognitive computing and scenario planning their implementation remains limited (Maymir-Ducharme, et al., 2014).

This article highlights a research gap arising from the absence of a coherent framework for leveraging tacit knowledge in auditing, as well as the fragmented nature of studies connecting internal audit and management practices.

The aim of this paper is to analyze and synthesize existing literature on the role and mobilization of tacit knowledge in internal auditing and to propose a new conceptual perspective on audit practice.

2. Literature review

Tacit knowledge, which encompasses the experience, intuition, and unwritten expertise of auditors, plays a critical role in internal audit processes. Unlike formal procedures or documented standards, tacit knowledge allows auditors to interpret complex organizational situations, detect subtle risks, and provide nuanced recommendations (Albawwat, 2022). This type of knowledge is often developed through years of practical experience and personal judgment, making it a key factor in the effectiveness and adaptability of internal audits (Lucena, Popadiuk, 2020). Understanding how tacit knowledge influences internal audit outcomes is essential for enhancing audit quality, developing auditor competencies, and improving the overall governance of organizations (Hadjimichael, Tsoukas, 2019). Organizations operate two separate processes that serve different purposes. The internal control system focuses on ensuring the entity's compliance with legal and regulatory requirements and enhancing operational efficiency. In contrast, internal audit is concerned with evaluating the overall management system's conformity with a selected normative standard (IOVIȚU, et al., 2013). While these processes are distinct in their objectives, the methods and principles applied in internal audits often benefit from insights derived from internal control practices, particularly when integrating tacit knowledge into audit decision-making. It should also be emphasized that, despite differences in reference criteria, the assessment methods and procedural principles remain largely analogous, which enables the transfer of good practices between these areas.

The historical evolution of internal auditing can be traced from the 19th century to the present, reflecting changes in organizational practices, regulatory frameworks, and governance expectations. In the United States, internal auditing emerged in the mid-19th century, particularly within the American railroad industry, where internal and shareholder auditors played a critical role in financial reporting and safeguarding audit independence (Boockholdt, 1983). At the same time, statutory auditing developed in Europe during the latter half of the

century, with individual countries establishing their own regulatory frameworks and professional standards (Fournès et al., 2024). The development of internal auditing continued with the formalization of structural controls over labor and operational processes, driven by the growing demands of industrial capitalism. During this period, internal auditing served as a mechanism to monitor labor processes, improve operational efficiency, and ensure the generation of surplus value (Mihret, 2014). The introduction of the Sarbanes-Oxley Act (SOX) in 2002 marked a major turning point in internal auditing, placing strong emphasis on internal control, risk management, and corporate governance. This era saw the implementation of more rigorous standards, formalized procedures, and enhanced responsibilities for internal auditors, reflecting the increasing complexity and accountability requirements of modern organizations (D'Silva, Ridley, 2007).

The development and adoption of international standards have been instrumental in shaping the internal auditing profession. Recognized globally, these standards provide a framework that ensures consistency, quality, and credibility in internal auditing practices across diverse organizations (Idiab et al., 2012).

Over time, internal auditing has expanded beyond its traditional focus on financial and compliance processes to encompass a broader scope, including risk management, control evaluation, and advisory services. This evolution reflects the increasing strategic importance of internal auditing in supporting organizational governance, decision-making, and operational improvement (IOVIȚU et al., 2013).

Despite significant progress, internal auditing continues to face challenges related to professional identity, autonomy, and alignment with evolving organizational needs. The profession must adapt to rapid changes in business environments, emerging risks, and technological innovations, while maintaining its relevance, credibility, and contribution to corporate governance. Continued efforts are required to strengthen the role of internal auditors as strategic partners and knowledge-driven professionals within modern organizations (Lenz, Jeppesen, 2022).

Figure 1 illustrates the process of conducting an ISO 27001 internal audit. The proposed approach goes beyond basic compliance checks and establishes a risk-based, rigorous audit cycle that meets the expectations of external auditors.

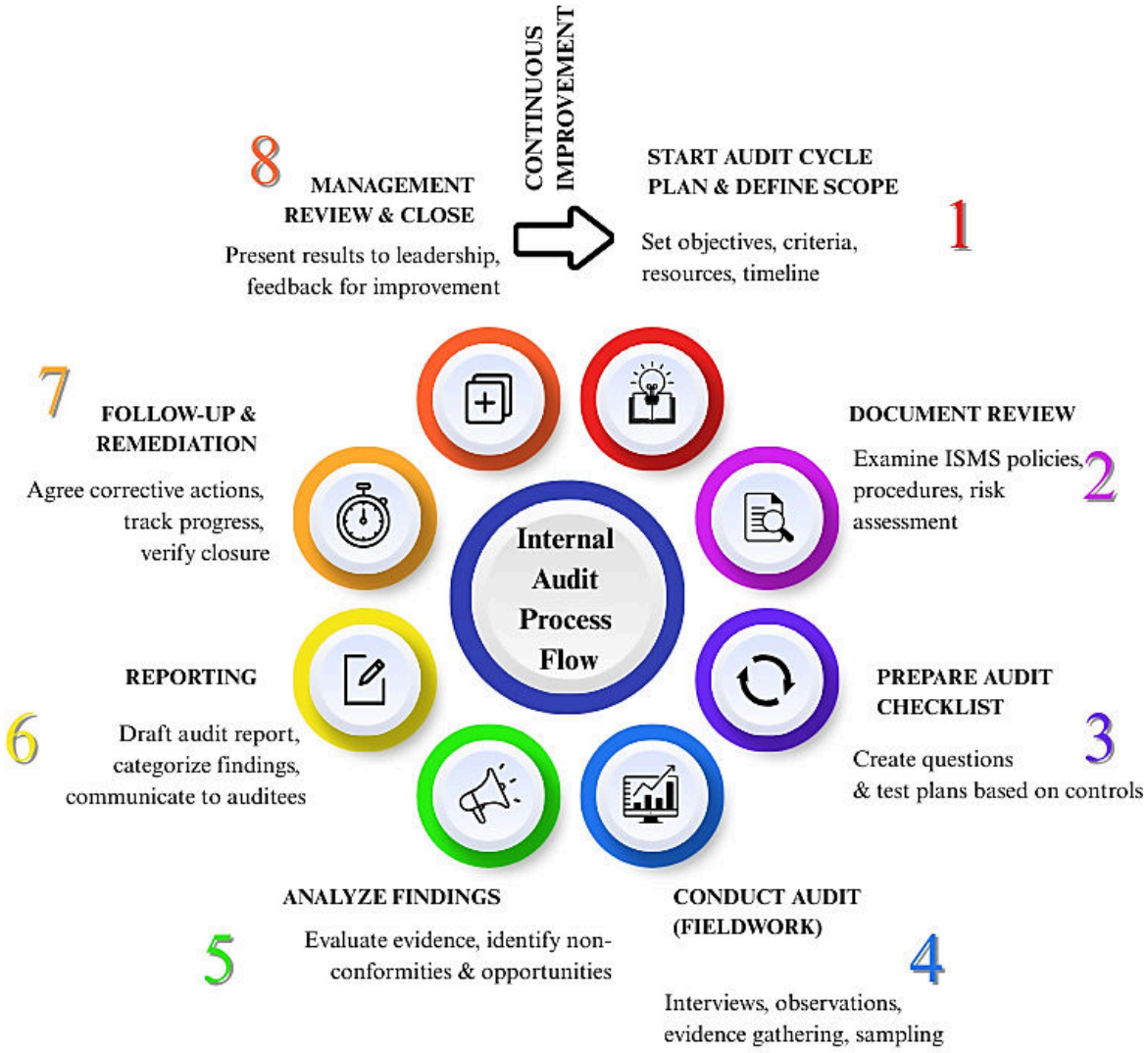

Figure 1. ISO 27001 Internal Audit Process Flow.

Source: own study based on (ISO 27001, 2022).

The sharing of tacit knowledge has a positive impact on key determinants of audit quality, including auditors' values, ethics, attitudes, experiences, skills, and overall expertise. This highlights that creating an environment that encourages the active exchange of tacit knowledge can significantly strengthen audit effectiveness. Existing studies confirm that social capital—encompassing structural, relational, and cognitive dimensions indirectly influences audit quality inputs through the sharing of tacit knowledge. This indicates that the development of strong social networks within audit functions and audit organizations can facilitate tacit knowledge exchange and, in turn, enhance audit quality (Albawwat, 2022; Hadjimichael, Tsoukas, 2019). Tacit knowledge sharing enhances an organization's ability to adapt to change, which is essential for continuous improvement and innovation in internal auditing processes (Herlina et al., 2024).

There are studies that emphasize the critical role of tacit knowledge sharing in enhancing audit quality within small audit firms. Drawing on the IAASB audit quality framework, research has shown that active sharing of auditors' experience, skills, values, and professional judgment positively influences audit quality inputs. Furthermore, structural, relational, and cognitive social capital indirectly support audit quality by facilitating the exchange of tacit knowledge. These findings suggest that promoting knowledge-sharing practices and leveraging social capital can be effective strategies for improving audit quality, particularly in the context of quality-focused audits (Albawwat, 2022). Although direct research on the link between tacit knowledge and auditing is scarce in both Polish and global literature, the broader body of work on tacit knowledge within organizations offers indirect insights that may inform auditing practices. Procedural fairness may enhance managers' willingness to share tacit knowledge with auditors, especially outsourced internal auditors, underscoring the role of fair processes in enabling tacit knowledge exchange during audits (Seymore, Robertson, 2020).

Audit organizations conducting quality audits increasingly recognize the importance of tacit knowledge among auditors, as it directly affects audit quality and the reliability of conformity assessments within quality management systems. Effective knowledge management and trust-based relationships support tacit knowledge sharing, although its inherently personal nature makes it difficult to formalize and transfer systematically (Pasipamire, 2025; Bol et al., 2018; Avdimiotis, 2016).

The literature emphasizes that internal audits play a critical role in fostering continuous improvement and ensuring the protection of employees' health and safety. Audit outcomes provide a structured basis for the implementation of corrective and preventive actions, which support systematic, year-on-year organizational improvement. Moreover, prior studies highlight that the continuous development of audit practices, regulatory frameworks, and corporate governance mechanisms is necessary to fully realize the positive contribution of auditing to organizational performance (Hassouni et al., 2026; Carvalho et al., 2025).

3. Methods

The primary approach employed in this study was a systematic literature review (SLR). This type of review enables the identification, collection, and synthesis of all relevant publications available on a given topic. The analysis focused on the development of internal auditing methods, the significance of tacit knowledge within auditing activities, as well as the opportunities, challenges, and potential risks associated with its utilization (Van Dijk et al., 2017). To structure the investigation, the authors established a set of targeted research questions designed to explore these specific aspects:

1. How can tacit knowledge be effectively identified, captured, and mobilized in internal auditing?
2. What barriers and risks are associated with leveraging tacit knowledge in audit processes, and how can they be mitigated?
3. What contemporary tools and approaches are currently being applied to support tacit knowledge mobilization in auditing?

The purpose of the systematic literature review (SLR) was to address the research questions outlined. The results were compiled and analyzed in the paper. As organizational practices continue to evolve, so does internal auditing transitioning from traditional checklist-based inspections to collaborative, knowledge-driven approaches that integrate human expertise, experience, and judgment (Ramutsheli, Musundwa, 2024).

The second research method used in this study was the questionnaire, which aimed to reflect the actual state of enterprises' approaches to tacit knowledge in internal audits. This method complemented the literature review survey by providing an in-depth view of practical solutions, organizational contexts, and real-life challenges related to tacit knowledge mobilization that cannot be fully captured through SLR (Zarestky, 2023; Crowe et al., 2011).

4. Results

To gain a thorough understanding of the current developments in tacit knowledge in internal audits, a systematic literature review was carried out in accordance with PRISMA guidelines (Figure 2). The search for relevant publications was conducted using two primary databases: Scopus and Google Scholar. In the Scopus database, 50 records were initially identified as of 17 February 2026 using the keywords “TACIT KNOWLEDGE” AND “MOBILIZATION”.

However, when attempting to narrow the search specifically to “INTERNAL AUDIT”, no relevant publications were found, indicating a research gap in this area. The search was repeated using the terms “TACIT KNOWLEDGE” AND “INTERNAL AUDIT”, which yielded 5 results. The findings indicate that issues related to internal audit are not primarily associated with management system audits, but rather with the internal control system. This observation prompted a shift in the research focus toward internal control, with the aim of identifying analogies and assessing the potential for extrapolating relevant solutions to the field of internal audit.

The initial Google Scholar search yielded a large number of records; however, after assessing relevance, 4 articles closely aligned with the research scope were selected, as many others focused exclusively on either internal auditing or tacit knowledge. Given the rapidly evolving research, the review focused primarily on publications from the past six years, while studies outside this timeframe were excluded. The selected articles confirm that mobilizing tacit

knowledge within internal auditing requires a multifaceted approach, including procedural fairness, adaptive organizational cultures, effective knowledge management processes, and advanced technological tools. By addressing these areas, organizations can strengthen their internal audit functions, foster innovation, and maintain a competitive edge. However, the topic has not yet been sufficiently explored (Seymore, Robertson, 2020; Herlina et al., 2024; Mai, Nguyen, 2022, 2024; Albawwat, 2022; Aghazadeh et al., 2023).

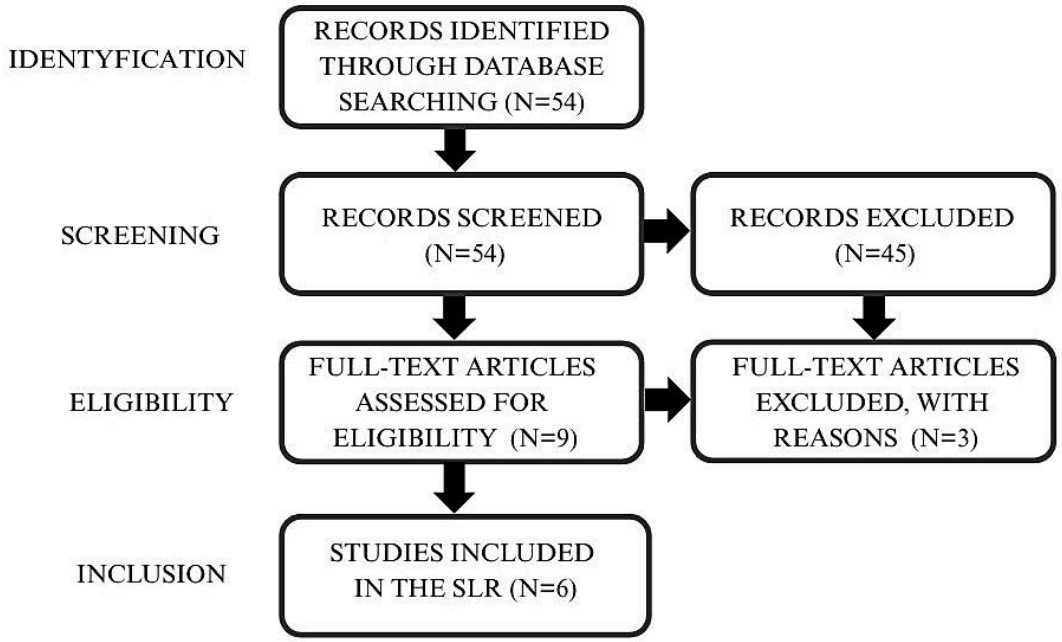

Figure 2. PRISMA flow diagram for tacit knowledge in internal audits review.
Source: own study.

The scarcity of existing studies motivated the authors to extend their investigation and examine related research areas.

Tacit knowledge in internal auditing can be effectively identified, captured, and mobilized through a combination of organizational, social, and procedural mechanisms. These include mentoring, learning by doing, team-based audits, communities of practice, storytelling, case-based reasoning, post-audit retrospectives, and digital platforms.

Each of these mechanisms has distinct strengths and applications in mobilizing hidden knowledge. The literature identifies eight key mechanisms that are particularly relevant and worth applying in the conduct of internal audits. Table 1 presents a detailed look at how these mechanisms can be utilized.

Table 1.
Summary of Mechanisms

Mechanism	Description	Benefits
Mentoring	Experienced auditors guide less experienced ones	Transfers tacit knowledge, builds relationships
Learning by Doing	Hands-on experience in audit tasks	Internalizes procedures, enhances practical skills
Team Audits	Collaborative audit approach	Pools diverse knowledge, improves audit quality
Communities of Practice	Informal groups for sharing experiences	Fosters continuous learning, develops best practices
Storytelling	Sharing audit stories and experiences	Conveys complex ideas, embeds knowledge in culture
Case-Based Reasoning	Analyzing past cases to solve current problems	Applies historical insights, enhances problem-solving skills
Post-Audit Retrospectives	Review sessions after audits	Identifies areas for improvement, captures lessons learned
Digital Platforms	Tools for discussion, document management, and knowledge sharing	Facilitates collaboration, stores and retrieves knowledge easily

Source: own study based on: (Mai, Nguyen, 2022; Franganito, 2010; Kunthi, Sensuse, 2019; Selhorst, 2007; Luechoowong et al., 2016).

For each mechanism, a description and the associated benefits were identified. Such a consolidated table may serve as a useful tool for improving work with tacit knowledge in internal audits.

An important issue that may explain the limited number of studies on this topic is the barriers and risks related to tacit knowledge in auditing. Situations such as the loss of knowledge following employee turnover, the subjectivity of judgment, lack of formalization, the risk of cognitive biases, and ethical and confidentiality constraints contribute to the growth of these barriers and risks (Khavis, Szerwo, 2025; Hu et al., 2025; Kennedy, Rotvik, 2026). This realistic yet critical perspective highlights the challenges faced in conducting research in this area and helps to explain the existing research gap. The barriers and risks related to tacit knowledge in internal auditing can be mitigated through a combination of organizational, methodological, and ethical measures (Abudu, Syed, 2025; Idiab et al., 2011). Knowledge loss resulting from employee turnover can be reduced through mentoring, job shadowing, team-based audits, and systematic post-audit reviews that help externalize experience-based insights (Phaladi, 2024; Supanitchaisiri et al., 2020). The subjectivity of judgment and the risk of cognitive biases can be addressed by using structured audit methodologies, peer reviews, professional skepticism training, and diverse audit teams. A lack of formalization may be mitigated by translating key tacit insights into guidance notes, case libraries, and digital knowledge repositories. Ethical and confidentiality constraints can be managed by establishing clear governance rules, access controls, and anonymization practices within knowledge management systems, ensuring that sensitive information is protected while still enabling learning and knowledge sharing (Austin et al., 2012; Seymore, Robertson, 2020; Misztal, Ratajszczak, 2025).

To support tacit knowledge mobilization in auditing, contemporary tools and approaches are increasingly applied to enhance knowledge sharing and improve audit quality. Digital platforms, including wikis, town hall meetings, mentor programs, HRIS, and advanced data analytics, facilitate interaction, collaboration, and documentation while keeping human expertise central to audits (Mayfield et al., 2008). Knowledge audits and management models such as SECI help identify, capture, and integrate tacit knowledge into business processes, addressing gaps and promoting collaborative modeling (Guitián, Dante, 2016). Organizational culture and social capital through structural, relational, and cognitive networks foster knowledge sharing, with leadership, procedural fairness, and incentives further encouraging managers and auditors to exchange tacit insights (Albawwat, 2022). While digital tools and remote work can present limitations, strategies like mentorship programs, virtual communities, and emerging technologies such as AI and blockchain help mitigate knowledge erosion and enhance transfer (Amanova et al., 2023). Overall, integrating these tools, cultural practices, and technological innovations is crucial for capturing, sharing, and leveraging tacit knowledge to improve audit effectiveness (Castaneda, Toulson, 2021).

The results of the literature analysis conducted to date prompted the authors of the article to develop a questionnaire aimed at verifying approaches to tacit knowledge in internal audits within enterprises. Due to the novelty of the proposed approach, the authors conducted preliminary research on a small sample to assess the justification for undertaking more in-depth studies in the future. The results provide an initial basis for further research on an expanded sample. The questionnaire was designed to examine how enterprises identify, use, and manage tacit knowledge in the context of internal audits. Table 2 presents the questionnaire template prepared for the purposes of the study. It consists of two parts: Section I – Organization and Respondent Profile, and Section II – Tacit Knowledge in Internal Auditing.

Table 2.
Tacit knowledge in internal auditing questionnaire

TACIT KNOWLEDGE IN INTERNAL AUDITING **Section I: Organization and respondent profile** Indicate your answer by marking an X in the appropriate box.
Size of the enterprise: Micro ▫ Small▫ Medium-sized ▫ Large ▫
Internal audit function: In-house ▫ Co-sourced ▫ Fully outsourced ▫
Industry: Manufacturing ▫ Services ▫ Other ▫
Respondent's role: Internal auditor ▫ Senior auditor ▫ Other ▫
Years of experience in internal auditing: <3 ▫ 3–5 ▫ 6–10 ▫ >10 ▫
Which management systems are you an auditor of? ☐ ISO 9001 ☐ ISO 45001 ☐ ISO 14001 ☐ ISO/IEC 27001 ☐ ISO 26000 ☐ Other (please specify): _____

Section II: Tacit Knowledge in Internal Auditing
Please indicate your level of agreement using a 5-point Likert scale: (1 – Strongly disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 – Strongly agree).

Nr	Statements	1	2	3	4	5
1	Tacit knowledge (experience, intuition, professional judgment) is essential to the effectiveness of internal audits.					
2	Internal auditors rely on experience-based knowledge when assessing risks and controls.					
3	Tacit knowledge is actively shared among members of the internal audit team.					
4	Mentoring, learning by doing, and team-based audits support tacit knowledge transfer.					
5	Post-audit reviews are used to capture lessons learned and experiential knowledge.					
6	Trust within the internal audit team facilitates tacit knowledge sharing.					
7	Trust between auditors and auditees encourages open knowledge exchange.					
8	The organization supports initiatives to develop and retain tacit knowledge in internal audit.					
9	The departure of experienced auditors poses a risk due to loss of tacit knowledge.					
10	The internal audit function has an effective approach to managing tacit knowledge.					

Optional question: *What practices/methods could most effectively improve the use of tacit knowledge in internal auditing?*

The preliminary research was conducted in February 2026 in Greater Poland. Responses were obtained from five enterprises, of which three were manufacturing companies, one was a service company, and one operated in both manufacturing and services. All enterprises were medium-sized. In one company, the internal audit function was performed in-house, while in the remaining enterprises it was fully outsourced. The respondents' roles included owners in three cases, and a production managers in the remaining cases. The level of experience in internal auditing was relatively limited, as all enterprises reported 3-5 years of experience. Based on the evaluation statements, the results were obtained:

- Highest-rated areas: the importance of tacit knowledge, reliance on auditor experience, and the risk of knowledge loss due to staff turnover (ratings 4-5).
- Moderately developed: trust and informal knowledge sharing mechanisms (ratings 3-4).
- Weakest areas: formal management of tacit knowledge and systematic post-audit reviews (rating 2).

High ratings for the importance of tacit knowledge (5) and auditors' reliance on experience-based judgment (4) indicate that internal audits already extend beyond purely procedural and checklist-driven approaches typical of the traditional audit model. This suggests a growing recognition of experiential knowledge as a key input to audit effectiveness, which is a defining feature of the knowledge-based audit stage.

Moderate ratings related to tacit knowledge sharing, mentoring, and team-based audits (3), as well as trust within audit teams and between auditors and auditees (4), further support the presence of knowledge-based audit practices. These elements demonstrate that social

interaction and professional judgment play an increasing role, although they are often informal and not systematically managed.

At the same time, low ratings for post-audit reviews (2) and the overall effectiveness of tacit knowledge management (2) highlight the continued dominance of traditional audit characteristics, particularly the lack of formal mechanisms for capturing and institutionalizing experiential knowledge. This limits the transition toward an intelligent audit model, which requires structured knowledge management processes and technological support.

Finally, the very high perceived risk associated with the departure of experienced auditors (5) underscores the absence of mature systems for retaining and transferring tacit knowledge. This finding reinforces the need for progression toward an intelligent audit model, where tacit knowledge is systematically captured, integrated with digital tools, and leveraged for continuous learning and strategic decision-making.

Overall, the results of the preliminary research allow us to conclude that Polish medium-sized enterprises are primarily at the knowledge-based audit stage, with clear dependencies on individual experience and trust, but with significant gaps that hinder the transition toward the intelligent audit model.

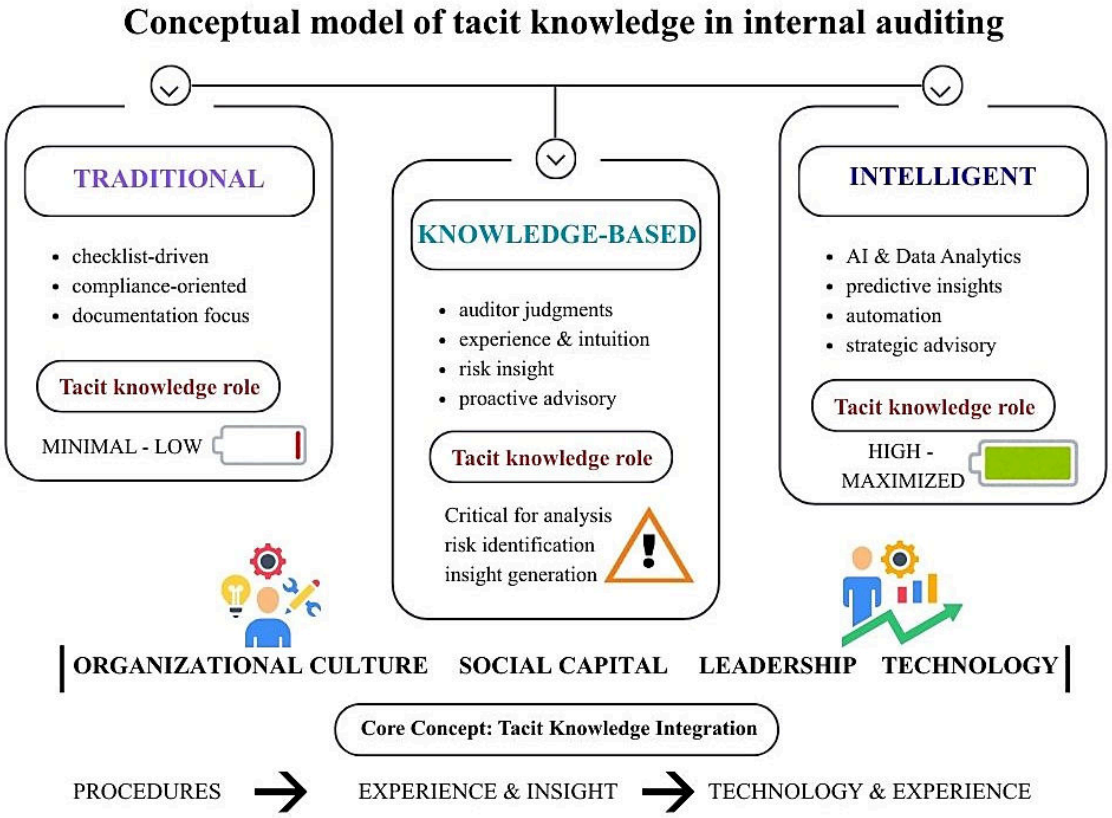

Figure 3. Conceptual model of tacit knowledge in internal auditing.

Based on questionnaire research conceptual model of auditing grounded in tacit knowledge was proposed, integrating audit procedures, technological tools, and auditors' experiential knowledge. Figure 3 illustrates the evolution of internal auditing from traditional, procedure-driven practices toward intelligent, technology-enabled auditing, emphasizing the increasing

importance of tacit knowledge across this progression. As auditing moves into a knowledge-based approach, tacit knowledge becomes central, with auditors drawing on experience, intuition, and contextual understanding to identify risks, interpret evidence, and generate meaningful insights beyond formal procedures. The effective mobilization of tacit knowledge occurs through ongoing interaction, judgment, and sense-making during audit planning, execution, and reporting, transforming individual experience into collective audit capability. This integration is enabled by organizational culture, social capital, leadership, and technology, ensuring that tacit knowledge enhances audit quality, relevance, and value creation rather than remaining an implicit, underutilized resource.

To sum up, Figure 3 shows that it is possible to quickly gain an understanding of an organization's situation in order to determine the stage of internal auditing it is at and identify the steps that should be taken next.

5. Summary

This paper reviews and integrates existing research on how tacit knowledge is utilized and shared within internal auditing. It examines the ways auditors mobilize their implicit expertise and insights in practice. Based on this analysis, a study was conducted in five enterprises, and as a result, the paper proposes a new conceptual framework to enhance the understanding and effective use of tacit knowledge in audit processes.

This preliminary study has several limitations that should be acknowledged. First, while the research included empirical investigations in several companies, the sample size was limited, which does not yet allow for the generalization of the results, but rather provides justification for further, more in-depth research on an expanded sample. Second, the systematic literature review revealed a relatively small number of publications directly addressing tacit knowledge in internal auditing, constraining the depth of comparative analysis. Future research should therefore expand empirical studies, such as case studies, interviews, or surveys involving internal auditors, to further validate and extend the findings. Additionally, further research could explore the role of digital technologies and artificial intelligence in supporting the mobilization of tacit knowledge in internal auditing and examine their impact on audit quality and organizational performance.

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EFFICIENCY INDICATORS OF PUBLIC TRANSPORT AS A TOOL SUPPORTING SMART CITY DEVELOPMENT

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Purpose: To conceptualize AI-based algorithmic governance in smart cities as a multi-layer system linking urban data, AI models, and governance structures, and to propose a QoL-oriented evaluation framework for assessing its impact on citizens' quality of life**.**
Design/methodology/approach: The study adopts a conceptual, framework-development approach, building an integrated analytical framework and proposing the QoL-Algorithmic Governance Indicator System (QAGIS) for evaluating AI governance in smart cities.
Findings: The study shows that AI can improve QoL-oriented urban governance by increasing the relevance, accuracy, and consistency of governance actions, but only when algorithmic governance is integrated with existing governance structures and supported by explainable, transparent, and accountable AI mechanisms.
Originality/value: The article contributes by introducing the QAGIS framework for evaluating AI governance through both objective and subjective QoL dimensions and by clarifying the distinction between Smart City Governance and AI Governance, treating AI Governance as a necessary subsystem of responsible smart city governance.
Keywords: Artificial Intelligence, Algorithmic Governance, Quality of Life.
Category of the paper: Research paper.

1. Introduction

The increasing integration of Artificial Intelligence (AI) into smart city infrastructural environments is gradually transforming how cities are administered, governed, and assessed. The increasing instrumentalization of cities through sensing technologies, smart platforms, and a comprehensive data environment means that decision-making at the city level is now not limited to traditional administrative processes or occasional statutory reporting (Gil et al., 2026;

Rehman, 2026; Theocharis, Tsihrintzis, 2026). Rather, cities now increasingly depend on analytics models and decision-support algorithms that leverage data analysis and predictive capabilities in order to rationalize public services and manage increasingly complex socio-technical relationships. Here, the idea of ‘algorithmic governance' has assumed significance as an interpretative tool in understanding how AI-related technologies can shape decision-making on public matters, effectively changing how citizens interact with institutions of governance (Ragab et al., 2025; Salhi et al., 2025; Tamtam et al., 2025; Jayanthiet al., 2025).

Regarding the governance aspects of decision support systems powered by artificial intelligence, there is a notable operational benefit provided. It can help achieve higher precision and real-time response of interventions in administrative matters, achieve a certain level of stability in decision-making activities, and optimize the use of resources in the most important sectors of smart city management, including transport, energy, the environment, and the digital government. This is particularly important when a strategic focus of a smart city is the improvement of the quality of living in the city. The growing presence of artificial intelligence in decision-making processes creates fundamental challenges in governance. This may increase the level of decision-making ambiguity and decrease the objectivity of administrative decision-making processes. Thus, the effectiveness of decision-making in the field of artificial intelligence powered governance cannot be judged solely upon the basis of decision-making effectiveness (El Moussaoui et al., 2025; Xiang, 2025; Shah et al., 2025; Skotnicka-Zasadzień, Wolniak, 2026; Wolniak et al., 2024a, 2024b).

The challenges listed in this section are overcome in this paper with an integrated framework that conceptualizes the multi-layered structure between (i) urban data systems, (ii) AI systems and analytics, and (iii) institutional governance frameworks. The framework helps in assessing AI outcomes across objective urban performance metrics, as well as across dimensions that are relevant to aspects of QoL, such as those based on citizens' perceptions. Specifically, methodological and ethical aspects surrounding AI systems used in the public domain, that is, transparency, bias, model ability, and interpretability, would receive special attention in the framework, and their implications for the correctness and validity of AI systems in governing would be explored. The main point that this paper would like to make is that AI can be useful in QoL-oriented urban governance by bringing about relevance, accuracy, and cohesion between governance actions; however, this is not possible without integrating algorithms with pre-existing governance frameworks and incorporating mechanisms like "explanation-oriented AI systems" that would help in understanding, auditing, and trusting AI systems.

We formulated two goals in this paper:

1. G1 - To conceptualize AI-based algorithmic governance in smart cities as a multi-layer system linking data, AI models, and governance structures.
2. G2 - To propose a QoL-oriented evaluation framework (QAGIS) for measuring how AI governance affects citizens’ quality of life without undermining accountability and trust.

2. Conceptual Foundations

The smart city has developed from being essentially a technological vision, emphasizing information and communication technology infrastructure, sensors, and digital service provision, to encompassing an increasingly socio-technological and governance-focused approach. Today, the studies on smart cities increasingly take into consideration that urban "smartness" not only depends on the number of digital devices but on the capacity to convert data into public value. In this context, it has increased the relevance of governance frameworks because cities need to integrate different actors in the urban space, from government institutions and private providers to citizens and civil society organizations, and manage different goals from efficiency, sustainability, equity, to resilience (Derbas et al., 2026; Ali et al., 2025; Wang et al., 2025). The urban governance has developed from hierarchical administrative systems toward new governance frameworks focused on network-oriented systems that include distributed decision-making processes with increased use of policy instruments based on scientific knowledge. In this context, urban governance is increasingly informed by data streams and digital infrastructure and provides frameworks for the impact of algorithms in strategic and priority domains and in operational service delivery (Hamza, Ilyas, 2026; Zhang, Deng, 2025; Rosak-Szyrocka, Wolniak, 2025; Wolniak, Turoń, 2025). A possible conceptualization of algorithmic governance is the deliberate integration of computational models and algorithms with AI and decision rules based on data into the structures of public governance. This is not merely the automation of governance, but rather the metamorphosis of the very process of governance itself as guided by the output of algorithms (Zhuang, 2025; Lukić et al., 2025; Varghese, 2025; Voutyrakou, Skordoulis, 2025; Escudero et al., 2025). Thus, algorithmic governance can be considered to be multi-layered, consisting of city data environments (data collection, integration, and governance), the analytical side (AI and statistical models), and the governance side itself (authority and accountability).

Typologies of AI-governed governance generally distinguish between degrees of involvement of algorithms in the decision-making process: (i) advice systems assisting decision-makers; (ii) semi-automated governance systems implementing actions within specific boundaries; and (iii) autonomous governance systems operating under limited human control. There is another important distinction regarding the object of governance as a whole (Anastasopoulou, 2025; Kusumasari, Yahya, 2025; Ambroselli, 2025; Sullivan, 2025; Rosak-Szyrocka, Wolniak, 2025; Wolniak, Turoń, 2025). So, the scope of algorithmic governance may encompass decision-making at the level of micro-decisions (for instance, traffic management at intersections) as well as at the macro-level of policy choices (priorities in regional spatial planning, eligibility for social services). Lastly, the procedures of decision-making through algorithms may generally be transparent (with traceable rules and model operability), as opposed to "black box" machine learning methods.

Quality of Life is a paramount normative target of smart city initiatives. However, QoL is a very challenging topic in regard to conceptual definitions and methods used for its measurement. Speaking generally, QoL in the context of urban studies can be assessed using a combination of two approaches—the objective and the subjective one. Speaking specifically, the objective QoL measures involve the use of quantitative methods of study of city performance variables (Wijayasinghe, Sachitra, 2025; Padrón Nápoles et al., 2025; Huang et al., 2025; Jonek-Kowalska, Wolniak, 2025; Skubis et al., 2024; Jonek-Kowalska, Wolniak, 2023). This might concern air quality, noise level, traveling time, housing conditions, accessibility of healthcare and educational services, energy saving rates, crime rates, and the level of digital services. On the other hand, the subjective QoL research is focused primarily upon the citizen's living experience. This might include perceptions of citizen wellbeing, citizen satisfaction with public services of the city, trust of the public in city administrations as well as perceptions of balance and safety (Sverstiuk et al., 2025; Rondón-Duarte, Largacha-Martínez, 2025). The measurement of QOL in urban settings is fraught with several challenges. First, QOL is inherently multicriteria, and trade-offs between different goals are necessary; what enhances efficiency in traffic flow management could impair equity in-redistribution of congestions. Second, objective measurement could disregard local diversity and individualization. In objective measurement, an average-based governance policy could be inadequate since it ignores the needs of the minority. Moreover, objective measurement does not capture individuality in local settings. Objective measurement could be less useful because it is not sensitive to local conditions and local census. Subjective measurement could be useful because it is sensitive to local conditions. However, it could be less reliable because it could adapt to low quality. Subjective measurement could be useful because citizens could compare services with their expectancies. There could be risks in integrating QOL measurement in algorithmic governance (Davutoğlu, 2025; Liu, 2025; Jalal-Eddeen, 2025; Bax, 2025; de Castro, 2025).

3. AI-based analytics and decision-support systems to improve the quality of life (QoL)

Decision Support Systems (DSS), leveraging AI technology, support real-time and predictive governance. They can detect potential urban risks, forecast public service demand, dynamically assign resources, and minimize the variation in the delivery of services. However, the relationship of DSS with QOL is not straightforward; it manifests at a different stage through intermediate variables like enhanced service provision, less exposure to the stressors of the urban environment (noise, pollution, and environmentally unsafe areas), and increased

incorporation of citizens' needs in the decision-making cycle of the governance process. As such, the improvement of QOL can be framed as follows:

AI systems impact QoL in several specific ways that can be operationalized:

a. Predictive governance and prevention.
   AI models detect weak signals of congestion, pollution spikes, infrastructure failure, or safety risks. Preventive interventions reduce disruptions that impact QoL through stability and reliability of services.
b. Resource optimization and service accessibility.
   Allocation models enhance the scheduling of public transport, energy balancing, deployment of emergency responses, and maintenance planning. QoL improves when these services become more accessible in time and space.
c. Personalization and citizen-centric service delivery.
   AI can segment citizen needs-for example, elderly mobility patterns, disability accessibility requirements-and allow differentiated policy instruments. This may raise perceived relevance and satisfaction but also raises fairness and bias risks.
d. Management of the urban environment.
   AI-based environmental monitoring facilitates decisions pertaining to green spaces, emission control, waste logistics, and noise regulation. These improvements will affect QoL through health, comfort, and perceived livability.
e. Digital governance and trust.
   AI-enhanced platforms will improve both citizen contact channels and administrative effectiveness. On the other hand, such algorithmic opacity undermines trust in the government. Hence, QoL is dependent on legitimacy and governance transparency.

AI-based governance requires an evaluation logic that goes beyond operational efficiency and technical functionality. Many smart city programs still rely on narrow performance dashboards focusing on service outputs (e.g., response time, punctuality, throughput), which can create a misleading impression of success. In reality, algorithmic governance should be assessed as an intervention in a socio-technical system: it modifies decision processes, reshapes service allocation, and affects citizen perceptions of fairness and legitimacy. For this reason, the proposed QoL-Algorithmic Governance Indicator System (QAGIS) adopts a layered structure that captures the full chain from baseline urban conditions, through AI model quality and governance outputs, to objective and subjective QoL outcomes. The conceptual advantage of this architecture is that it prevents “output-only” evaluation and forces analysts to track whether AI-driven decisions actually improve human wellbeing and remain socially acceptable.

The first layer consists of Urban Condition Indicators and represents the pre-intervention context in which AI-based governance is operating. These metrics describe exposure conditions and service accessibility that shape QoL independently of any particular governance tool. Typical indicators include air pollution levels (PM2.5, NO_2, O_3), day/night noise exposure, urban heat stress days, travel time to key services, and safety environment proxies such as

incident density in public space. This layer methodologically plays the role of a baseline covariate set: it controls for the differences in initial conditions across the districts, enabling robust longitudinal comparisons. Without such a baseline layer, improvements attributed to AI may actually reflect exogenous variation rather than the governance impact of weather, seasonal tourism, or macroeconomic fluctuations.

The second level, AI System Performance Indicators, assesses the quality of models deployed in governance. This is an important task because algorithmic models have the ability to be very confident in their results, whether these models' predictions have any genuine, stable validity or not. The metrics that fall under this level include Forecast Accuracy (RMSE/MAE), Classifier Performance (F1/AUC), robustness to data drift, completeness of set coverage, and explainability properties (such as SHAP coverage, rule set availability). In addition to typical ML metrics, governance-relevant metrics, which include its traceability (logging, traceability of decisions) and fairness diagnostics (statistical parity, disparate impact approximations) measures, have to be incorporated. The purpose of this level of governance metrics is to ensure that all decisions made by governance, through the use of AI, have some technical soundness, which can be evaluated, argued against, or optimized through monitoring.

The third layer is "Governance Output Indicators," which seeks to address the operational effectiveness of decision support through AI. The items within this layer regard changes in the level of service delivered within the smart city domains of mobility (congestion index, reliability of travel times, punctuality), energy (frequency of outages, effectiveness of demand response, losses reduced), environment (response time for incidents, reliability of waste collection), digital governance (completion rate of services, processing speed, complaint resolution), and public safety (response time for emergencies, rate of mitigation in risk hotspots). What is important is the fact that this layer does not currently quantify QoL itself, instead focusing on the outputs of governance as the alleged key drivers of QoL changes. It essentially acts as the linkage between the technical validity of AI and social outputs in the sense that it essentially tracks whether "AI does anything at all to the output of governance as opposed to being a 'symbolic' or 'pilot only' phenomena".

The fourth and fifth layers focus specifically on QoL outcomes, distinguishing objective QoL outcome changes from subjective legitimacy and perception. The Objective QoL Outcome Indicators (Layer 4) measure the objective, tangible, and well-being-outcome-related impact, including exposure-normalized pollution load (PM2.5, population-normalized), health proxy variables (number of heat-related incidents, respiratory hospitalizations where available), walkability metrics, time poverty (lost hours due to commuting time and waiting time in queues), and equity of access to services (dispersion/Gini coefficient metrics). Finally, Subjective QoL and Legitimacy Indicators (Layer 5) aim to measure subjective, experiential, citizen-perceived values via survey research, crowd-sensing initiatives, or other participative means, including service satisfaction, sense of justice/fairness, trust in digital governance, trust in the transparency of AI governance decisions, sense of voice, and trust in

cybersecurity/privacy. The motivation to distinguish these layers stems from the fact that, through algorithmic governance, it can improve objective performance simultaneously with decreased subjective perception (for example, due to non-transparent decisions). Success in QAGIS means the achievement of convergence between objective QoL improvements and legitimacy, which makes it possible to assess whether it is practical to sustain and adapt these new AI governance projects in real-world urban settings.

Table 1 presents the proposed QoL-Algorithmic Governance Indicator System (QAGIS) as a structured framework for evaluating AI-based governance in smart cities through five complementary layers. The table operationalizes the logic that QoL impacts cannot be credibly inferred from service outputs alone, because AI interventions influence both technical decision processes and social legitimacy conditions.

Table 1.
A QoL-Oriented Indicator Concept for AI Governance

Layer	Indicator	Unit	Data Source	Frequency	Interpretation/Role
Layer 1: Urban Conditions (Baseline Exposure)	Air quality (PM2.5, NO_2, O_3)	µg/m	Environmental sensors, national monitoring	Hourly/ Daily	Population-weighted exposure index
Layer 1: Urban Conditions (Baseline Exposure)	Noise exposure	dB(A)	Noise sensors / GIS modelling	Daily/ Monthly	Day-night exposure differentiation
Layer 1: Urban Conditions (Baseline Exposure)	Accessibility to key services	Minutes	GIS + transport network data	Monthly/ Quarterly	Average travel time to healthcare, education, hubs
Layer 2: AI System Performance (Model Quality)	Predictive accuracy (forecasting)	RMSE/ MAE	Model validation logs	Per model update	Technical validity of prediction outputs
Layer 2: AI System Performance (Model Quality)	Classification performance	F1/AUC	Model validation logs	Per model update	Robustness in event classification
Layer 2: AI System Performance (Model Quality)	Model drift stability	% change	Monitoring pipeline	Weekly/ Monthly	Detects degradation over time
Layer 2: AI System Performance (Model Quality)	Explainability coverage	% interpre-table outputs	XAI tools (SHAP/LIME	Per model update	Degree of transparency for oversight
Layer 2: AI System Performance (Model Quality)	Bias/fairness diagnostics	Parity ratio/ DI	Bias audit reports	Quarterly	Measures distributional harms
Layer 3: Governance Outputs (Service Delivery KPIs)	Mobility reliability	% punctuality	Transport operations data	Daily/ Weekly	Travel time predictability and punctuality

Cont. table 1.

Layer 3: Governance Outputs (Service Delivery KPIs)	Energy outage frequency	Events/ year	Utility grid logs	Monthly/ Yearly	Infrastructure resilience indicator
Layer 3: Governance Outputs (Service Delivery KPIs)	Environmental incident response time	Minutes	City management system	Per event	Speed of reaction to pollution spikes
Layer 3: Governance Outputs (Service Delivery KPIs)	Digital service completion rate	% successful trans-actions	E-government platform logs	Monthly	Administrative efficiency indicator
Layer 4: Objective QoL Outcomes	Exposure-adjusted pollution burden	Index	Sensor data + population maps	Monthly/ Quarterly	Captures health-relevant exposure
Layer 4: Objective QoL Outcomes	Time poverty (commuting + queues)	Hours/ month	Transport logs + surveys	Quarterly	QoL loss via wasted time
Layer 4: Objective QoL Outcomes	Spatial equity of service availability	Gini/ Dispersion index	Service registry + GIS	Yearly	Measures fairness across districts
Layer 5: Subjective QoL & Legitimacy	Citizen satisfaction with services	Likert scale	Citizen surveys/app feedback	Quarterly/ Semiannual	Perceived QoL improvement
Layer 5: Subjective QoL & Legitimacy	Trust in AI-supported governance	Likert scale	Citizen panels/surveys	Semiannual	Legitimacy and acceptance measure
Layer 5: Subjective QoL & Legitimacy	Perceived transparency of decisions	Likert scale	Citizen surveys	Semiannual	Signals explainability effectiveness
Layer 5: Subjective QoL & Legitimacy	Perceived fairness/inclusio n	Likert scale	Citizen surveys	Semiannual	Captures risk of marginalization

Source: Own study.

A QoL-oriented AI governance system should be conceptualized as a cyclical evaluation architecture rather than a one-time implementation of algorithms and dashboards. The fundamental reason is that cities are dynamic socio-technical systems: exposure conditions, mobility patterns, service demand, and citizen expectations change over time, which means that any AI model embedded in governance will inevitably face instability, drift, and shifting contextual constraints. The evaluation cycle begins with baseline mapping (Layer 1) to establish the initial state of urban conditions and service accessibility, followed by model and data validation (Layer 2) to confirm that AI systems are technically reliable, explainable, auditable, and fair before they influence public decisions. Without these first stages, later outcome improvements cannot be causally attributed to AI governance, and governance actors may mistake short-term correlations for genuine improvements.

The cycle then progresses to the operational level via operational monitoring (Layer 3), whereby the actual output effects of AI-driven governance on key service domains (transport, energy, environment, digital) are ascertained. Nevertheless, mere operational optimization does not represent a sufficient condition for AI-driven governance by itself. Thus, the subsequent

layers centre on collective, social-level results: QoL outcome evaluation (Layer 4), whereby modifications pertaining to concrete living circumstances (pollution load, time poverty, geographic distribution, health-related proxies) are ascertained, together with the quantification of subjective perceptions like satisfaction, fairness, transparency, and confidence regarding protection, via legitimacy and trust evaluation (Layer 5). This two-faceted outcome assessment has particular theoretical importance, as algorithmic governance may translate into improved technical efficiency on the one hand, but, on the other, culminate in social opposition if, for instance, the system is perceived as opaque, unjust, or unaccountable by the citizenry.

The evaluation model must include a structured feedback loop in which evidence from all layers triggers recalibration of models, redefinition of governance priorities, and systematic policy learning. In practice, this means updating datasets, adjusting model parameters or replacing models when drift is detected, redesigning decision rules to improve equity, and revising QoL targets based on citizen feedback. While this cyclical architecture aligns with theories of evidence-based governance and continuous improvement, it contributes an often-missing dimension: algorithmic legitimacy. Here, legitimacy is treated not as a normative slogan but as an indicator-driven condition for sustainability—meaning that AI governance is considered viable only if it remains transparent, contestable, and trusted over time, alongside measurable improvements in objective QoL outcomes (table 2).

Table 2.
Cyclical Evaluation Architecture for QoL-Oriented AI Governance

Cyclical stage/ element	**Purpose and evaluation focus**
Principle: cyclical architecture (not one-time deployment)	AI governance must be evaluated continuously because cities are dynamic socio-technical systems; exposure conditions, demand, mobility patterns and citizen expectations change, causing model instability and concept drift.
Layer 1: Baseline mapping (urban conditions)	Establish the initial state of the city (environmental exposure, accessibility, safety context) as baseline covariates enabling longitudinal comparison; prevents misleading attribution of changes to AI interventions.
Layer 2: Model and data validation (AI system quality)	Verify that AI models are technically and procedurally fit for governance: reliability, explainability, auditability, fairness, data completeness; ensures AI does not enter decision-making without methodological legitimacy.
Layer 3: Operational monitoring (governance outputs)	Track the measurable outputs of AI-supported governance in service sectors (mobility, energy, environment, digital services); demonstrates whether AI influences real operational performance, not only "pilot metrics".
Layer 4: Objective QoL outcome evaluation	Quantify tangible QoL outcomes causally linked to governance outputs (pollution burden, time poverty, spatial equity, health proxies); shifts evaluation from efficiency to citizen living conditions.
Layer 5: Subjective QoL and legitimacy assessment	Measure citizen perceptions (satisfaction, fairness, transparency, privacy confidence, trust); captures legitimacy constraints, since objective improvements may still trigger resistance if governance is perceived as biased or opaque.
Feedback loop: recalibration and policy learning	Evidence from all layers triggers updates: dataset refresh, model tuning/replacement under drift, redesign of decision rules (incl. equity constraints), QoL target adjustment via citizen feedback; operationalizes continuous improvement in AI governance.
Algorithmic legitimacy as a sustainability condition	Legitimacy is treated as an indicator-based requirement (not a philosophical add-on): AI governance is viable only when it remains transparent, contestable, trusted over time, and yields measurable QoL gains.

Source: Own study.

The article employs a comparative analysis methodology to evaluate business analytics educational programs in bachelor's and engineering degrees across selected Polish universities. This method was chosen because it enables a systematic examination of differences and similarities in curricula and their alignment with labour market demands. Moreover, it facilitates identifying trends, strengths, and weaknesses in educational approaches to prepare business analysts. This approach is consistent with the article's goal of examining how educational offerings match market needs.

The data sources were the syllabi from official university websites and course catalogues. These are primary sources of information, ensuring accuracy and relevance in the analysis of educational content. Each subject included in the study programmes was assigned skills that students could acquire by completing these courses. Since the study programs contain a huge number of subjects (several dozen), the research was narrowed down to subjects taught within the specializations related to data analysis.

Skills were grouped into four categories—analytical, technical, communication, and project management. This classification reflects the competencies expected of modern business analysts, as identified in industry reports and literature (e.g., PMI Guide to Business Analysis). It ensures the study's findings are directly applicable to workforce requirements. Five bachelor's degree programs and five engineering degree programs from leading Polish universities were selected for the analysis, including Silesian University of Technology, Warsaw School of Economics, University of Economics in Katowice, University of Szczecin, Adam Mickiewicz University in Poznań, Wrocław University of Science and Technology, Cracow University of Technology, Lodz University of Technology and Kielce University of Technology.

In addition, the analysis results were correlated with labour market data (e.g., wage reports and labour demand statistics). The source of this data were platforms such as wynagrodzenia.pl and Google Trends, as well as IT market reports. This ensures that the analysis is based on real-world relevance, linking education to industry.

4. Smart City Governance vs AI Governance

The difference between Smart City Governance and AI Governance is more than just semantic: rather, it corresponds to two different levels of analysis and two different objects for the governance (see table 3). In particular, Smart City Governance captures an umbrella term for the characterization of the coordination of cities in the presence of stakeholders, infrastructure, and public services in digitally enabled cities. It is thus primarily focused on the governance of the city as a sociotechnical system, in which technology is understood as an instrument which supports strategic objectives of efficiency, sustainability, resilience, and overall enhancement of citizens' quality of life. By contrast, AI Governance has primarily

been focused on the governance of AI systems themselves, and this encompasses issues like design choice, accountability, and risk management, without relation to the particular application domain of AI. This thus makes AI Governance more limited in scope but more detailed in technology and procedural terms, since AI Governance encompasses the entire life path of AI, from data governance in AI training up through auditing of AI system deployments (Abraham, 2025; Ottmann, 2025; Nieuwenhuizen, 2025). One of the major points of divergence relates to the governance target or the thing that is governed. Smart City Governance has the governance target as the delivery of urban services and the coordination of institutions related to transportation, energy, the environment, safety, digital administration, and engagement tools for the community. The role of AI, in this case, is only one of the enabling technologies for modernization in governance. AI Governance, with a focus on the algorithms, data, and decision pipelines, presents the governance target as the algorithms and data themselves and aims to create governance by defining the rules and control frameworks for making the outputs of AI more transparent, robust, reliable, and contestable. The importance of this viewpoint cannot be underestimated because the use of AI in smart city initiatives is increasing, and it is being used for prioritization and recommendations, which indirectly affects governance decisions (Sinha, Chopra, 2025; Hassan et al., 2024; Alakoum, Nica, 2024). The goals and performance logic of these governance concepts also differ. Smart City Governance evaluates success through service-level KPIs and QoL outcomes, including both objective indicators (e.g., pollution exposure, commuting times, service accessibility) and subjective assessments (e.g., citizen satisfaction and trust). AI Governance uses a different evaluation regime: model performance, drift stability, bias diagnostics, explainability coverage, and auditability. These metrics are not optional technical details; they constitute the conditions under which AI can be legitimately integrated into public governance. Thus, Smart City Governance answers whether the city functions effectively and inclusively, whereas AI Governance answers whether AI systems used in governance are controllable, reliable, and aligned with ethical and legal standards (Dash, 2024; Vella et al., 2025; Wolniak et al., 2025). Another distinction arises from the risk landscape. Smart City Governance is typically concerned with systemic urban risks such as infrastructure reliability, cyber threats, service disruptions, and inequalities in access to public goods. AI Governance focuses on algorithm-specific risks, including bias and discrimination, opacity ("black-box" decisions), automation bias in decision-making, dataset shift and concept drift, and the inability to attribute responsibility. These risks are qualitatively different because they can emerge even in high-performing service contexts. For example, a predictive policing or welfare allocation model may increase operational efficiency while simultaneously intensifying social inequality through biased training data, undermining legitimacy even if service KPIs appear improved (Varghese, 2025; Kusumasari, Yahya, 2025; Ambroselli, 2025).

The accountability structure further highlights the divergence. In Smart City Governance, accountability is generally institutional: elected officials, city departments, operators, and contractors can be held responsible through formal administrative and political procedures. In AI Governance, accountability becomes distributed and technically mediated. Responsibility may be shared among municipal authorities, AI vendors, data owners, model developers, and external auditors. This distribution complicates governance because it introduces gaps between decision authority and technical causality. In algorithmic systems, the "reason" for a decision may be embedded in complex model behavior rather than explicit administrative logic. Hence, AI Governance emphasizes traceability and audit trails precisely to reconstruct responsibility and enable contestability.

The relation between these concepts is best understood as a structural dependence: AI Governance often represents a requisite sub-system of Smart City Governance in cities that pursue algorithmic decision-support. A smart city may exist independently from comprehensive AI deployment-e.g., it may be focused on IoT monitoring and digital services-but it cannot responsibly deploy AI-based governance without AI Governance mechanisms. Hence, AI Governance represents the methodological and ethical infrastructure that enables algorithmic governance to become part of the general smart city governance framework without undermining transparency, accountability, or civic trust. In this sense, the table explains how Smart City Governance is directed toward the management of the city and its outcomes, while AI Governance is oriented toward the control of the technology that increasingly defines those outcomes.

Table 3.
Distinction between Smart City Governance and AI Governance

Dimension	Smart City Governance	AI Governance
Core focus	Governance of the city as a socio-technical system (public services, infrastructure, stakeholders) supported by digital technologies	Governance of AI technologies: design, deployment, monitoring, auditing, and accountability of AI systems
Scope	Broad: all urban domains (mobility, energy, environment, health, safety, planning, digital services)	Narrower and technology-focused: AI lifecycle (data → model → deployment → monitoring) across domains
Object of governance	Urban institutions and service ecosystems (public administration, PPPs, citizen participation)	AI models and decision systems (algorithms, datasets, risk controls, compliance mechanisms)
Primary goal	Improve service quality, efficiency, sustainability, resilience, and citizens' quality of life	Ensure safe, lawful, transparent, fair, and controllable use of AI while minimizing harms
Main drivers	Digital transformation, urbanization pressures, sustainability agendas, demand for better services	Rapid ML/AI diffusion, automation of decisions, opacity and bias risks, emerging AI regulation
Key mechanisms	Multi-stakeholder coordination, participatory governance, urban data platforms, performance dashboards	AI risk management, model auditing, explainable AI, fairness testing, drift monitoring, MLOps governance
Decision-making model	Institution-driven decisions increasingly informed by analytics and digital tools	Algorithm-influenced decisions (recommendations, predictions, scoring); potential semi-automation

Cont. table 3.

Typical instruments	Smart city strategies, service KPIs, policy programs, citizen engagement platforms, open data initiatives	AI policies, model/data documentation (model cards, datasheets), algorithmic impact assessments, audit trails
Ethical emphasis	Inclusion, equitable access to services, privacy in city platforms, legitimacy of public decisions	Fairness, non-discrimination, explainability, accountability, contestability, privacy-by-design
Data orientation	Open data, integrated city data ecosystems, IoT/sensor integration, interoperability	Data lineage, data quality and bias control, minimization, secure data pipelines, governance of training data
Performance evaluation	Urban service performance + QoL outcomes (objective indicators and subjective perceptions)	Technical and governance metrics: model performance, robustness, transparency, fairness, auditability
Risk landscape	Systemic urban risks: infrastructure failures, cyber risk, inequality, service disruption	Algorithmic risks: bias, black-box decisions, automation bias, drift, adversarial vulnerabilities
Accountability model	Institutional accountability (mayor/city council, departments, operators, contractors)	Distributed accountability: city authorities + vendors + data owners + model owners + auditors
Stakeholders	Citizens, NGOs, city departments, utility operators, private providers, academia	AI developers/engineers, data stewards, model owners, regulators, auditors, affected users
Outputs	Effective, adaptive, inclusive governance of urban services and development	Responsible AI deployment ensuring legitimacy, transparency, control, and prevention of social harms
Relationship between concepts	Umbrella concept structuring digital and service governance in cities	Typically a component/ subsystem within smart city governance, but can exist independently

Source: Own study.

5. Conclusion

This paper has explored the increasing use of Artificial Intelligence in the governance of smart cities by defining the use of AI in the governance of smart cities as an embedded governance system with quantifiable implications for society. The implications of this governor system were exemplified by the fact that the governance of smart cities can be defined as the integration of data environments, artificial intelligence analysis, and governance systems as mutually enabling technologies. This is an important definition because the focus of this issue is moved away from efficiency and towards the area of legitimacy.

The first objective of this paper (G1) was fulfilled by describing AI-driven algorithmic governance as a multi-layered system integrating (i) urban data ecosystems, (ii) AI models and decision-support analytics, and (iii) institutional structures of governance in general. By this multi-layered definition, it becomes clear that "AI in cities" is not only an operational optimization method, but it is mainly a socio-technical system of governance that affects not only how problems are defined, but how interventions should be treated as priorities, and how accountability may or may not be attained on a public governance level by applying this AI-driven socio-technical subsystem of governance in cities. By identifying advisory,

semi-autonomous, and fully autonomous dimensions of algorithmic interventions, and by indicating that governance outcomes depend on transparence, bias, and explainability characteristics of models, this paper offers a unified theoretical background on how this paradigm of governance should be understood, and not perceived as an add-on feature of governance at all.

The second goal (G2) was realized through the development of the QoL-oriented evaluation framework QAGIS, which operationalizes the causal chain from AI model quality to governance outputs and finally to citizen wellbeing. The framework explicitly avoids the methodological mistake of evaluating AI governance only through operational KPIs. Instead, QAGIS introduces a structured five-layer logic: baseline urban exposure conditions (Layer 1), AI system performance and procedural governance indicators (Layer 2), governance service outputs (Layer 3), objective QoL outcomes such as pollution burden, time poverty and spatial equity (Layer 4), and finally subjective QoL and legitimacy indicators including perceived fairness, transparency and trust (Layer 5). In this way, the paper establishes a measurable and audit-friendly structure for assessing whether AI governance actually improves quality of life without undermining accountability and public confidence.

A key implication of the proposed approach is that QoL-oriented algorithmic governance must be treated as a continuous cyclical evaluation architecture, not a one-time deployment of algorithms. Cities are dynamic systems characterized by demand shifts, mobility fluctuations, seasonal environmental variability, and evolving citizen expectations; therefore, AI models will inevitably face drift and contextual instability. The QAGIS logic supports governance learning through feedback loops: evidence from QoL outcomes and legitimacy indicators should trigger model recalibration, rule redesign, and policy adjustment. This interpretation positions legitimacy as a measurable sustainability condition: AI governance is viable only when it remains transparent, contestable, and trusted while delivering tangible QoL improvements.

This article advances smart city governance knowledge by shedding new light on the difference between Smart City Governance and AI Governance, thereby indicating that AI Governance needs to be a required subsystem whenever AI decision support has a strong impact on a particular smart city. Further smart city-related knowledge development may incorporate empirical evaluation, such as studying long-term effects on smart cities of deploying AI, as well as simulation tests regarding comprehensive indices like AI Governance Readiness, as well as building common data for comparison of smart cities.

The research has a conceptual nature, being framework-developing, hence it neither empirically verifies QAGIS in a real city setting nor investigates the causal effect of AI governance on QoL metrics. The indicator layers proposed are based on the underlying quality of the urban datasets, besides requiring effective monitoring systems, but the reality could be hindered by the presence of gaps in the data, lock-in effects, privacy restrictions, etc.

Future studies should empirically validate QAGIS in real smart-city deployments using longitudinal and quasi-experimental designs to identify causal QoL effects of AI-supported governance across sectors (mobility, energy, environment, digital services). Research should develop and test standardized measurement protocols for legitimacy-related indicators (trust, perceived fairness, perceived transparency) and investigate how these subjective constructs interact with objective QoL improvements under different levels of algorithmic autonomy.

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DETERMINANTS OF SOCIO-ECONOMIC DEVELOPMENT IN CITIES WITH COUNTY RIGHTS IN POLAND

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Purpose: The aim of the article is to identify and assess the conditions for socio-economic development in cities with county rights in Poland.
Design/methodology/approach: The article identifies and assesses the determinants of socio-economic development in cities with county rights in Poland. The empirical material of the article concerns all cities with county rights in Poland. The numerical data come from the Local Data Bank of the Central Statistical Office in Warsaw. The collected and organised empirical material was developed in descriptive, tabular, and graphical form, using the comparative analysis method. The article also makes a point assessment of the diagnostic features illustrating the determinants of socioeconomic development in selected groups of cities against the background of all cities with county rights in Poland, which is a new approach to the research problem.
Findings: The analysis of the collected and processed statistical data confirmed the research hypothesis put forward in the article, which assumes that cities with county rights in Poland are diversified in terms of the conditions of socio-economic development, with the group of cities with the largest number of inhabitants having the best situation in this respect.
Originality/value: The originality of the work lies in the approach to the analysis of the undertaken research issues. The article presents a point assessment of the diagnostic features illustrating the conditions of socio-economic development in selected groups of cities against the background of all cities with county rights in Poland. The work is addressed primarily to local government officials responsible for creating conditions, possibilities, and directions of socio-economic development of cities with county rights in Poland.
Keywords: conditions of socio-economic development, cities with county rights, Poland.
Category of the paper: research paper.

1. Introduction

Economic growth is the improvement of quantitative relations in the scope of the growth of production and services, consumption, production potential, etc., leading to an increase in their quantity per capita in a given country. The most important elements of economic growth are factors that ensure an increase in the flow of products and services, the sum of products and services per capita, and the rate of economic growth. Economic growth refers only to quantitative changes, assuming that basic macroeconomic values are characterised by a long-term trend. Economic development is a broader term because, in addition to quantitative changes, it also includes qualitative changes. Economic development means changes in the structure of the productive potential of the economy, the structure of production and consumption, socio-economic relations, and the system of functioning of the economy. It covers the entire sphere of human economic activities, both production activity and the division of produced goods, not only through quantitative growth, but above all through structural and qualitative changes in the broadly understood management process. Development is a category that is inextricably linked to change and time. Without changes, we cannot talk about development. In the most general terms, development is defined as an ongoing process of changes in which successive changes occur in an orderly manner and are maintained relatively permanently. This process consists of: progress, regression, and stagnation. Progress means changes assessed positively, regression negatively, while stagnation is a development phase characterised by a lack of changes. The broadest concept is socio-economic development, which, in addition to growth and development, also includes social and institutional changes. Economic growth means changes that are reflected by the relationships between numbers, and economic development adds qualitative changes to this. These concepts, often used interchangeably in practice, differ significantly from each other. The long-term issue that should be analysed is economic development and the factors that determine it that influence the growth of the international competitiveness of a given country. Achieving economic growth is one of basic goals of the economic policy pursued by the governments of most countries. Economic development is something natural today, inscribed in the economic order of each country. Therefore, socio-economic development can be defined as a process of desired changes, both quantitative and qualitative, not only in the economic sphere, but also in the social, cultural, political, institutional, systemic, etc. (Marciniak, 1997; Szałańska, 2000; Budnikowski, 2001; Miszczuk, Żuk, 2007; Kupiec, 2008; Jańczuk, 2013).

Each city is concentrated in a certain territory with its own separate administrative and political organisation. In connection with this, it can be treated as a specific organisation and a system of interconnected goals, structures, people, and procedures that can be distinguished from the environment. The size of the city, as well as the correlated offer of multidirectional possibilities and activities, and the diversity and complexity of the social, cultural and

organisational structure are the cumulative product of evolution in the process of historical development. However, the evolution of each urban centre is directly related in terms of feedback to the functioning and hierarchical changes of the entire system of cities at the regional, national, and international level. Only very few urban centres enter the path of transformations that lead to the formation of a metropolis during their development. Most urban centres, despite the structural and spatial changes that occur in them at different rates and scopes, remain in the initial phase of development. A metropolitan area is usually considered to be an urban centre with the surrounding zone of influence and connections that, through the multifunctional and specialised nature of space in terms of production and services, meets its own needs and those of the broadly understood region and attracts external activities. Urban centres, and in particular large urban agglomerations, often called metropolises, are a fundamental element of functioning regional structures. In this sense, the links between the socio-economic and political-cultural impact of urban centres and the functioning of regional systems are extremely strong. Therefore, cities are local government units with an exceptional influence on supralocal, and even regional, national and international development, because it is in them that the potentials, activities and entities deciding on its course are concentrated. The measure of a city's strength is primarily its ability to shape socio-economic development, including generating new solutions and new processes characterised by innovation and creativity (Wrana, 2013; Heffner, 2023).

The concept of a large city (metropolis) as an economic region was formulated using the theory of the economic base of the city. It is based on the assumption that all employment in a city can be divided into two sectors, i.e., primary and secondary. The first sector includes all types of activities that mainly meet external and export needs, and their location is the result of the impact of factors of national or international importance. On the other hand, the second sector includes those activities that are locally orientated, and their function is to meet the needs of the entire urban population and their immediate surroundings. They play a fundamental role in shaping the conditions of functioning of the urban structure and the level and quality of life of the residents, and are also an important element in attracting city-forming factors and influencing the image of the urban centre and its attractiveness. It should be added that the size of a city measured by the number of residents is usually a derivative of the sum of employment in both of the above sectors (Matwiejczyk, Glińska, Barkun, 2020; Heffner, 2023).

Larger urban centres, both in international, national, and regional systems, create hierarchical relations that depend on the scope and degree of development of the so-called central functions. They are considered typical urban functions and, in the classical sense, include the production of goods and the provision of services with varying degrees of specialisation. Urban centres with more central functions are located at higher levels of the hierarchy of the settlement system. The greater their concentration in the city, the greater its influence range. Central centres are also characterised by a larger population, which translates into offering a wider range of goods, services, and activities compared to cities from lower

levels of the settlement system hierarchy (Heffner, 1992; 2023; Duranton, Puga, 2014; Khiali-Miab, van Strien, Axhausen, Grêt-Regamey, 2019).

The effective implementation of urban policies is based on the role that individual cities due to their position in the hierarchical network of cities. In particular, it is about indicating which of them performs or is predisposed to perform the function of growth centres. In connection with this, the identification of the nodalness of cities takes place, i.e. their absolute importance in the urban network and centrality, i.e. the accumulation of functions that the city performs for its hinterland. Determining the centrality of cities in turn makes it possible to indicate the position of individual urban centres, as well as the nodal function they perform in the urban network, which is an important condition necessary to determine their potential as growth centers. It should be added that the following attributes are a manifestation of the fact that cities are becoming real centres of socio-economic growth and development:

- high attractiveness for entities seeking conditions for the implementation of unconventional, innovative projects,
- significant share in the city's economic structure of companies creating local and supra-local cooperation networks around themselves, including with the participation of entities transferring intellectual values to the economy,
- the presence of numerous potential partner entities in the city that enable enterprises to outsource functions and, as a consequence, specialise their own activities and constantly strengthen leading strategic competences,
- extensive relations connecting economic entities with scientific, research and development and educational institutions as well as with local government institutions. (Wrana, 2013; Heffner, 2023; Sobala-Gwosdz, 2023).

The socio-economic development of a territorial unit depends on the conditions in which it takes place and on the factors used or exploited. It can proceed in different ways according to different development models or scenarios, and it also brings different effects. Although a distinction is made in the literature between conditions and factors of development, conditions and factors are considered more often together or interchangeably under the name of factors. These conditions and factors are classified according to various criteria of a natural, spatial, economic, social, cultural, historical, or political nature. Another commonly used division is the division into internal and external factors or material and non-material factors. The factors of city development are understood as its resources and characteristic features that determine its growth. The scope of impact of the factors of urban development is strongly dependent on the specificity of their location in local, regional, national, and international systems. The factors indicated in the literature include, first of all:

- demographic situation, including the number of inhabitants,
- quality of human and social capital,
- culture,

- the economic and financial situation of the city as a local government unit,
- local economy, its structure and production capabilities,
- heritage,
- housing,
- the level of development of technical infrastructure,
- the ability to generate knowledge and improve technology related to the location of research institutes and universities,
- the presence of a creative class,
- post-industrial zones with strong potential and importance for the regional and local environment,
- urban transport infrastructure projects,
- strong urban regime,
- and marketing activities and eco-innovation strategies.

It should be added that each city develops using different potentials, and usually it is an original, own combination of the indicated factors, and the possibilities of their use also differ in terms of its different parts (e.g., districts). In turn, as research shows, the main factors of great importance for regional development are the size of the city expressed in terms of population, economic potential and employment structure (Jasnosz, 2008; Jadach-Sepioło, 2016; Krzysztofik, 2016; Adamowicz, 2020; Heffner, 2023).

Studies on the direction of changes in the level of development of Polish regions indicate that regional differences in Poland have been growing for a long time. The reasons for the persistence or even growth of differences in the level of socio-economic development of regions and their urban centres are diverse and often very complex. However, they lie primarily in:

- weakening demographic potential (outflow of population, deterioration of demographic indicators),
- shortage of very well-educated cities with metropolitan functions,
- weaker urbanisation (densifying and deconcentrating central parts of cities, numerous so-called "downtown voids"),
- poorer communication and transport accessibility,
- relatively low human and social capital,
- weak innovation trends,
- low level of entrepreneurship,
- technological maladjustment and backwardness (Heffner, 2010; 2023; Majorek, 2019; Korenik, 2020).

Moreover, an important cause of the growth of regional differences is the policy pursued in economic, socio-political, and cohesion practice that strengthens polarisation. In terms of the so-called polarisation-diffusion model, the polarisation component is implemented, i.e. the strengthening and development of the largest regional centres, while the process of

diffusion of development is much weaker both towards weaker regions and intra-regional systems, especially those with peripheral characteristics. The benefits resulting from this are revealed primarily in the low level of unemployment, high entrepreneurship and innovative activity, good condition of technical and transport infrastructure, and consequently also in much better accessibility, concentration of public sector investments, foreign investments and concentration of higher-order services. Therefore, economic and socio-political benefits are usually concentrated in metropolitan-type centres themselves and in relatively narrow zones of their direct impact, not even moving to subregional-type centres, not to mention intra-regional peripheries. Metropolises and some regional centres, focused on increasing their competitiveness at the supraregional, national, and international level, have only a small activating impact on their regional structures, which rather only constitute a base providing them with appropriate resources and means and multiplying their development potential (Dignan, 1995; Churski, 2014; Zarówna, 2014; McCann, Ortega-Argiles, 2015; Heffner, Gibas, 2017; Heffner, 2023).

2. Research aim, empirical material, and research methods

The aim of the article is to identify and assess the conditions of socio-economic development in cities with county rights in Poland.

The article puts forward a research hypothesis which assumes that cities with county rights in Poland are diverse in terms of the conditions of socio-economic development, with the best situation in this respect being that of the group of cities with the largest number of inhabitants.

The empirical material of the article concerns all cities with county rights in Poland. The numerical data come from the Local Data Bank of the Central Statistical Office in Warsaw. The collected and organised empirical material was developed in descriptive, tabular, and graphical form, using the comparative analysis method.

In order to identify and assess the conditions for socio-economic development in cities with county rights in Poland, the following diagnostic features illustrating them in 2023 were analysed: population density (population per 1 km^2), percentage of working-age population, nonworking-age population per 100 people of working age, natural increase per 1000 population, net migration for permanent residence per 1000 population, percentage of population using the water supply, sewage, and gas networks, total revenues of municipal budgets per capita (PLN), own revenues of municipal budgets per capita (PLN), share of own revenues in total revenues of municipal budgets (%), total expenditures of municipal budgets per capita (PLN), investment expenditures of municipal budgets per capita (PLN) and share of investment expenditures in total expenditures of municipal budgets (%).

In addition, the article included a point assessment of the analysed diagnostic features illustrating the conditions of socio-economic development in selected groups of cities against the background of all cities with county rights in Poland. Individual diagnostic characteristics were compared with the average for all cities with county rights, which was assumed to be 100 points, and their advantage or disadvantage in all selected groups of cities was assessed accordingly. Then, all points were summed up and the average was calculated (Figures 1-4). It should be emphasised that this is a new approach to the research problem undertaken in this article.

3. Results

As research shows, in national and regional settlement systems, there are most small urban centres and fewer medium-sized towns, while the number of large centres, and especially very large ones, is small (Cardoso, Meijers, 2017). The situation is similar among cities with county rights in Poland, where the largest share belongs to the group of cities with the smallest number of inhabitants, that is, up to 100,000 (43.9%). This is followed by the group of cities with the number of inhabitants 100-200 thousand (36.4%). On the other hand, the smallest is the group of cities with the highest number of inhabitants, i.e. 200 thousand and more (19.7%) (Table 1).

The data in Table 1 show that cities with county rights in Poland are very clearly differentiated in terms of population density. The group of cities with the largest number of inhabitants has the highest population density, while in the other two separate groups of cities with smaller numbers of inhabitants, it is much lower and close to the average for all cities with county rights in Poland. Additionally, the differentiation of this feature between individual cities is quite large in all of their separate groups, but it is the smallest in the group of cities with 100-200 thousand inhabitants.

The data in Table 1 indicate that the cities analysed in Poland are slightly diversified in terms of demographic features such as the percentage of the working-age population and the number of nonworking-age population per 100 people of working age. It should be noted, however, that both of these features are the most favourable in the group of cities with the largest number of inhabitants, while the worst situation in this respect occurs in the group of cities with the smallest number of inhabitants. It is also noteworthy that the differentiation of these characteristics between individual cities is almost negligible in all of their separate groups. Therefore, all of them are relatively homogeneous in this respect.

Table 1.
Selected features characterising demographic conditions in cities with county rights in Poland in 2023

Specification	Cities with county rights *			
	Total	**I**	**II**	**III**
Number of cities	66	29	24	13
Population density - people per 1 km^2				
Average	1506,3	1350,4	1460,4	1938,5
Variation coefficient V (%)	45,2	48,2	36,9	43,0
Percentage of working-age population				
Average	57,2	56,6	57,2	58,5
Variation coefficient V (%)	2,6	2,2	2,1	2,9
Non-working age population per 100 working age persons				
Average	74,9	76,8	74,8	70,9
Variation coefficient V (%)	6,0	4,9	4,8	7,2
Natural increase per 1000 population				
Average	-5,0	-5,0	-5,5	-3,8
Variation coefficient V (%)	51,6	51,7	43,4	68,3
Net migration for permanent residence per 1000 population				
Average	-2,7	-3,7	-2,5	-0,7
Variation coefficient V (%)	93,3	60,9	81,6	381,9

Table explanations: * I – cities with up to 100,000 inhabitants; II – cities with 100-200,000 inhabitants; III – cities with 200,000 inhabitants and more.

Source: Central Statistical Office in Warsaw.

Based on the data in Table 1, it should be stated that cities with county rights in Poland are clearly differentiated in terms of demographic features such as natural increase per 1000 inhabitants and net migration for permanent residence per 1000 inhabitants. In the case of both of these features, the best situation occurs in the group of cities with the largest number of inhabitants, and in the case of the second feature, i.e. net migration for permanent residence per 1000 inhabitants, it is the worst in the group of cities with the smallest number of inhabitants. In turn, the differentiation of these features between individual cities is large and very large in all their distinguished groups, and this is especially true for the group of cities with the largest number of inhabitants.

In cities with county rights in Poland, the best developed component of technical infrastructure is the water supply network, and the least developed is the gas network, and this applies to all of their separate groups, depending on the number of residents (Table 2).

Furthermore, there are no major differences between the separate groups of cities with county rights in Poland in terms of the access of their residents to the water supply, sewage and gas networks (Table 2).

It should also be noted that the differentiation of these characteristics between individual cities is small in all their separate groups, while it is greater in the case of a characteristic such as access to the gas network, and this applies especially to the group of cities with the smallest number of residents (Table 2).

Table 2.
Selected features characterising infrastructure conditions in cities with district rights in Poland in 2023

Specification	Cities with county rights *			
	Total	I	II	III
Percentage of the population using the water supply network				
Average	97,6	97,0	98,3	97,3
Variation coefficient V (%)	2,6	3,4	1,7	1,6
Percentage of the population using the sewage system				
Average	92,5	92,7	92,0	93,0
Variation coefficient V (%)	4,7	4,3	5,7	3,6
Percentage of the population using the gas network				
Average	76,6	73,9	80,4	75,3
Variation coefficient V (%)	19,5	27,7	9,9	9,5

Table explanations: * I – cities with up to 100,000 inhabitants; II – cities with 100-200,000 inhabitants; III – cities with 200,000 inhabitants and more.

Source: Central Statistical Office in Warsaw.

The data in Table 3 show that cities with county rights in Poland are slightly differentiated in terms of the value of total revenues of city budgets per capita in PLN. The highest value of this revenue is noted in the group of cities with the smallest number of inhabitants and the lowest in the group of cities with a population of 100-200 thousand. Additionally, the differentiation of this feature between individual cities is small in all of their distinguished groups, and there are no major differences in this respect between them.

The data in Table 3 indicate that the cities analysed in Poland are clearly differentiated in terms of such economic and financial features as: the value of city budgets' own revenues per capita in PLN and the share of own revenues in the total revenues of city budgets. In the case of both of these features, the best situation occurs in the group of cities with the largest number of inhabitants, then the group of cities with a population of 100-200 thousand, and the worst is in the group of cities with the smallest number of inhabitants. It should be added that the differentiation of these features between individual cities is small in all of their distinguished groups, and it is smaller in the case of the second feature, i.e. the share of own revenues in the total revenues of city budgets.

Based on the data in Table 3, it should be stated that cities with county rights in Poland are differentiated in terms of the the value of total expenditure of city budgets per capita in PLN. The highest value of these expenditures is characteristic of the group of cities with the largest number of inhabitants, whereas in the other two separated groups of cities this value is lower and similar. The differentiation of this feature between individual cities is, in turn, small in all their separated groups, and there are no major differences in this respect between them.

Table 3.
Selected features characterising the economic and fi Total revenues of city budgets per capita in PLN nancial conditions in cities with district rights in Poland in 2023

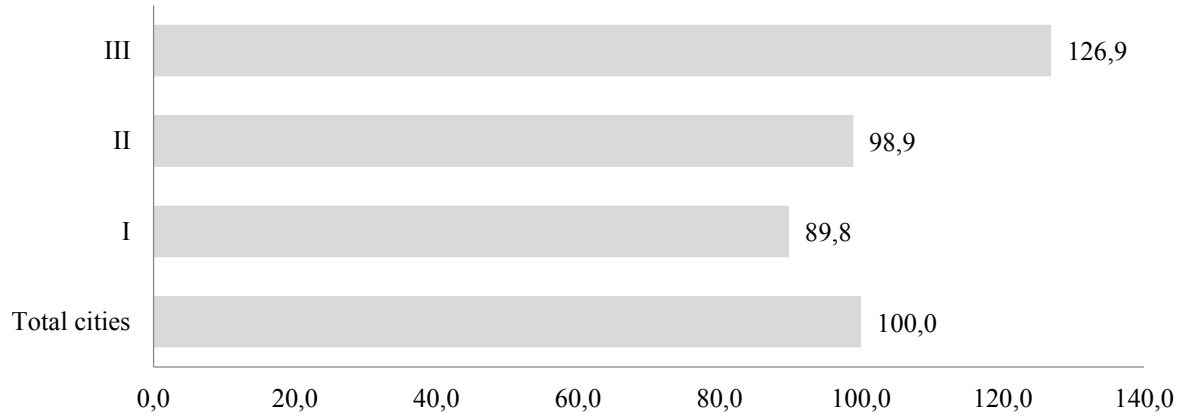
Specification	Cities with county rights *			
	Total	I	II	III
Total revenues of city budgets per capita in PLN				
Average	8940,8	9122,0	8675,3	9026,9
Variation coefficient V (%)	17,7	21,7	14,4	12,3
Own revenues of city budgets per capita in PLN				
Average	4610,4	4229,3	4562,9	5548,4
Variation coefficient V (%)	27,8	32,4	20,2	22,5
Share of own revenues in total revenues of city budgets in %				
Average	51,3	46,1	52,4	60,9
Variation coefficient V (%)	16,4	15,7	9,3	11,2
Total expenditure of city budgets per capita in PLN				
Average	9518,6	9453,2	9310,7	10048,5
Variation coefficient V (%)	16,6	19,8	13,6	13,9
Investment expenditure of city budgets per capita in PLN				
Average	1514,7	1429,0	1530,3	1677,0
Variation coefficient V (%)	51,4	59,9	51,2	35,6
Share of investment expenditure in total expenditure of city budgets in %				
Average	15,4	14,5	15,9	16,6
Variation coefficient V (%)	38,2	41,4	39,3	29,8

Table explanations: * I – cities with up to 100,000 inhabitants; II – cities with 100-200,000 inhabitants; III – cities with 200,000 inhabitants and more.

Source: Central Statistical Office in Warsaw.

The data in Table 3 show that the cities analysed in Poland are diversified in terms of such economic and financial characteristics as the value of investment expenditures of city budgets per capita in PLN and the share of investment expenditures in total expenditures of city budgets. In the case of both of these features, the best situation occurs in the group of cities with the largest number of inhabitants, followed by the group of cities with a population of 100-200 thousand, while the worst situation occurs in the group of cities with the smallest number of inhabitants. Moreover, it should be noted that the differentiation of these features between individual cities is large in all of their distinguished groups, while it is smaller in the case of the second feature, i.e., the share of investment expenditures in total expenditures of city budgets, and this is especially true for the group of cities with the largest number of inhabitants.

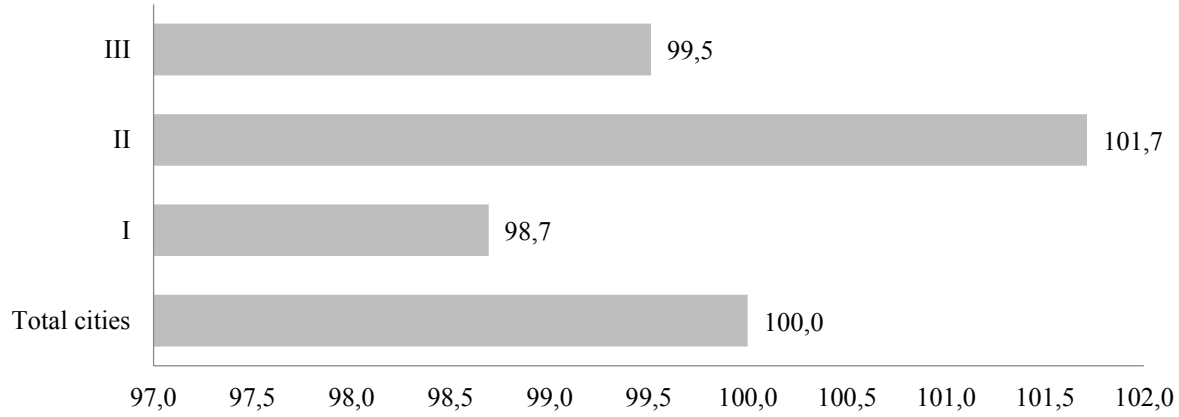
Figure 1 presents the results of the point assessment of the diagnostic features illustrating the demographic conditions of socio-economic development in selected groups of cities, depending on the number of their inhabitants, against the background of all cities with county rights in Poland. It should be noted that these conditions are clearly differentiated between the selected groups of cities. The best demographic conditions of development are characterised by the group of cities with the largest number of inhabitants, while they are the worst in the group of cities with the smallest number of inhabitants. In turn, in the group of cities with a population of 100-200 thousand, they are the closest to the average for all cities with county rights in Poland. This therefore partially confirms the research hypothesis put forward in the work.



Explanations: I – cities with up to 100,000 inhabitants; II – cities with 100-200,000 inhabitants; III – cities with 200,000 inhabitants and more.

Figure 1. Point evaluation of diagnostic features illustrating demographic conditions of socio-economic development in selected groups of cities against the background of all cities with county rights in Poland (total cities = 100.0 points).

Source: Own study.

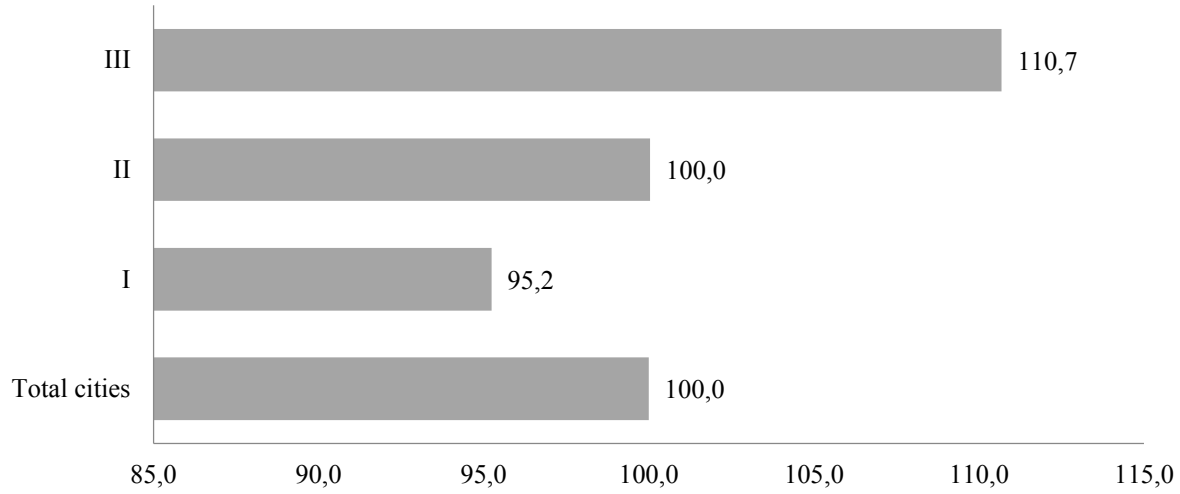


Explanations: I – cities with up to 100,000 inhabitants; II – cities with 100-200,000 inhabitants; III – cities with 200,000 inhabitants and more.

Figure 2. Point evaluation of diagnostic features illustrating the infrastructure conditions of socio-economic development in selected groups of cities against the background of all cities with county rights in Poland (total cities = 100.0 points)

Source: Own study.

Figure 2 presents the results of the point assessment concerning the diagnostic features illustrating the infrastructure conditions of socio-economic development in the selected groups of cities, depending on the number of their inhabitants, against the background of all cities with county rights in Poland. In view of this, it should be stated that in all the selected groups of cities, the analysed development conditions are very similar and close to the average for all cities with county rights in Poland.



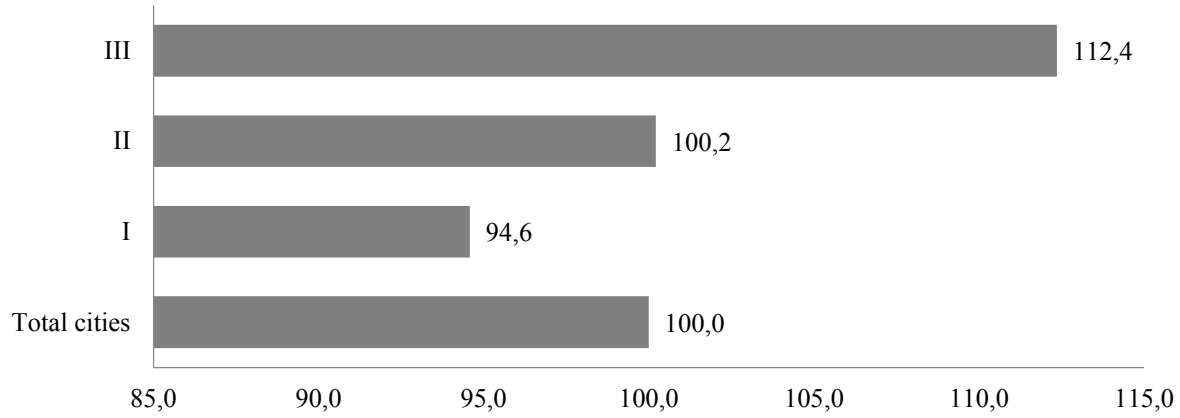
Explanations: I – cities with up to 100,000 inhabitants; II – cities with 100-200,000 inhabitants; III – cities with 200,000 inhabitants and more.

Figure 3. Point evaluation of diagnostic features illustrating the economic and financial conditions of socio-economic development in selected groups of cities against the background of all cities with county rights in Poland (total cities = 100.0 points).

Source: Own study.

Figure 3 presents the results of the point assessment of the diagnostic features illustrating the economic and financial conditions of socio-economic development in selected groups of cities, depending on the number of their inhabitants, against the background of all cities with county rights in Poland. It follows from this that the selected groups of cities are diverse in terms of the analysed development conditions. The best economic and financial conditions occur in the group of cities with the highest number of inhabitants. In the group of cities with a population of 100-200 thousand, they are identical as in the case of all cities with county rights in Poland. On the other hand, the worst situation in this respect is characterised by the group of cities with the smallest number of inhabitants. Therefore, this partially confirms the research hypothesis formulated in the work.

Figure 4 presents the results of the point assessment concerning all diagnostic features illustrating the conditions of socio-economic development in the selected groups of cities, depending on the number of their inhabitants, against the background of all cities with county rights in Poland. On this basis, it should be stated that the selected groups of cities are diverse in terms of the development conditions. The best conditions of socio-economic development are distinguished by the group of cities with the largest number of inhabitants, while the worst are in the group of cities with the smallest number of inhabitants. On the other hand, in the group of cities with a population of 100-200 thousand, these conditions are the closest to the average for all cities with county rights in Poland. This therefore confirms the research hypothesis put forward in the work.



Explanations: I – cities with up to 100,000 inhabitants; II – cities with 100-200,000 inhabitants; III – cities with 200,000 inhabitants and more.

Figure 4. Point evaluation of all diagnostic features illustrating the conditions of socio-economic development in selected groups of cities against the background of all cities with county rights in Poland (total cities = 100.0 points).

Source: Own study.

4. Summary and conclusions

The analysis of the collected statistical data conducted in the article allows the following conclusions to be drawn:

- ✓ cities with county rights in Poland are clearly differentiated in terms of such features as population density, natural increase, migration balance, value of city budgets' own revenues per capita, and share of own revenues in total city budget revenues,
- ✓ separate groups of cities with county rights in Poland are clearly differentiated in terms of demographic conditions for socio-economic development, with the best occurring in the group of cities with the largest number of inhabitants, and the worst in the group of cities with the smallest number of inhabitants,
- ✓ in cities with county rights in Poland, the best developed component of technical infrastructure is the water supply network, and the worst is the gas network, and this applies to all their separate groups, depending on the number of inhabitants,
- ✓ in all separate groups of cities, the infrastructural conditions for socio-economic development are very similar and close to the average for all cities with county rights in Poland,
- ✓ cities with county rights in Poland are diversified in terms of the economic and financial conditions for socio-economic development, with the best ones being in the group of cities with the largest number of inhabitants, while the worst are in the group of cities with the smallest number of inhabitants.

In addition, the analysis of statistical data allows for the confirmation of the research hypothesis, which assumes that cities with county rights in Poland are diverse in terms of the conditions of socio-economic development, with the best situation in this respect being the group of cities with the largest number of inhabitants. In view of the above, it should be stated that the number of inhabitants is an important factor that positively affects the conditions and possibilities of socio-economic development in cities with county rights in Poland.

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SEARCH SPACE FOR THE OPTIMAL PRODUCTION PLACEMENT

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Purpose: The purpose of the paper is to develop a conceptual framework for identifying the search space for the optimal production placement (SSOP) and to systematize the main factors that determine its formation. The study aims to demonstrate that the correct definition of SSOP is a fundamental stage in justifying optimal production placement.
Design/methodology/approach: The study is based on a systemic and conceptual analysis of spatial economic organization. The authors apply a theoretical synthesis of location theory, facility location research, and contemporary developments in global production organization. On this basis, a classification approach is used to distinguish different types of SSOP and to analyze the influence of production-side and place-side factors on their formation.
Findings: The research identifies five main types of search space for optimal production placement: global (universal), nationally secure, economically secure, production-logical, and place-logical. It is demonstrated that the boundaries of SSOP are determined by economic, technological, security, and spatial factors. The study shows that the same optimality criterion may lead to different location decisions depending on the type of SSOP adopted. Therefore, the correct definition of SSOP becomes a critical prerequisite for scientifically justified decisions on production placement.
Research limitations/implications: The study is conceptual in nature and focuses primarily on the theoretical justification and classification of SSOP types. As such, it does not provide empirical validation or quantitative testing of the proposed framework. Further research is required to identify and systematize detailed subtypes within the production-logical and place-logical SSOP, as well as to develop robust quantitative methods and models for determining SSOP boundaries for specific goods, technologies, and market conditions. In addition, future studies should incorporate empirical case analyses and comparative cross-country research to verify the applicability of the proposed approach under different economic, technological, and institutional settings.
Originality/value: The paper proposes a systematic conceptualization of the search space for optimal production placement and introduces a structured typology of SSOP. The study highlights the importance of explicitly incorporating SSOP boundaries into the formulation of optimal location criteria, which is often overlooked in traditional location analyses.
Keywords: spatial economic organization; location factors; production location.
Category of the paper: Research paper.

1. Introduction

Research on issues related to improving the placement of goods production is important, as optimal production placement is a significant and sometimes even a decisive factor in its efficiency. Therefore, production placement should not be carried out on random or intuitive decisions, but requires scientifically grounded methodological approaches. One of the promising areas for improving the production placement is the research of the search space for the optimal placement (SSOP). Correct identification of the SSOP makes it possible to reduce the volume of spatial modeling, which, in turn, enables the simplification, cost-effectiveness, and acceleration of information support processes without losing the quality of scientific justification.

The issue of the correct spatial economic organization, within which the concept of SSOP was formed, has been the subject of research since the inception of economic science. Despite the long history of this research, a systemic answer to the key problems of SSOP has not yet been formulated (Drezner, Eiselt, 2024; Card et al., 2025; Marianov, Eiselt, 2024). This applies both to research on the optimal production placement of material goods (Melo et al., 2009; Owen, Daskin, 1998; Chakravarty, 2005) and to the production placement of intangible goods, i.e., services (Roig-Tierno et al., 2013; Fildes et al., 2022; Hernandez, Bennison, 2000). Some research focuses on the factors that determine production placement (Falck, Heblich, 2008; Krenz, 2024; Mueller, Morgan, 1962), while others focus on the barriers that limit it (Cordeiro et al., 2024; Newell et al., 2006; Alsheyadi, 2024). Research focusing on SSOP in high–production-cost countries is of particular scholarly value (Kano et al., 2020; Ancarani, 2019; Castagnoli, 2022). A significant amount of scientific research is focused on developing methods for justifying the optimal placement of facilities in various fields (Hale, Moberg, 2003; Hamacher, Nickel, 1998; Eldemir, Onden, 2016), with the aim of creating universal approaches suitable for improving the spatial economic organization, in particular through improving the identification of SSOP. A critical review of the existing body of research on the search space for optimal production placement (SSOP) across specific strands reveals a pronounced bias toward the analysis of individual regions (Malecki, 1987; Sekeroglu, Celik, 2025; Sternberg, 2022) and countries (Bakar et al., 2022; Deichmann et al., 2008; Mohammed, Luundo, 2019), thereby reflecting a predominantly political-geographical orientation. However, the absence of a systemic and integrative analytical framework results in a fragmented understanding of the phenomenon, leaving insufficiently explored a wide range of factors that have shaped, continue to shape, and are likely to shape the formation of SSOP.

2. Types of search space for the optimal placement (SSOP)

According to the approach developed in our previous research (Stadnicki, Terebukh, 2022; Stadnicki, Bashynska, 2023), one of the key stages in justifying production placement is to define the space boundaries in which the search for a location or a system of locations for effective (optimal) placement is conducted. SSOP can cover various levels: from global (including the entire planet and even outer space, which, due to its properties, is gradually becoming attractive for the production placement of certain goods) to local (for example, a basic-level administrative-territorial unit or part thereof). The size of the SSOP is determined by a system of factors, among which economic, technological, and security factors are key. According to the proposed approach, it is reasonable to identify the following types of SSOP:

1. Global (universal) — covers the entire planet and outer space.
2. Nationally secure — formed in accordance with state decisions.
3. Economically secure — depends on investor decisions.
4. Production-logical — determined by the characteristics of the "production" side.
5. Place-logical — determined by the properties of the "place" side.

The global (universal) type of SSOP means that the search for a location or locations for effective (optimal) placement is carried out within the widest possible spatial boundaries — not only within the jurisdictions of individual countries, but also in areas outside their sovereignty. Such areas do not belong to any state, but are regulated by international law. These include, in particular, the deep-sea floor and outer space.

The issue of production placement in outer space deserves attention as an emerging extension of the global (universal) SSOP. At the present stage, space-related production activities can be grouped into three main areas: information systems (e.g., communication, navigation, Earth observation), scientific research in microgravity conditions, and industrial production of advanced materials for high-tech industries.

In addition, prospective directions include resource extraction from celestial bodies, space tourism, and waste disposal. The unique properties of space — such as microgravity, vacuum, and high solar energy availability — create specific conditions for material processing, enabling the production of high-purity crystals, advanced pharmaceuticals, and materials with enhanced physical properties.

In the long term, space industrialization is increasingly considered a potential response to global challenges such as environmental degradation and resource scarcity. However, due to current technological and economic constraints, outer space should be treated primarily as a potential, rather than dominant, component of the global SSOP.

Choosing a global type of SSOP during the determination of production placement ensures that the realistic optimal options (rather than the “calculated optimal” options, obtained as a result of incorrect determination of the SSOP type) are not left out of the analysis. At the same

time, this approach requires significant calculations for a large number of potential locations, taking into account production costs for different capacity options and transportation costs to all possible sales markets. Therefore, if abandonment of the global SSOP type does not create a risk of obtaining incorrect results and does not affect the validity of the conclusions, it is advisable to narrow the search space to rational boundaries that correspond to the purpose and context of a particular study.

One of the key factors limiting the SSOP is national security. The COVID-19 pandemic and Russia's military aggression against Ukraine have been powerful catalysts for many countries and intergovernmental associations to establish a nationally secure type of SSOP for the production of strategically important goods — electricity, medicines, food, weapons, etc. The definition of this type of SSOP means that the appropriate goods may be sold on the market of a particular country (or integration association) only if their production is located on the territory of that country or, in extreme cases, on the territory of allied countries (e.g., other EU members). Given the growing risks of disruptions in global logistics chains caused by the pandemic and geopolitical factors, external cost advantages are gradually giving way to the priority of internal supply stability.

A striking example of the implementation of a nationally secure type of SSOP is "Pharmaceutical Strategy for Europe", which aims to reduce dependence on supplies from third countries (primarily China and India) by creating conditions for the production placement of critically important medicines within the EU. As of 2020, more than 60% of the raw materials used by the European pharmaceutical industry came from these countries. Disruptions in pharmaceutical production in Asia, export bans, and transport restrictions related to the COVID-19 pandemic have caused medicine shortages and price increases in the European market. In response, the EU's strategic goal is to strengthen pharmaceutical autonomy by transferring the production of medicines and active pharmaceutical ingredients (APIs) to the territory of EU member states, which should increase the resilience of the healthcare system and its ability to respond to crisis situations.

After 2022, and especially since early 2024-2025, the EU has experienced a strategic shift toward the accelerated development of its own defense-industrial complex (DIC), resulting from a decline in the United States of America's willingness to guarantee European security. The new EU strategy for the defense industry (European Defense Industry Strategy, EDIS) provides for:

- investment in European weapons and ammunition factories,
- financial and political support for the location of DIC enterprises in EU member states,
- prohibition or restriction of cooperation with arms and ammunition manufacturers outside the EU, even if their products are cheaper or technologically attractive (in particular, with Israel, South Korea, and the USA).

Sometimes, in order to strengthen national security, the concept of a nationally secure type of SSOP is applied not only at the level of the country as a whole, but also to individual components of its territorial structure. In Poland, these levels are gminas, counties, and provinces. In this case, the production of certain goods intended for consumption within a specific administrative unit must be located within its territory. Similarly, the concept of energy self-sufficiency of gminas, the smallest administrative units in Poland, is implemented (Stec, Szymańska, 2022).

The concept of energy self-sufficiency of gminas in Poland is a strategic initiative aimed at providing each gmina, the basic administrative unit of the country, with its own production of energy from renewable sources to meet local needs. This approach combines energy security, environmental sustainability, and economic efficiency at the local level. Within this concept, there is no single national standard for the share of energy that needs to be covered by local production. At the same time, the results of studies conducted in a number of Polish gminas show that the potential of renewable energy sources can meet up to 76.1% of the needs of the local community (Woch et al., 2017).

The need to strengthen national security is the main driver behind the development of the concept of energy self-sufficiency for gminas in Poland. With the growing threat from Russia, especially after the full-scale invasion of Ukraine, it has become clear that centralized energy systems are highly vulnerable: a single enemy sabotage is enough to leave a significant part of the country without power. Distributed (decentralized) energy production offers several strategic advantages:

- greater resistance to attacks — the enemy is physically incapable of destroying thousands of small installations located throughout the country,
- community autonomy — a gmina can function independently for a certain period of time, even in case of a large-scale energy crisis,
- rapid recovery — damaged elements are easy to replace, unlike large energy hubs,
- increased local responsibility and participation — communities invest directly in their own energy security.

This logic is consistent with Ukrainian approaches to critical infrastructure protection, in particular, the development of autonomous power sources for hospitals, schools, and local authorities. In Poland, this model is supported by both the government and the EU as part of its energy transition programs (Green Deal). At the same time, it is based on a pragmatic response to the immediate threat of war.

In terms of improving the economic security of companies, the COVID-19 pandemic has led to a profound structural reassessment of risks in global logistics chains. Companies are increasingly shortening their length, strengthening their own resilience and supply chain management. Production is returning closer to key sales markets in order to:

- reduce logistical risks (supply disruptions, delays, rising transport costs),
- improve quality control and technological processes,
- cost reduction under conditions of rising freight rates.

In addition to traditional criteria (salary levels, tax conditions, access to resources), modern companies are increasingly taking additional factors into account:

- the possibility of disruptions in logistics,
- infrastructure stability (transport networks, energy supply),
- geopolitical stability.

The management of these risks is gradually being integrated into corporate strategies as a separate component of the risk management system. This means that the production placement is considered not only through the prism of costs and revenues, but also as a tool for ensuring the long-term sustainability of the business model. Companies are creating special units to monitor geopolitical and infrastructure risks, applying scenario planning, and diversifying supplies to minimize the likelihood of critical disruptions. Thus, spatial decisions in production are increasingly becoming an element of strategic risk management.

In modern conditions, the SSOP of production is gradually narrowing toward more stable, less distant, and more predictable locations, even if they are not characterized by minimal costs. In other words, an increasingly higher priority in production placement is given to those spaces that ensure short, controllable logistical chains and a high reliability of supply. A striking confirmation of this trend is the relocation of part of the production of American and European companies from China to Mexico, Poland, Turkey, and the Baltic countries — that is, to countries that combine relative proximity to sales markets with political and economic stability.

The concepts of “reshoring” and “nearshoring” are closely related to nationally and economically secure types of SSOP. “Reshoring” is the process of returning production to its country of origin after it has been moved abroad (usually to countries with lower production costs, such as China, India, or Vietnam). The main goal of “reshoring” is to reduce logistical risks, shorten supply chains, strengthen product quality control, and strengthen the national economy by creating new jobs and preserving technological sovereignty. An example is a USA company that manufactured electronics in China but decided to move part of its production back to the USA due to geopolitical tensions, increased moving costs (transportation costs and customs duties), and a desire for greater supply chain resilience.

“Nearshoring” is the transfer of production capacity from distant countries (e.g., in Asia) to geographically closer countries. This approach reduces logistics costs and delivery times, lowers the risks associated with disruptions in global supply chains, and simplifies communication between the producer and the sales market. An example is a German company that previously produced automotive components in China but decided to locate its plant in Hungary or Poland to be closer to the European sales market.

A comparison of "reshoring" and "nearshoring" is provided in Table 1.

Table 1
Comparison of Reshoring and Nearshoring

Characteristic	Reshoring	Nearshoring
Location of transfer	To the country of origin	To a geographically closer country
Main goal	Regaining control and stimulating the national economy	Reducing logistics costs and risks
Often associated with	Political motives	Economic expediency
Typical example	Relocation of production from China to the USA, owned by USA investors	Relocation of production from China to Mexico, owned by USA investors

Source: own elaboration.

Often, the factor that determines the formation of SSOP (production-logical type of SSOP) is the properties of the "production" side, which are related to:

- the goods to be produced,
- production technology,
- the resources needed for the production process,
- pollution generated as a result of production.

The production-logical type of SSOP largely depends on the specifics of the goods to be produced. An illustration of this is the centralized heat supply system in a settlement where the heat source (thermal power plant or boiler house) must not be located more than 10 km from consumers. In such a situation, the SSOP is defined as a circle with a radius of 10 km centered on the respective settlement. A similar principle applies to the production of certain confectionery products, which cannot be located more than 30 km from the sales market. At the same time, it is possible to produce for several sales markets, which leads to competition with producers located outside the 30-kilometer SSOP around a single market (for example, a city). This affects the choice of a specific location within the SSOP, but does not change its boundaries.

Thus, the SSOP is determined by the properties of the 'production" side, while the "competition chain" affects not the SSOP, but the optimal locations within its boundaries. This does not lead to the formation of a single large SSOP serving many sales markets, although it does create a transitive interaction effect, where production can become part of a broader chain rather than just a local service center. Thus, the SSOP is determined by the internal characteristics of production, and the optimum within its boundaries is formed under the influence of external strategic interrelationships. This position is universal and applies to infrastructure and network solutions — energy, logistics, water supply, education, etc.

The impact of technology on the formation of SSOP is best illustrated by electricity generation, which is possible using various technologies, resulting in significant differences in the determination of SSOP. For example, coal-fired power generation (1) is concentrated in areas where this resource is extracted, as it is cheaper to transmit electricity to consumers than to transport large volumes of coal for production close to the sales market. The location of

electricity generation by solar power plants (2) is focused on areas with high solar radiation potential. Only when the intensity of solar flux exceeds a certain threshold can a specific location be considered promising for the placement of a solar power plant.

The location of electricity generation by burning natural gas (3) is focused on areas with concentrated demand, as transporting gas by pipeline for production close to the sales market is relatively cheap. The location of power plants in close proximity to consumers makes it possible to avoid the electricity losses that inevitably occur when it is transmitted over long distances. In addition, gas-fired power plants are characterized by relatively low levels of environmental pollution, which is an important factor when locating them in densely populated areas.

Electricity generation by wind power plants (4) is focused on areas with significant wind energy potential, since only when the wind flow intensity exceeds a certain threshold value can a specific location be considered promising for their placement. Thus, even with an identical benefit — electricity — the location factors and, accordingly, the SSOP for each production technology will be different.

The properties of resources significantly influence the formation of SSOP, which is best illustrated by low-mobility and immobile resources. For example, immobile climatic resources (solar radiation, wind, temperature regimes) naturally form the SSOP of the production of respective goods (e.g., tourism, energy, agriculture). In turn, the low mobility of fresh raw materials (e.g., fresh fish, vegetables, and fruits) is one of the key factors determining the SSOP of enterprises that process it. Fresh fish, vegetables, and fruits are characterized by:

- a short shelf life without processing (from several hours to several days),
- sensitivity to temperature and mechanical damage,
- a decrease in quality during long-term transportation, even under refrigerated conditions,
- high weight and volume at a low unit cost, which makes transportation economically inefficient over long distances in fresh form.

These properties make this fresh raw material immobile, i.e., difficult and unprofitable for long-distance transportation in its original form. Accordingly, processing plants are located near the places of origin — fruit growing or fishing.

The impact of pollution generated during the production process is an important factor in determining the search space for the optimal placement (SSOP). Enterprises whose activities are accompanied by significant levels of pollution tend to locate in areas where:

- environmental legislation is less stringent,
- enforcement of environmental standards is weak,
- payments for negative environmental impacts are low or non-existent.

An example is the relocation of many chemical and textile companies from EU countries to South Asia (in particular, Bangladesh, Pakistan, and Cambodia), where environmental standards remain low. Similarly, electronic waste (e-waste) is often processed in West African countries (Ghana, Nigeria), where hazardous substances are disposed of using primitive methods that are unacceptable in the EU.

Regarding the impact on SSOP of the characteristics (properties) of the "place" factor. This impact determines which features of a particular space (geographical, legal, political, infrastructural, etc.) make it promising or unpromising for a particular type of production. For example, mountainous areas are poorly suited for mass production due to logistics, but are well suited for tourism-related crafts (an example would be craft cheese production in the Alps). Desert areas are suitable for solar farms and hydrogen production, but have limited infrastructure for all other types of production. Thus, the properties of space determine not only the possibilities but also the limitations for the formation of SSOP, setting specific conditions for the optimal location of production.

A specific characteristic of the "place" dimension is the legal status of the relevant space, which can significantly influence the formation of SSOP. For example, special economic zones provide incentives that stimulate production, and the membership of countries in certain regional economic groupings creates a single economic space (e.g., EU countries). Regional economic integration is a process whereby several countries in the same region join forces to form a common economic space. It may include:

- the removal of trade barriers;
- coordinating economic policy;
- creation of supranational institutions.

The main goal of integration is to increase economic efficiency, expand markets, and strengthen competitiveness.

Looking at regional economic integration through the lens of SSOP, it can be argued that integration associations actually expand or reformat the SSOP of production. This happens due to:

- the removal or reduction of trade barriers — producers can choose the location without fear of export duties to participating countries,
- simplification of the movement of production factors — labor, capital, and technology move more freely,
- unification of standards and rules – the number of legal barriers between participating countries is reduced,
- joint infrastructure projects – new transport and energy corridors change logistics conditions.

Thus, regional integration not only removes barriers but also creates new opportunities for optimizing the location of production, influencing the formation of SSOP.

Another characteristic of the "place" factor that influences the formation of SSOP is the currency used within the relevant space (country or integration group) to finance expenses. A telling example is the decision made by the South Korean corporation Hyundai in the early 21st century to locate a new car plant in the USA. As a result, the city of Montgomery, Alabama, was chosen (production started in 2005). The basis for identifying the USA as SSOP was that the company received revenue from the sale of cars on the American market in US dollars.

If a significant portion of expenses (wages, utilities, localised components, energy) is paid in dollars, then:

- currency risk is reduced — the company does not need to convert large amounts of revenue into Korean or other currencies to cover expenses, and dependence on exchange rate fluctuations is reduced,
- financial planning becomes more stable — expenses and income in one currency make it easier to forecast financial flows and ensure the predictability of the business model.

An important characteristic of the "location" factor is infrastructure accessibility. Locations near ports, railways, and highways are strategically advantageous for many types of production. A prime example is the logistics parks in the Netherlands near Rotterdam, equipped with direct connections to the railway network, pipelines, and intermodal terminals. Accordingly, the space affected by infrastructure forms a specific SSOP, within which the optimal production placement is determined by the accessibility of transport and communication corridors.

An important characteristic of the "place" factor is demographic and social potential, as high-tech production requires a highly skilled workforce. This leads to a focus on locations near university cities, where an appropriate environment for knowledge and innovation is formed. Notable examples include IT clusters in Krakow, Lviv, and Brno. Since demographic and social potential has its own sphere of influence, it directly determines the formation of the respective SSOP.

Obviously, the above list of characteristics of the "place" that influence the formation of the SSOP is not exhaustive. At the same time, the examples given convincingly demonstrate that the characteristics of the "place" — geographical, legal, political, infrastructural, socio-demographic, and others — can significantly determine the parameters of the SSOP and form specific conditions for the optimal production placement.

When studying the issue of optimal placement of goods production, one should take into account the influence of the correct definition of SSOP on the choice of optimal locations and production volumes. The influence of SSOP lies in the fact that the justification of optimal decisions always refers to a specific SSOP, rather than an undefined space. Therefore, the application of the same criterion of optimal placement (for example, minimization of total production costs and costs of moving goods to sales markets) for different types of SSOP (for example, nationally secure or global) can lead to different results regarding the locations and volumes of production in these locations.

Thus, SSOP is so important that it must be taken into account when formulating the criteria for the optimal placement of goods production. The impact of SSOP is that any criterion for optimal placement applies specifically to a particular SSOP, rather than to an abstract space. Therefore, the formulation of the criterion must always include information about the boundaries of the SSOP. The criterion for optimal placement, taking into account SSOP, does not necessarily give a different result than the criterion without spatial restrictions. However, justification within one type of SSOP may lead to different conclusions about the optimal placement and production volumes than a similar justification within another type of SSOP.

3. Conclusions

In summary, we emphasize the key points:

1. The correct definition of the search space for the optimal placement (SSOP) is a determining factor in improving the production placement.
2. The issue of spatial economic organization, within which various forms of SSOP have been raised, has been studied since the very beginning of the development of economic science. At the same time, a systemic answer to these questions has not yet been formulated, as numerous important factors that have influenced, influence, and will influence SSOP have been overlooked.
3. It is advisable to distinguish five types of SSOP: global (universal), nationally secure, economically secure, production-logical, and place-logical.
4. The properties of the “production” side that influence the formation of SSOP are related to: the goods planned for production; production technology; resources necessary for production; pollution generated during production.
5. The properties of the “location” side that influence the formation of SSOP cover the characteristics of a specific space (geographical, legal, political, infrastructural, etc.) that make it promising or unpromising for a particular type of production.
6. The formulation of the criterion for optimal production placement must always include information about the boundaries of the SSOP, since the application of the same criterion to different types of SSOP can lead to different results regarding optimal locations and production volumes.

Further research on SSOP is promising in several areas. First of all, this concerns the identification of subtypes within the fourth (production-logical) and fifth (place-logical) types of SSOP, which will be based on the specific properties of the "production" and “location” sides. It is also important to justify the type of SSOP for various goods that can be produced using interchangeable technologies. In-depth research in these areas will contribute to the

improvement of the theory of SSOP for the goods production and, accordingly, the development of the theory of production placement, which is key to improving business efficiency.

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MANAGEMENT IN STUDENT ORGANIZATIONS – CHALLENGES FROM THE PERSPECTIVE OF 3 YEARS (2022-2025)

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Purpose: The study explores the challenges of management development in student organizations over a three-year period. Also, it detects similar patterns in the approaches to managing these issues.
Design/methodology/approach: Longitudinal qualitative approach, using semi-structured interviews conducted in 2022 and 2025.
Findings: In their work, students identify teamwork and motivational-related challenges rather than administrative ones (like funding). Actions that they take to handle them do not resolve issues but often change a problem or the emphasis on it to a different one.
Research limitations/implications: Research scope being confined to one university and a specific period. Future research could compare different institutions or extend the timeline to assess long-term trends.
Practical implications: The results are useful for supervisors, leaders, trainers, and other staff members connected with scientific organizations, as they provide practical guidance in today's reality of these organizations.
Social implications: Students can better prepare for societal challenges by consciously developing leadership and teamwork skills – by looking at common issues and patterns in other, similar student organizations.
Originality/value: The study provides a rare longitudinal insight into student organization challenges and management evolution across multiple years.
Keywords: student organizations, student projects, management, resilience.
Category of the paper: Research paper.

1. Introduction

The development of students' activity at universities is a multidimensional and dynamic phenomenon, reflecting both social changes and the evolution of universities themselves. Student organizations – including research clubs and cultural/social ones – play a significant role in shaping the competencies of future professionals as well as integrating the academic community and building the university's identity.

A literature review on student organizations was conducted using the PRISMA standard, based on keywords related to student organizations, student projects, and project management (since 2000). The Web of Science and Scopus databases were used. The aim was to answer the question: "How are student organizations described in literature?" What problems do they face? How have they changed over time?

1.1. Student organizations - overview

Student organizations are described as self-governing communities that allow students to develop many skills through non-academic activities. These include academic initiatives as well as social, sports, and artistic organizations. They conduct a wide range of activities, including primarily scientific and research projects, but also popularization, integration, and social initiatives. Participation in student organization activities significantly impacts student performance by developing social, professional, leadership, and time management competencies. However, excessive involvement or participation in too many of them can lead to time conflict and stress, which can negatively impact the outcomes of the course of study itself (Fu et al., 2024). Available articles also discuss strategies for supporting youth communities in educational environments, emphasizing the need for favorable conditions for activity, cooperation, and development (Wang, Deng, 2015; Munoz, 2016; Nolen et al., 2021; Gruzina et al., 2022).

1.2. Challenges

However, despite numerous successes and a rich tradition, the activities of these organizations face a number of challenges. These difficulties concern, for instance, physical aspects, such as limited funding, complex administrative procedures at universities, and a lack of space for activities (classrooms, laboratories) (Urania.edu.pl, 2024; Forum Kół Naukowych, 2022). On the other hand, there are attitudinal and organizational challenges. Research points challenges related to different organizational management models, internal cohesion, and member motivation. These challenges include, mismatches between members, unstable cohesion, limited practical benefits, lack of leadership or coordination, and high turnover of organizational members (Bush et al., 2017; Godwin, Ferrarese, 2014; Zhang, 2017; Yao, 2018; Ren, 2018; Dvorkin et al., 2015). Considering today's Generation Z is also important in this

context. They are characterized by greater individualism, a preference for short-term activities, and difficulties in long-term commitment to team projects (Katalog Aktywności Studenckiej, 2023).

The article "Student Organizations: State of the Art and Perspectives for Future Research" by Iwona Michałowska, Ewa Więcek-Janka, and Ada Domańska (Michałowska et al., 2023) presents a bibliometric analysis of research on student organizations from 1900 to 2022. The study identifies key trends, such as the standardization of student organization management processes modeled on university management and the challenges associated with overseeing diverse groups. The authors point out that existing research on this topic in scientific literature is limited, but its number is increasing year by year. They also emphasize the need for in-depth research on management models, competency development, and governance of these organizations in the academic environment.

1.3. Challenges

Analysis of the evolution of student organizations' problems indicates that despite the professionalization of organizational activities and increasing cooperation with external institutions (Hu et al., 2010), the basic challenges remain similar – financing, bureaucracy, access to infrastructure, and student motivation – and these challenges remain relevant and require constant monitoring and flexible support from universities.

1.4. Research Gap

Despite some studies and reports, there is a lack of in-depth comparative research on changes in student organizations' problems and the projects they implement over the medium term (several years). Most available publications focus on the current state or individual cases, omitting the broader historical and social context. The literature review raises the following question: "How do problems in student organizations change over the course of several years? What aspects do they primarily concern? Can the same problems occur within a few years?"

2. Methods

This chapter outlines the key points regarding the study's objectives, the methodological approach, the gathered data, and the tools used. These components are discussed both from a broad perspective and in detail.

2.1. Objectives and data collection

The aim of the research conducted was to check the status of student teams/projects, teamwork, delivery, problems and solutions. The study was divided into 2 stages, the first took place in 2022 and the second in 2025. This allowed to look closer at this environment and to observe whether there have been any changes in this area – research was done at the Wrocław University of Science and Technology (Poland). The main research questions were formulated as follows:

Q1: What is the current status of student project implementation and teamwork inside organizations? (2022; 2025)

Q2: What problems do student teams encounter and how do they try to solve them? (2022; 2025)

Q3: Is there a difference in the approach to teamwork in student projects between 2022 and 2025? (2022; 2025)

A significant challenge at this stage was the vast amount of information involved in project work - comprising many variables and interdependencies. One major uncertainty was determining which aspects to prioritize in research. Certain areas, such as individual members' private work habits or personal productivity tools, were intentionally excluded. They are important, but focusing on such details could dilute the study's impact by shifting attention away from core project activities. Instead, the data-driven strategy emphasized a broader, team-based perspective.

The selection of key data areas included:

1. Planning and work regularity – How actions are planned and how consistently the team works over time.
2. Goal orientation and success metrics – Clarity of purpose, focus on outcomes, and the use of performance indicators.
3. Communication and team dynamics – Internal communication practices and the quality of team relationships.
4. Team autonomy and responsibility – Level of self-organization, task delegation, and accountability mechanisms.
5. Delivery standards and learning – Definitions of task completion, project reviews, and learning from experience.

6. Leadership and organizational development – Evolution of leadership styles and how the organization matures.
7. Challenges – Recognition of recurring problems.

2.2. Research plan

The study was structured into three phases. The first phase involved an assessment of the existing state of knowledge regarding student-led organizations and projects (as a literature review). The second phase consisted of empirical research conducted in 2022. Whereas the third phase entailed the analysis and synthesis of the data obtained in the second stage. Three years later, a follow-up round of empirical research was carried out (2025). The findings from both data collection periods were subsequently compared, providing the basis for the final conclusions and responses to the research questions. A visual summary of the research process is presented below:

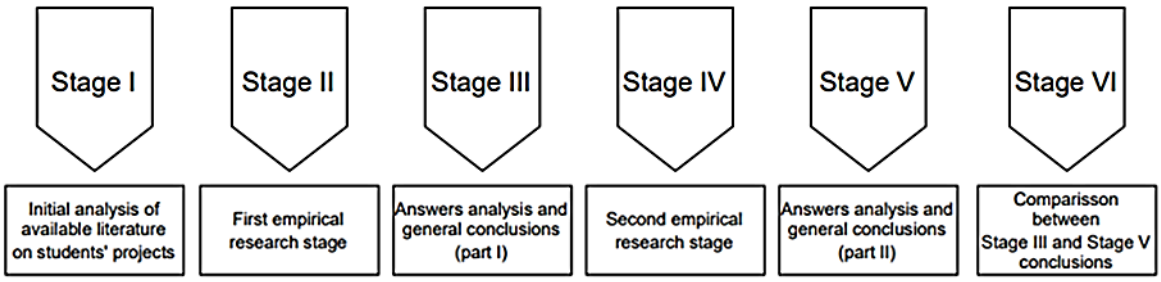

Figure 1. Research stages.

Source: Own elaboration.

2.3. Method

Once the objective and scope were established, the next step was to determine the most appropriate research method. The primary methodological choice was between quantitative and qualitative approach.

Given basic methods standard limitations (e.g. response rates), the authors opted for a qualitative research approach - specifically, semi-structured in-depth interviews (Creswell, 2014). To enhance the validity and depth of insights, the authors used a two-stage interview process (spread over time). This multi-phase design aligns with best practices in qualitative research, where iterative data collection helps refine findings and adjust lines of inquiry based on emerging themes (Seidman, 2013).

In the first stage, interviews were conducted with individuals in leadership roles and general members within the students' teams. Discussions focused on team structure, project goals, planning tools, and communication. In the second stage, interviews were carried out with the same-positioned people within organizations, from the same organizations as previously, but three years later. This two-stages approach enabled triangulation, improving the credibility and richness of the findings (Patton, 2002).

In summary, the chosen qualitative methodology, structured around two stages of individual interviews, provided a flexible, in-depth, and context-sensitive means of exploring team dynamics and project practices in student environments. This approach is well-aligned with Creswell's (2014) emphasis on using qualitative methods when the goal is to explore processes, meanings, and relationships that cannot be quantified effectively.

2.4. Research Tools

The first stage of research was conducted in early 2022, during the period when COVID-19 restrictions required a remote approach. Video conferencing tools, already widely adopted by students and faculty, were used for conducting interviews. During the interviews, the authors took handwritten notes, visible on camera to simulate an in-person interaction. Notes were later transcribed digitally for analysis. The second stage of research took place in 2025. This stage was conducted by face-to-face interviews.

2.5. Interviews script and conducting

The interview form consisted of two main parts. The first provided general information, such as a guarantee of participant anonymity and a request to give answers in the context of completed or ongoing projects. The second part covered thematic areas, each corresponding to a specific aspect of project work or management.

The form functioned as an interview guide, accessible to both the author and the participant throughout the session (see Appendix - Script). It was structured to ensure that all essential areas were discussed, thereby enabling comprehensive insights into participants' project experiences.

The approach to each interview included a brief review of the participants. After an introductory segment explaining the research, interviews began with a question about the participant's role in past projects (figure 2 & 3 - participants). Participants were then invited to select which thematic area to address first. The discussion focused on how that topic was handled in their project experience - e.g., leadership roles. The author used open-ended and follow-up questions to deepen the discussion and ensure all relevant points were covered. Prompts like "how frequently", "to what extent", or "how strongly" were commonly used.

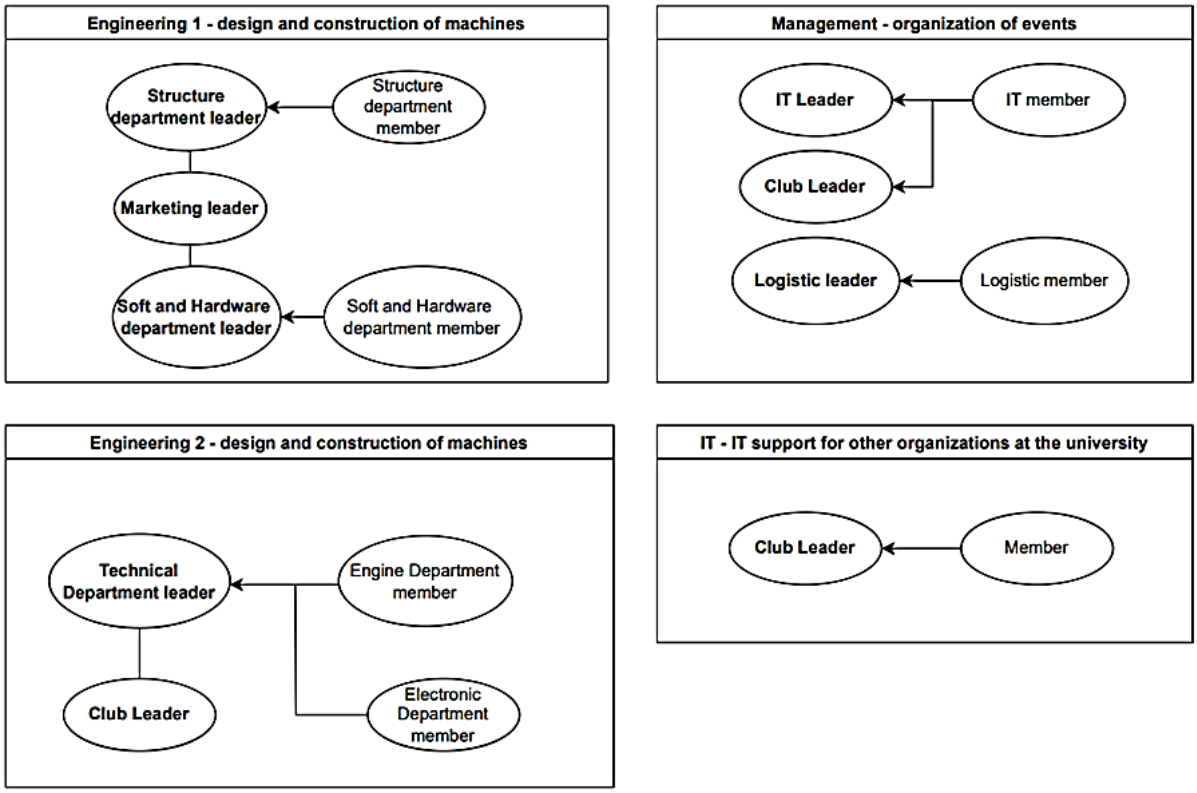

Figure 2. First empirical stage (2022) research participants.

Source: Own elaboration.

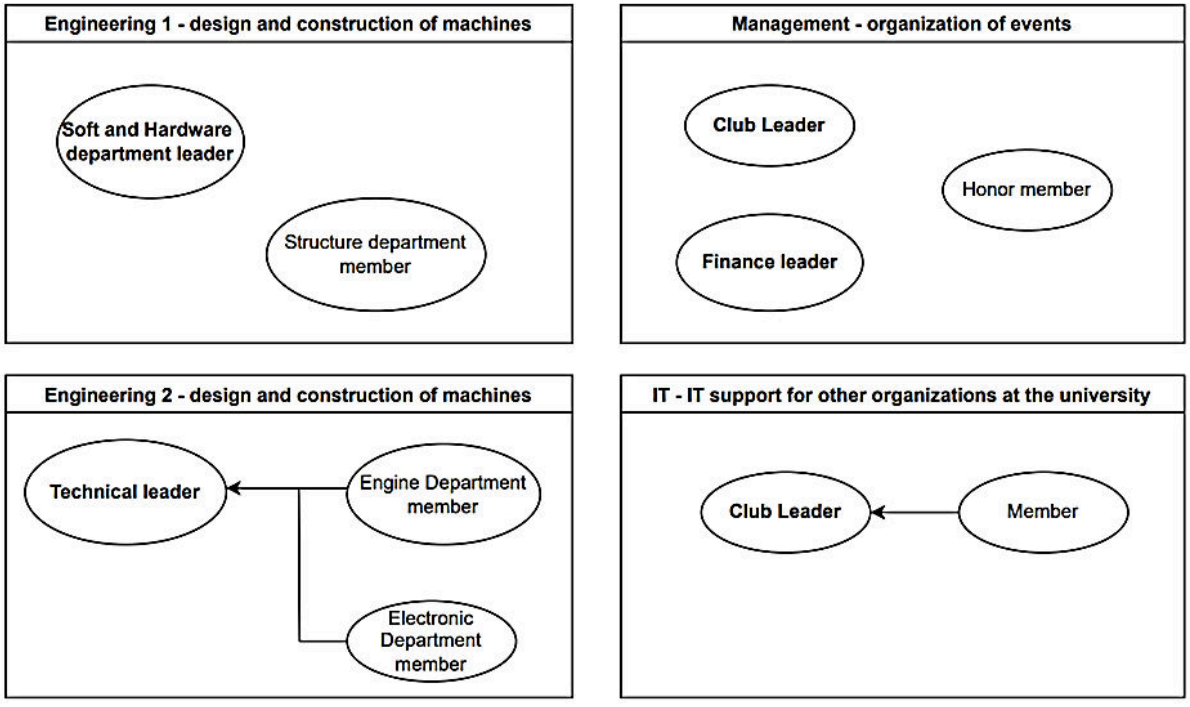

Figure 3. Second empirical stage (2025) research participants.

Source: Own elaboration.

Interviews from 2022 and 2025 were analyzed using qualitative content analysis. An initial round of open coding was conducted to label fragments relented to categories selected at the beginning of research (2.1), which later formed the basis for the comparative tables presented in the Results section. The coding scheme was refined in steps: similar codes were merged, unclear ones clarified. The data triangulation was also present, by including respondents with different roles (leaders and regular members) and by contrasting within organization perspectives when they differed.

2.6. Participants

As outlined in the previous chapter, the purpose of the study was to explore how student teams manage projects and organize their work. To achieve this, individual in-depth interviews were conducted, which maximized the potential to meet the research objectives. Two stages research approach was selected – the first stage in 2022, the second in 2025. A total of sixteen student club members from four different organizations participated in the first stage. Ten people participated in the second stage. These students represented the same student organizations in both stages.

Two clubs primarily focused on building mechanical systems but also relied heavily on software, sensors, automation, and managing complex assembly processes. Their annual work cycles could be seen as large-scale projects. Another organization operated within the field of information technology. This association supported the university's digital infrastructure, particularly for students and teachers use. Their projects included software licensing and developing platforms used within the university. The final club work involved organizing conferences, workshops, lectures, as well as training sessions. The club's leadership demonstrated strong project experience and organizational competence.

First stage participants included 9 individuals in leadership or leadership roles and 7 regular members – 16 participants. Most participants were already well-acquainted with the university and their respective organizations, which contributed to relatively objective responses grounded in experience rather than novelty. These factors increased the credibility and relevance of the study's conclusions to the broader context of student project work. Ten individuals participated in the second stage of the research. There were 5 regular members, and 5 people in leadership roles.

It is worth noting the difference in the number of participants between the first stage (16 people) and the second stage of the study (10 people). A smaller number of respondents in the second phase could have influenced the results. However, both the number and type of organizations studied remained unchanged. In our opinion, this difference did not have a that significant impact on the overall conclusions, as the key aspects of project activity and management were represented in both stages by the same members' roles (both leadership and general members).

3. Results

Results of the first stage of the research that took place in 2022 revealed crucial insights into the mechanisms of students' teams and organization management - through the individual in-depth interviews conducted with sixteen members from four different student clubs. The diverse project environments - from mechanical systems to IT infrastructure - highlighted varying challenges and strategies that clubs undertook. Notably, the balance between leadership and regular member perspectives provided a comprehensive understanding of both macro and micro elements of work. These results set a foundational benchmark for the second stage of research, scheduled for 2025, aiming to delve deeper into evolving practices and challenges in student group work.

The general findings will be presented below to give an overview of problems that students face during work (not assigned to specific organizations). These insights were later used to verify the changes in organizations in the second part of research in 2025.

3.1. First stage results

1. Planning:
   - Lack of comprehensive planning.
   - Misallocation of resources in activities per project phase.
   - Ineffective delegation for new solutions.
   - Scope creep.
   - Wrong prioritization of project elements.
   - Superficial analysis yielding substandard outcomes.
2. Work regularity:
   - Incomplete projects.
   - Lack of documentation of individual project stages.
   - Predilection for simpler tasks over critical ones.
   - Challenges in estimating task workload.
   - Recurring delays managed through last-minute efforts.
3. Team autonomy and responsibility:
   - Reluctance to acknowledge problems and seek assistance.
   - Problem of deciding when the team only delivers the MVP (basic version of the assumed effect, device, etc.) and when the team refines the solution to the end.
   - Hesitation to accept responsibility.
   - Varied levels of involvement among team members.
   - Adherence solely to assigned tasks.

4. Purpose and its perception:
   - Absence of goal discussions during the project.
   - Boredom in large group goal discussions.
   - Lack of reflection on project assumptions.
   - No designated role overseeing scope implementation (big/long projects).
5. Communication and team dynamics:
   - Intermingling of project-related and personal conversations.
   - Suboptimal information flow between departments/projects.
   - Insufficient discussion concerning emotional barriers.
   - Information grain size for reports, meetings.
   - Many separate communication spaces (on-line ones).
   - Inconsistent information dissemination.
   - Unstructured meetings resulting in unproductive discourse.
6. Challenges:
   - Problem with removing harmful or unproductive people from the team.
   - The importance of dilemma - studies vs. science club.
   - Rewarding people.
   - Resistance to management methods.
   - Concerns arise that student projects may adopt overly corporate-like structures.
   - Underestimation of management's significance in projects.
   - Perfectionism leading to excessive allocation of time and resources.
   - Infrequent retrospective meetings, typically annual or board-exclusive.
   - Recurrent errors across analogous projects.
   - Inadequate learning from previous team experiences.
   - Teams deficient in requisite skills for project execution.
   - Deficiency in work tools/platforms expertise.
   - Surplus of tools lacking clear usage guidelines.
   - Inefficient management of collaborative workspace.
   - Limited knowledge amongst new recruits.
   - Limited allocation of space for collaborative input and an individual's propensity to dominate task execution.
7. Successes:
   - Success is perceived as a final, acceptable result.
   - Milestones celebrated rarely.
   - Definition of success is not defined and discussed at forum, especially by non-board members.
   - Celebrating success is spontaneous.

8. Leadership and organizational development:
    - Problem in mediation between sections dealing with one project.
    - Whole-project knowledge confined to board meetings.
    - Negligence in emphasizing in-club work benefits.
    - Motivation predominantly derived from competition.
    - Team members unfamiliar with one another.
    - Leaders avoiding conflict resolution.
    - Deficient charisma and decisiveness.
    - Addressing issues exclusively to the leader without preemptively formulating potential solutions.

Many of these challenges pertain to communication and coordination rather than substantive or direct financial issues.

3.2. Second stage results

The second stage of research, conducted in 2025, also aimed to gather data on how student teams manage projects and organize their work. The study in the second part was conducted in a very similar way to the first segment, by conducting interviews with members of student organizations. This time, 10 members from the same 4 student organizations, as in previous stage, were interviewed. This enabled a comparison of findings to identify changes and advancements in management practices.

The final findings indicated significant development in some organizational competencies and improvements in team efficiency, and on the other side - reduced efficiency in other areas. The results of the second part of the study, were categorized into 8 significant areas – as interview questionnaire followed. Recommendations based on the collected data will help in further enhancing student projects and optimizing management practices.

3.2.1. Planning

The first area of research was "planning in student organizations", the table below presents the summarized results across student organizations.

Table 1.
Results in planning area

Planning
Organization 1
• The Management Board coordinates general matters. • Submissions and decisions are made on the forum. • KOs are planning their own projects. • Large upfronts are planned, while smaller ones are sometimes spontaneously done. • Lack of consistent discipline in sticking to the plan. • Task control in Trello and on team meetings. • Former obligatory project cards, currently they are optional. • Members initiate planning themselves even before the start of project. • Main calendar of organization events.

• Organizational planning is done in short-term horizons (~1 month). • Project statuses once per week. • Finance written down on paper. • "Lessons learned" are written down after misguided projects.
Organization 2 • Almost all members of organization are new. • The scope of activities can be unclear. • Organization starts with small optimizations that later turn into larger projects. • Large activities are planned and analyzed beforehand. • Members work on an ongoing basis within a roughly defined scope. • Improvisation is limited to non-beginners, because greater autonomy equals greater risk. • At meetings members discuss the scope together and ask "who wants to do it". • Adaptation to changes is agile, but not always formal.
Organization 3 • There are quarterly plans with milestones made regularly. • Project kickoffs are now being organized, which is new. • The plan often changes ("lives its own life"). • Less elasticity than before. • Weekly meetings with KOs drag on actual time up to 1 h versus planned time of 15 min. • Changes in the plan are at least visible.
Organization 4 • Change in project planning from Waterfall to Iterative. • Project cycles are according to the test schedule. • Risk assessment is made. • Tasks are located on one platform. • Monthly meetings of the KOs board are organized. • A lot of time is used for coordination. • Rigidity of plans inhibits innovation. • Sometimes there is too much planning, even with things that do not require a plan. • Members return to old ideas instead of constantly creating new ones.

Source: Own elaboration.

Similar patterns can be noted among the results. All organizations have a designated planning framework and schedules of activities that give direction to projects. And it is worth noting that priorities are defined, although they are not always subject to regular revision. However, the differences can be found in the fact that Organization 1 and Organization 2 plan strategically for longer periods, while Organization 3 and Organization 4 act more reactively and in the short term.

Organizations are moving to combine strategic planning with agility, with a growing interest in digital task management tools like Jira, Trello, and Asana. There were also comments on the further development of the organization, which indicated that it is worth developing long-term planning methods, combined with cyclical revision and updating schedules.

The table below also presents the changes that have been observed in the area of planning in organizations considering first and the second stage of research (Figure 1 – Reserach stages).

Table 2.
Changes in planning area

Planning – changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
Mandatory project cards are now optional. There is greater emphasis on shorter cycles and forum decisions.	A lot of new members involved in planning. Clarification of the scope of activities. Change from ambiguity to clarity.	Formerly more flexibility in planning, now quarterly milestones, kick-offs, longer weekly meetings.	Change from Waterfall to Iterative Cycles for Testing and Risk Assessment.

Source: Own elaboration.

3.2.2. Regularity of work

The second area of research concerned the regularity of work in student organizations, the table below summarizes the findings.

Table 3.
Results in regularity of work area

Regularity of work
Organization 1 • Greater regularity thanks to growing know-how. • Informal checkpoints in projects. • Year-round operations are maintained, which provides continuity for organization. • Differences in regularity between sections - Milestones and MVP minimum scope.
Organization 2 • Cyclical meetings increase regularity, but work is still done in waves ("sine work wave"; a lot is done at the last minute). • Completion of tasks expected for the next meeting. • Diverse engagement of members. • There is difference of opinion, where one person says, "no bottlenecks" and another: when no one comes forward to do the task, the boss does it (potential bottleneck). • No formal checkpoints.
Organization 3 • Generally, more regularity than the former chaos. • Greater emphasis on control. • A group of "pseudo-systematic" members report without work done. • Crunch before the deadline is still there, but less than 3 years ago. • There are sine waves in work engagement (after the session decrease in engagement). • There are new "bottlenecks", for example waiting for approval.
Organization 4 • Work is done more systematically than before. • Constant development with buffers. • Still a lot of work is done just before the deadline. • There were periods of chaos, now there is more structure. • Some people "break away" from deadlines (processes that have no end). • A lot of things are done quickly without documentation, which creates problems later. • Organization implements incremental approach (MVP first, the rest later). • Members test what works before building something new.

Source: Own elaboration.

Common patterns can be identified in the results, such as the organization's desire to maintain business continuity and regular work meetings, but real-time progress analysis is not always included. There are also differences such as Organization 1 follows rigid procedures and a fixed schedule, Organization 4 operates at a more flexible pace to adapt to the current situation, and Organization 2 combines planning and regularity with the ability to make ad hoc changes.

There is also a trend towards real-time progress monitoring tools such as boards, sprints, and weekly reports. It was also pointed out that clear procedures for monitoring progress (for example, Kanban boards or Scrum sprints) can increase the regularity and transparency of work.

The table below also presents the changes that have been observed in the area of systematic work in organizations.

Table 4.
Changes in regularity of work area

Regularity of work – changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
Regularity increases along with the accumulation of know-how.	Change from very few meetings to cyclical meetings. Work is still completed in waves.	Change from chaos to more regularity. Pseudo-regularity and waiting for approval appeared.	Change from periods of chaos to more structural approach with buffers. There is still a lot of pressure before deadlines.

Source: Own elaboration.

3.2.3. Autonomy and delegation

The third area of research concerned autonomy and delegation in student organizations, the table below summarizes the findings.

Table 5.
Results in autonomy and delegation area

Autonomy and delegation
Organization 1 • Difficulties with delegation, which results from lack of competence, trust or willingness. • People take and do some things by themselves. • Hierarchical structure means that there is need to delegate, the leader watches over the coordinators. • After gaining the know-how there is less work, which leads sometimes to too few tasks. • Competence is stable in organization, because know-how is written down. • There are some overdue tasks (e.g. website development). • Motivation is a bigger problem than skills, because onboarding provides competence.
Organization 2 • Responsibilities are shared. • People usually take work up, although recently there is less willingness (there are young, inexperienced members). • Organization trains members in organizational knowledge. • Progress is checked in meetings. • Habit of "flipping the frog" is growing. • The leader assigns tasks when there are no volunteers or he does it himself.

Cont. table 5.

Organization 3 • Leaders have full autonomy. • Most of the tasks are done within the team thanks to knowledge transfer, more than before. • Mentors support new members, which is time-consuming, which makes delegation difficult. • Now there is almost no shifting inconvenient tasks between each other. • People take on tasks without a sense of responsibility for them.
Organization 4 • Coordinators decide locally within teams. • Everyone has their own "plot of land" after basic training. • Small team's equal clear responsibilities. • Organization developed specialist knowledge. • Members consult with the alumni of organization. • There are weekly section meetings. • Members working together when someone cannot do it alone.

Source: Own elaboration.

The analysis of the results allowed for the identification of recurring patterns – delegating tasks occurs, but most often functions, within clearly defined roles, are treated without a full sense of responsibility on the part of members. Significant differences were also observed such as Organization 2 and Organization 4 show greater flexibility in decision-making, while Organization 1 and Organization 3 stick to the central control model and limit independence of students.

There is a growing need to find a balance between autonomy and control. It is increasingly emphasized that effective delegation of responsibilities is conducive to increasing work efficiency and team development. Attention was also drawn to the need to implement training and workshops on effective delegation to strengthen the sense of responsibility among members.

The following table also shows the changes that have been observed in the area of autonomy and delegation in organizations.

Table 6.
Changes in autonomy and delegation area

Autonomy and delegation - changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
Delegation is still difficult despite the structure. There is now frequent self-performance.	Initial willingness to take on tasks decreased (young, less willing).	There is greater autonomy of Team Leaders. There was decrease in shifting unwanted tasks, but responsibility is still lacking.	Now there are stabilized "plots" of responsibility and basic training. Members receive support from alumni.

Source: Own elaboration.

3.2.4. Purpose and its perception

The fourth area of research concerned the purpose of the organization and its projects and their perception in student organizations, the table below summarizes the findings.

Table 7.
Results in purpose and its perception area

Purpose and its perception
Organization 1 • Overall goal of organization is to create space to train skills. • There are annual goals and regulations on the wall. • Integration of people is important. • The tendency to optimize may displace the development goal. • There is a need for more process focus. • There is lack of formal metrics (attendance, graduates, MVP achieved means project is "managed").
Organization 2 • Goals are set (integration and delivering projects). • Previously, there was a lack of clarity on the role of the team. • Some members claim that general goals are not known, for people the goal is learning. • There is emphasis on process / shared understanding. • There are discussions on what was done well.
Organization 3 • Tangible goal of "we build things" is known. • Transition from effect orientation to process. • The occasional question "does this make sense?" is asked (lack of regularity in checking sensibility).
Organization 4 • Before the tests, the question "why this test?" is asked. • Team understands the elements critical to success. • Analysis after each test is made (what worked / what did not / what to improve). • There are monthly coordinators-board meetings.

Source: Own elaboration.

The results identified recurring patterns: in all organizations, goals are present and known to leaders, but their degree of understanding and relationship to team motivation varies. There are also differences – in Organization 1 and Organization 2 the goals are defined in detail (in KPIs), while in Organization 3 and Organization 4 they are rather general and are not always translated into everyday activities. The question remains, if members share the same goal perception as leaders and coordinators.

There was also a tendency to increase the emphasis on making goals both understandable and motivating for team members. It also pointed to the need to communicate more effectively the links between strategic goals and operational tasks to help the team understand the meaning of work.

The table below also shows the changes that have been observed in the area of the organization's purpose and its perception in organizations.

Table 8.
Changes in purpose and its perception area

Purpose and its perception - changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
Development goal partially overshadowed by optimization.	Change from "you don't know what we do" to setting integration/project goals.	Shifting focus from the effect to process. Questions about the meaning arise.	There is a systematic question "Why the test?". Awareness of critical elements is growing.

Source: Own elaboration.

3.2.5. Communication

The fifth area of research concerned communication in student organizations, the table below summarizes the findings.

Table 9.
Results in communication area

Communication
Organization 1 • Discord is the official communication channel. • Messages often turn into broadcast without discussion. • Members react faster in projects than in team sections. • The requirement to install a Discord reduced the lack of reading messages. • The Management Board monitors the lack of reaction. • Team channels communication is open to whole organization. • Section reports every 2 weeks on Discord. • After the meetings, people stay to talk. • Relationships fluctuate. • Large projects strengthen "team spirit".
Organization 2 • Communication is based on Discord, Meetings and Messages. • Activity on discord is low. • Messages are often read, but left without reaction. • Meetings are organized every 2 weeks. • Tasks are often too big to be carried out "next week". • There is a need for greater integration. • People are cautious in giving feedback.
Organization 3 • The number of platforms has been limited, but there are still too many channels and formalities. • Relationships between members are good but less spontaneous. • Members leave emoji-reactions without reading. • Meetings are too long.
Organization 4 • There is excess of notifications, which creates informational noise. • Coordinators spend a lot of time in meetings. • Documentation overload leads people to stop reading. • There are more face-to-face meetings. • There is rarely no reaction on technical topics. • There were inter-team meetings. • Small teams communicate well. • Time for coordination takes away working time.

Source: Own elaboration.

Analysis of the results allows us to identify recurring patterns, such as regular meetings (status, briefings) and the use of email as the main channel for information exchange, with communicators playing a complementary role. There are also important differences such as Organization 3 is more likely to use informal face-to-face communication, while Organization 1 and Organization 2 prefer formal solutions, while Organization 4 uses a hybrid model.

There is a trend of implementing modern communication tools, such as Slack or Microsoft Teams or Discord, which results in a reduction in the use of traditional e-mail in the ongoing exchange of information. It was also pointed out that the optimization of communication tools and the reduction of unnecessary meetings can significantly increase the efficiency of information flow. The issue of no-reaction to meetings summaries, reports, massages is common – generally due to on-line communication as default one, outside team meetings.

The table below also shows the changes that have been observed in the area of communication in organizations.

Table 10.
Changes in communication area

Communication - changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
Discord is now official communication channel and introduction of section reports. There is monitoring of the reactions.	Low Discord activity persists. There is a need for more activity.	Now there are fewer platforms, but more channel formalities.	Now there is more documentation and cross-team meetings. Information noise arose as a problem.

Source: Own elaboration.

3.2.6. Problems

The sixth area of study concerned general problems in student organizations; the table below summarizes the findings.

Table 11.
Results in problems area

Problems
Organization 1 • Minor communication mishaps with people with poorer organization-knowledge. • Accumulated know-how shortens the learning of new members, yet it lessens educational experience. • There is less engagement/activity among members. • Different time availability of members. • Intention to combine finance + logistics (change to solution from a few years ago). • Struggle for a place to meet. • People are afraid to manage projects. • Changing the leader after 2 years means a big change.
Organization 2 • Late and poor transfer of responsibilities and information, sometimes it is even deliberate in conflicts. • New team means more competence gaps. • Lack of know-how for the leader (leader doesn’t know "how it used to be"). • Not all members are responsible. • Few people willing to take on tasks.
Organization 3 • Micro-management practiced by some Team Leaders. • Burnout manifests in some members of organization from processes. • Too much paperwork/documentation compared to core work. • It's harder to get to know everyone with a larger team.

Cont. table 11.

Organization 4
• Meetings cause fatigue. • Paralysis by a multitude of options/analysis (lack of decisiveness). • Problem with managing the complexity of dependencies between tasks. • Too much procedural bureaucracy (too many approvals for minor changes). • Limited testing resources due to cost. • Simulation to reality gaps. • Paralysis in analytics.

Source: Own elaboration.

In the analyzed results, recurring patterns were identified, among which the difficulties related to the underestimation of resources, ambiguity of priorities and delays caused by changes in the environment are particularly visible. Significant differences between organizations were also observed such as Organization 4 faces problems resulting from the lack of coordination and the occurrence of chaos, Organization 1 struggles with excessive formalization of processes, Organization 2 struggles with imprecise definition of roles, while Organization 3 experiences a deficit of process documentation.

Organizations tend to invest in risk analysis, retrospection, and learning from their mistakes to minimize the recurrence of problems. It also highlighted the need to develop proactive mechanisms to identify issues to limit their escalation.

The following table also shows the changes that have been observed in the problem area in organizations.

Table 12.
Changes in problems area

Problems - changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
Management and resource barriers have been revealed.	Change of team members exposed gaps in the transfer of power and knowledge.	Increase in processes, caused micromanagement and burnout.	With iterative approach there is visible bureaucracy, test costs and complexity of dependencies.

Source: Own elaboration.

3.2.7. Successes

The seventh research area concerned successes in student organizations, the table below summarizes the findings.

Table 13.
Results in successes area

Successes
Organization 1
• Teams celebrate the completion of projects. • In general, there are a lot of celebrations when there is success. • Individual successes are rarely celebrated outside the organization.

Cont. table 13.

Organization 2 • Success celebrations are rare. • Sometimes teams do "round of glory" (sharing recent success). • New people improved the atmosphere.
Organization 3 • Celebration is sometimes a mandatory ritual (less spontaneous).
Organization 4 • There is team celebration after successful testing.

Source: Own elaboration.

In the analysis of results, it is possible to distinguish recurring patterns, such as achieving success by organizations in the form of completed projects, effective implementations or efficiency improvements, although the definitions of these successes vary depending on the entity. Significant discrepancies were also identified such as Organization 2 and Organization 4 indicate flexibility and rapid adaptation as key determinants of success, while Organization 1 emphasizes the importance of quality and stability and Organization 3 focuses on small but regular improvements.

There was also a growing tendency to appreciate team achievements, celebrate smaller successes and strengthen team spirit. In addition, attention was drawn to the need to implement a culture of sharing best practices and analyzing the factors influencing the achieved results.

The following table also shows the changes that have been observed in the area of successes in organizations.

Table 14.
Changes in successes area

Successes - changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
There is a tradition of celebrating success in projects. Individual success celebration is still rare.	Change from no celebration to the appearance of "glory rounds".	Spontaneous celebrations turned into more obligatory rituals.	Now there are regular celebrations after testing.

Source: Own elaboration.

3.2.8. The role of a leader

The eighth area of research concerned the role of leadership in student organizations, the table below summarizes the findings of the four student organizations.

Table 15.
Results in the role of a leader area

The role of a leader
Organization 1 • Leadership style is situational, changes from supportive/developmental to authoritarian when necessary. • Leadership style now encourages the initiative of members. • ~3 years ago, leadership style was more authoritarian/formal. • The "cult of the leader" emerges. • A pro-social leader (parent/friend) is needed for the strategy and development of organization, although a lot is happening from the bottom-up initiatives.

Cont. table 15.

Organization 2 • Controls and watches over the transfer of tasks to the coordinators. • Leader organizes work and searches for new projects. • Leader controls execution of plan. • Leader takes on the role of the teacher / integrator. • Some members assess the leader as "too nice".
Organization 3 • Shift from authoritarian leadership to more collaborative/supportive leadership. • Leadership style is still not perfect.
Organization 4 • Leader serves as a technical mentor and coordinator (not a dictator). • Sometimes there is a lack of decisiveness. • Current leader is technical expert, which provides stability in comparison to the past leaders.

Source: Own elaboration.

In the analysis of results, recurring patterns can be identified such as leaders organize work, make key decisions, motivate the team, and act as the main "filters" of information and conflicts. However, there are important differences such as in Organization 1, the leader has a more controlling and formalized role, while in Organization 4, he or she is more of a partner and mentor. Organizations 2 and 3 present a combination of elements of control and mentoring, adapting the leadership style to the current situation.

There was also a trend of the evolution of the role of the leader towards coach and facilitator. Greater emphasis is placed on developing team competencies, not just on control activities. The need to develop soft skills of leaders, such as facilitation, motivation, change management and coaching, was also emphasized.

The following table also shows the changes that have been observed in the area of leadership role in organizations.

Table 16.
Changes in the role of a leader area

The role of a leader - changes			
Organization 1	**Organization 2**	**Organization 3**	**Organization 4**
Formerly authoritarian style of leadership, changed into more encouraging and initiative style. The cult of the leader appears.	The leader acts as a controller and teacher for new members.	Change from dictatorship-like leadership to cooperation/support-based leadership.	Change from leader as a dictator to technical mentor. Sometimes leader is not very decisive.

Source: Own elaboration.

4. Conclusions

Based on two carried out qualitative research stages and their comparison, conclusions were developed. They describe often and/or important issues that arose during whole research process – regarding student organization and their work.

Iterative planning may push out traditional Waterfall models

Teams declare that they are slowly moving away from rigid, linear project plans toward shorter development cycles. This shift enhances flexibility and adaptability, yet teams continue to face challenges in maintaining delivering milestones in set deadlines. It would be worthwhile to deepen research on management methodologies and their potential connection with developmental directions, e.g. in the business environment.

Work regularity improves but remains inconsistent

As teams accumulate knowledge, meetings and milestone schedules become more structured, which helps reduce disorder. However, work patterns still fluctuate in cycles, with frequent last-minute efforts before multiple deadlines during year. The persistent pre-milestone pressure indicates that existing procedures and tools have not fully resolved this uneven workflow.

Delegation remains a significant challenge

Despite efforts to clarify roles, effective task delegation is hindered by skill gaps, lack of trust, and reluctance among team members, especially newer or younger ones. Formal role definitions do not ensure accountability. Initial increases in autonomy diminish as responsibility avoidance and competence gaps reoccur, showing that structural changes alone are insufficient to ensure engagement.

Fragmentation of responsibility worsens

Although clearer role assignments have boosted technical delivery, individuals often undertake tasks without ownership, leading to fragmented responsibility and repeated errors. The problem of unclear accountability intensifies, particularly with high team member turnover.

Motivation issues overshadow skill transfer

While onboarding has improved competency acquisition, motivation has emerged as a more critical barrier. As initial enthusiasm declines, the willingness to accept tasks decreases, making motivation a new limiting factor even when skills are adequate. It is possible that this drop in motivation is connected to generational factors specific to Generation Z. However, our research

focused exclusively on Generation Z participants, so we cannot confirm this as a broader trend. Exploring this connection could be an interesting direction for future research, but meaningful comparisons will only be possible once Generation Alpha begins entering universities, which is expected to occur in at least five years.

Evolution in goal clarity and motivation

Goals are now more often specified and linked to integration and project delivery, sometimes considering the project's deeper significance. However, goals frequently remain undesignated on paper and are based on broad mission understanding without collective validation. Misalignment between strategic and operational objectives persists, adversely affecting team motivation.

Formalized communication increases information noise

Platforms such as Discord improve cross-team updates, but the multiplication of channels and excessive formalization result in information overload and reduced engagement. Members increasingly respond with superficial reactions rather than substantive interaction, indicating that more channels can dilute actual comprehension.

Feedback and integration decline despite mechanisms

Although meetings and cross-team reporting increase, genuine integration and face-to-face interaction diminish. Feedback changes from active dialogue to passive reactions or silence, reducing learning effectiveness and team cohesion.

Process bureaucracy leads to burnout

Enhanced documentation and micromanagement raise administrative overhead, causing fatigue and disengagement compared to earlier periods.

Knowledge management gaps persist

Documentation and mentorship protocols improve onboarding efficiency, yet knowledge transfer remains deficient, especially following member turnover or team restructuring.

Formal celebration rituals risk reduced authenticity

Spontaneous celebrations of project completion have given way to routine, obligatory, and more frequent acknowledgments of smaller successes. Members report that these ceremonies may feel less meaningful, suggesting potential cultural drift and decline in morale over time, though the actual impact requires ongoing observation.

Leadership is transitioning toward partnership but lacks consistency

Leadership approaches are shifting from authoritarian to more collaborative and supportive styles. Nevertheless, decision-making can still be unclear, and autocratic tendencies remerge during conflicts.

Formalized communication increases information noise

Platforms such as Discord improve cross-team updates. But the members report concerns the multiplication of channels and excessive formalization, that can result in information overload and reduced engagement. On the other hand, leaders increasingly often see emerging problems of responding with superficial reactions rather than substantive interaction, which can indicate that more channels can dilute actual comprehension and involvement of members. This topic should be further investigated with specific quantitative measures to determine the scale of the problem.

5. Summary

The article goal was to examine the evolving challenges within student organizations over a medium-term period, focusing on how student teams implement projects and organize their work from 2022 to 2025 at Wrocław University of Science and Technology.

For the literature review, the study applied a PRISMA-standard systematic search in WoS and Scopus databases targeting works on student organizations, student projects, and project management since 2000. It synthesized findings that student organizations contribute significantly to skill development and community integration but face persistent challenges such as funding limitations, administrative burdens, low member motivation, and high turnover. The review highlighted a research gap of these problems, prompting the key research question: "How do problems in student organizations change over several years? Are there recurrent issues how students manage them?".

In the empirical part, the authors conducted qualitative research using semi-structured in-depth interviews in two waves (2022 and 2025) with members and leaders of four separate student organizations. The research explored themes including planning, work regularity, communication, team autonomy, leadership, and recurring challenges. Findings revealed persistent problems like delegation difficulties, motivation fluctuations, communication noise, fragmented responsibility, and under-leveraged learning from past projects. Improvements were noted in iterative planning, formalization, and leadership styles shifting towards facilitation. However, some aspects deteriorated, such as increased workload bureaucracy and reduced spontaneity in celebrating success. The conclusions emphasized that despite professionalization and digital tools adoption, deep-rooted cyclical challenges related to team

dynamics, motivation, and task ownership remain resistant to change, often recurring in varied forms over time. Challenges that student organization faces, across 3-year period, do not change drastically – taking into account the external and internal influence of stakeholders as well as the entire environment. However, the approach to dealing with them changes. In a lot of cases, there are two solutions that are opposite to each other. Organizations tend to select one of them, and with all the benefits, they are trying to manage consequences. This underscores the necessity to align formal management structures with the real needs and cultures of student teams to enhance their effectiveness and sustainability.

Looking at all the findings, the following questions for further research occur:

- Do student organizations systematically change their approach in order to solve the general problems of this environment (such as motivation, delegation, regularity of work)?
- What specific actions can be taken in the management of student club projects to ensure they are more likely to achieve success and bring value?

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Appendix

Interview script

Hi! Thank you for agreeing to the interview – it's really valuable to me. Before we start, there are a few important things:

Firstly, the study is completely anonymous. There will be no information in the results that will allow you to identify a specific organization or indicate what projects were involved. I can even omit the fact of operating at Wroclaw Tech – it's up to you. The only thing I take into account is the general profile of the organization, i.e. whether you organize events, build something, program, etc. This is only important to understand the context of the action well.

Secondly, I really care about honesty and objectivity. The main goal of this study is to find a work model that fits real-world conditions. If something didn't work – it's worth talking about. If, for example, the team claims that communication was great, but in practice it looked different – then a model built on such a declaration will not work. It is not about judging but about capturing reality as accurately as possible.

You can talk about one specific project or recall different situations from several – everything that you think is characteristic and valuable. I want to better understand what teamwork really looks like in your environment.

Ready? Then we fly with questions!

Planning

1. What did planning activities in your organization look like in the past, and what does it look like now? Has anything changed in this area? What to look for: awareness of change, approach to planning (formalization vs improvisation).
2. Do you plan activities right at the beginning of the project, or do you rather act on an ongoing basis? Has this changed over the years? The key: agility vs long-term planning.
3. Do you control, do you stick to the plan or do you rather "let go of the steering wheel"? Have you changed your approach over time? The key: organizational maturity, evolution of work style.
4. Does it happen that you start doing something enthusiastically, and then it turns out that it didn't make much sense? Are such situations rarer than in the past? The key: reflectiveness, experience.

Regularity of work

1. Have you noticed a difference in the approach to systematic work – e.g. between "in the past" and "now"? The key: a change in the approach to time management.
2. Is the work evenly distributed, or does everything happen at the last minute? Are you trying to change it somehow? The key: deadline culture vs continuous work.
3. Do you use any checkpoints (e.g. milestones)? Has this changed over time? The key: growing organizational maturity.

Autonomy and delegation

1. What does the sharing of responsibilities look like now – and did it look different in the past? The key: an increase in structuring, changes in the style of work.
2. Does the team usually have the necessary competencies, or do you have to look for outside support more often? Has this changed over the years? The key: development of members' competencies, self-sufficiency.
3. Over time, have there been ways to monitor whether tasks are being carried out? The key: increasing responsibility.
4. Is it still possible to "flip the frog" – that is, running away from difficult tasks? Less or more than it used to be? The key: emotional maturity, a culture of responsibility.

Purpose and its perception

1. Do you talk more often about the purpose of the action these days, or is the focus still mainly on specific tasks? The key: strategic thinking, conscious action.
2. How has the team's approach changed – more result-oriented or process-oriented? Key: change the style of operation.
3. Do you think more about "why are we doing something" now than you used to? The key: reflectiveness, responsibility for decisions.
4. Are you currently held accountable for the effects? And someday? The key: changing liability mechanisms.
5. Have there been measures of success? Or maybe you also had them in the past, but they looked different? The key: the evolution of the way effects are evaluated.

Communication

1. What methods of communication do you use now and what were they before? What works better? Key: technology vs relationships, changing tools.
2. Have the relationships in the team deepened, weakened, changed? What did it look like in the past, and what does it look like today? The key: the impact of generational changes, hybridity.
3. Has the problem of "read but no reaction" always been present? Has it intensified/weakened now? The key: a culture of responsiveness.

Problems

1. What problems occur most often today, and which ones dominated in the past? Is there anything repeated? The key: changing challenges.

Success

1. Is celebrating success as important today as it used to be? What did it look like before? The key: a culture of appreciation.
2. Do you feel that commitment used to be more noticeable – or maybe more now? The key: motivation.

The role of the leader

1. Has the leadership model in your organization changed? What did it look like in the past, like today? Key: change in management styles.
2. What qualities of a leader/coordinator are more valued now than in the past? The key: expectations for leaders over time.

Definition of done

1. Have you put in place clear criteria for completing work on tasks? Were they less specific before? The key: formalization of work.

Retrospective

1. Do you make summaries after completing projects? When did it start – and has it always been present? The key: learning from mistakes.

Stakeholders

1. Has contact with the recipients of your activities (e.g. event participants, partners) changed over time? How? The key: orientation towards external recipients.
2. Do you show the effects of your work more often during or at the end? The key: transparency, interactiveness.

Management Knowledge

1. Where do you get your knowledge about project management now – and have the sources changed compared to previous years? The key: formal education vs practice, change of consciousness.

Conclusion: Thanks a lot for your sincerity! This information helps a lot in understanding what teamwork really looks like in projects. If you have any other thoughts after the interview, feel free to let me know.

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DIGITALIZATION OF CLINICAL AND ADMINISTRATIVE DOCUMENTATION IN PUBLIC HOSPITALS IN POLAND

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Purpose: The purpose of the study was to identify the processes in which the digitalization of documentation is implemented in public hospitals, both in the clinical area and in the administrative area. Additionally, the study aimed to identify the benefits and risks resulting from the digitalization of documentation in public hospitals within these two areas.
Design/methodology/approach: The research objectives were achieved through a qualitative study using semi - structured interviews.
Findings: The study demonstrated that the digitalization of documentation in public hospitals in Poland encompasses both administrative and clinical areas. However, the level of digitalization of documentation advancement varies. In the administrative area, digitalization is most developed in the following processes: finance and accounting, information flow and documentation management, and human resources and payroll. In the clinical area, digitalization primarily concerns the processes of patient registration, diagnostics and patient monitoring, as well as hospitalization and patient discharge. The findings also indicate that the digitalization of documentation in public hospitals contributes to reduced material consumption, improved process efficiency, and enhanced access to information. The identified risks associated with digitalization include technological and non-technological risks.
Research limitations/implications: Future research may focus on identifying the factors influencing the progress of digitalization of documentation in public hospitals, both in the administrative area and in the clinical area.
Practical implications: The findings may support public hospital managers in planning and implementing digital solutions.
Originality/value: The article provides insights into the key processes subject to the digitalization of documentation in the administrative and clinical areas of public hospitals with varying scopes of activity and levels of economic efficiency. Furthermore, it offers knowledge regarding the benefits and risks associated with the digitalization of documentation in public hospitals in Poland.
Keywords: Digitalization of documentation; public hospitals; Electronic Medical Documentation (EMD); healthcare management.
Category of the paper: Case study.

1. Introduction

Digitalization of documentation, understood as the process of converting documents previously maintained in paper form into digital format (Act of April 28, 2011 on the Information System in Healthcare, Article 13b, Dz.U.2025.302), constitutes one of the most significant directions in the transformation of the contemporary healthcare system. It forms part of the broader processes of informatization and digital transformation of public services, as well as the development of e-health (Sikorska, 2023).

In public hospitals, the digitalization of documentation has become a key component in the development of integrated information systems. It has enabled a transition from traditional registers, paper-based medical charts, and administrative forms to Electronic Medical Documentation (EMD), defined as a structured set of digital data that can be stored, shared, and processed in an automated manner (Płaciszewski, 2022).

With the development of the digitalization of documentation in public hospitals, this issue has increasingly attracted the attention of researchers. Nevertheless, the topic of digitalization of documentation remains relatively underexplored in relation to public hospitals, understood as healthcare entities providing hospital services (Act of April 15, 2011 on Medical Activity, Article 2(1)(9), Dz.U. 2011.654). Studies conducted to date in the Polish context concerning public hospitals have primarily focused on systemic solutions and regulatory conditions (Swałek, Steinerowska-Streb, 2023; Płaciszewski, 2022; Karlińska, 2014; Czerska et al., 2019). The issue of digitalization of documentation in public hospitals has been addressed only to a limited extent. Existing research has examined it mainly in relation to the functioning of information systems (Karlińska, 2018), technological and infrastructural solutions (Kaczmarska-Krawczak, 2023), organizational readiness for digitalization implementation (Sikorska, 2023; Kruszyńska-Fischbach et al., 2022), and changes in hospital management associated with digitalization of documentation (Wielki et al., 2024). Meanwhile, the analysis of actual organizational practices, including internal mechanisms for implementing digitalization within the structures of public hospitals, has thus far received marginal attention (Sikorska, 2023; Wielki et al., 2024). A review of the literature on digitalization of documentation in public hospitals indicates a lack of empirical studies demonstrating in which processes occurring within public hospitals—both in the administrative area and in the clinical area—the digitalization of documentation is implemented. Moreover, there is a scarcity of research providing evidence on the benefits and risks associated with the implementation of digitalization of documentation in these two areas.

The identified research gap motivated the present study, the results of which are presented in this article. The aim of the study was to identify the processes in which the digitalization of documentation is implemented in public hospitals, both in the clinical area and in the administrative area. Additionally, the study sought to identify the benefits and risks resulting

from the digitalization of documentation in public hospitals within these two areas. To achieve these objectives, the following research questions were formulated: (i) within which processes in public hospitals is the digitalization of documentation implemented in the clinical area, and within which processes in the administrative area?; (ii) what are the benefits and risks associated with the implementation of digitalization of documentation in these two areas? The research objectives were achieved through a qualitative study.

2. Literature Review

2.1. Public hospitals in Poland and their evolution toward documentation digitalization

Public hospitals in Poland operate as entities within the healthcare system that provide medical services in the form of hospital services financed from public funds, in accordance with regulations established by national legislation (Dz.U. 2011.654; Dz.U. 2024.146). They constitute key institutions within this system, fulfilling the constitutional obligation to ensure citizens equal access to healthcare services and serving as primary entities responsible for the implementation of national health policy (Constitution of Poland, 1997; Zgliczyński, 2018).

As systemic healthcare providers, public hospitals in Poland are dependent on centralized mechanisms of financing, supervision, and contracting of services by the National Health Fund (NHF), which determines their organizational model and governance structure (Bromber, 2014; Paszkowska, 2019). They are characterized by a high degree of process formalization, an extensive clinical and organizational structure, and multi-level institutional oversight exercised by both central and local government authorities. In this context, public hospitals may be regarded as public organizations with a complex decision-making architecture and limited strategic autonomy (Szetela, 2025; Czerw, 2016).

In public hospitals in Poland, the digitalization of documentation occurred gradually. Its foundation in the clinical area was established by the Act of April 28, 2011 on the Information System in Healthcare, which imposed on healthcare entities the obligation to progressively implement Electronic Medical Documentation (EMD) (Dz.U. 2011, nr 113, poz. 657). In order to comply with the requirements of this Act, public hospitals initially undertook the digital replication of paper-based documentation. This was followed by the computerization of workstations and the implementation of Hospital Information Systems (HIS), which enabled the integration of clinical and administrative data within hospitals. As a result of these measures, documentation began to be created directly within teleinformation systems, leading to the development of Electronic Medical Documentation (EMD). This stage of digitalization of documentation may be regarded as the beginning of the organizational and

systemic transformation of public hospitals, in which digital technologies became an integral component of management and coordination of clinical and administrative processes, and information infrastructure began to function as a strategic organizational resource (Kaczmarska-Krawczak, 2023; Buchelt et al., 2020; Pawuś et al., 2025; Wielki et al., 2024; Glinkowski et al., 2025).

2.2. Characteristics of activities undertaken in public hospitals in Poland within the administrative area and the clinical area

Activities carried out in public hospitals take place within two functionally distinct yet interrelated areas: the administrative area and the clinical area (Libura et al., 2023). The administrative area concerns organizational management and is oriented toward ensuring the long-term stability and development of the entity, as well as coherence between health policy and ongoing operational activities (Lisowska et al., 2024). In contrast, the clinical area refers to medical processes (Budzisz, 2015). The administrative area encompasses, among other elements, the management of human and material resources, the development of strategy and organizational structure, as well as management information systems and mechanisms of control and quality assessment (Karlińska, 2014). Within this area, processes such as strategic planning, resource allocation, contracting of services, settlements with public payers, and the development of internal policies and procedures are undertaken (Budzisz, 2015). These processes also include infrastructure and logistics management, covering procurement, materials and pharmaceutical management, warehousing, supply of hospital units, and the technical maintenance of buildings and medical equipment (Bartnicka et al., 2013). Among these processes, information and documentation management processes may be regarded as particularly critical, including record-keeping and archiving of documentation, statistical reporting, formal reporting obligations, and the operation of information systems (Budzisz, 2015).

The clinical area encompasses diagnostic, therapeutic, and rehabilitative processes, as well as the continuous monitoring of patients' health status, carried out by multidisciplinary medical personnel within organized care pathways (Kaczmarska-Krawczak, 2023). Processes taking place in the clinical area are patient-centered and focused on patient safety. The effectiveness of medical interventions and adherence to quality standards are fundamental to these processes (Czerska et al., 2019).

Despite their functional distinctiveness, both areas are interdependent. The efficiency of administrative procedures determines the continuity and accessibility of healthcare services delivered within the clinical area. At the same time, requirements arising from medical practice shape the actions undertaken within the administrative area (Libura et al., 2023).

The integration of administrative and clinical processes constitutes a key factor in improving organizational efficiency, quality of care, and health outcomes in public hospitals. In particular, it is emphasized that such integration enables the rational use of data, which,

once entered into the system, can be reused at different stages of patient care, thereby supporting the coherence of the decision-making process (Kamińska et al., 2022; Wielki et al., 2024). At the same time, in the administrative area, the integration of Hospital Information Systems (HIS) with financial and settlement modules facilitates the automation of service coding, improves the quality of settlements with the National Health Fund (NHF), and enables more precise calculation of hospitalization costs, thereby strengthening the economic efficiency of public hospitals (Budzisz, 2015; Wielki et al., 2024). From a systemic perspective, these solutions provide the foundation for the development of coordinated care and e-health by enabling seamless information flow across levels of care and supporting a more patient-centered model of service delivery (Libura et al., 2023).

3. Methods

The aim of the study was to identify the processes in which the digitalization of documentation is implemented in public hospitals, both in the clinical area and in the administrative area. Additionally, the study sought to identify the benefits and risks resulting from the digitalization of documentation in public hospitals within these two areas. The scope of the study concerned the digitalization of documentation in public hospitals in both the clinical area and the administrative area. The study population consisted of public hospitals understood as healthcare entities providing hospital services (Act of April 15, 2011 on Medical Activity, Article 2(1)(9), Dz.U. 2011.654). The territorial scope of the study was Poland. The primary research was conducted in the second half of 2024 and the first half of 2025.

Given that the issue of the processes in which the digitalization of documentation is implemented in public hospitals in Poland remains insufficiently explored, the research objectives were pursued through a qualitative study. Such research approaches enable the researcher to gain an in-depth understanding of the phenomenon under investigation and to identify the underlying mechanisms shaping the examined processes (Miński, 2017).

From the broad range of qualitative research methods and techniques, semi - structured interviews were selected for the purposes of this study. The primary rationale for choosing this technique was the opportunity to directly observe the examined processes and to interact with the study participants. Of particular importance was the possibility of asking follow-up questions that had not been anticipated in the initial interview protocol. This approach enabled an in-depth exploration of themes emerging during the interviews and allowed for a comprehensive examination of issues related to the digitalization of documentation in both the administrative area and the clinical area (Miński, 2017).

A purposive sampling was applied to collect information regarding the processes in which the digitalization of documentation is implemented across different public hospitals. The criteria for selecting entities for the sample were the territorial scope of the hospital (local, regional, nationwide) and the level of economic efficiency of the hospitals[1] (low, moderate, high). Consequently, the research sample consisted of nine public hospitals (3 × 3). Table 1. presents a matrix illustrating the public hospitals included in the study based on the adopted selection criteria.

Table 1.
Public hospitals participating in the study

TERRITORIAL SCOPE OF THE HOSPITAL	ECONOMIC EFFICIENCY OF THE HOSPITAL			
		Low economic efficiency hospital	**Medium economic efficiency hospital**	**High economic efficiency hospital**
	National hospital	A national public hospital with low economic efficiency	A national public hospital with medium economic efficiency	A national public hospital with high economic efficiency
	Regional hospital	A regional public hospital with low economic efficiency	A regional public hospital with medium economic efficiency	A regional public hospital with high economic efficiency
	Local hospital	A local public hospital with low economic efficiency	A local public hospital with medium economic efficiency	A local public hospital with high economic efficiency

Source: Own elaboration.

In the selected hospitals semi-structured interviews were conducted with key individuals responsible for managing the digitalization of documentation. Considering the competencies of staff engaged in documentation digitalization, interviews were carried out in each hospital with administrative directors, department heads, and chief nurses. This selection of respondents enabled an in-depth understanding of the processes in which the digitalization of documentation is implemented across different public hospitals and enhanced the validity of the obtained results.

Each interview lasted approximately one hour. With the prior consent of the respondent, all interviews were audio-recorded and subsequently transcribed and analyzed using MaxQDA software.

[1] The economic efficiency of each hospital was determined based on the number of points obtained in its Report on the Economic and Financial Situation for 2023. Hospitals with low economic efficiency achieved less than 50% of the maximum possible number of points; hospitals with moderate economic efficiency achieved between 50% and 75% of the maximum possible number of points; and hospitals with high economic efficiency achieved more than 75% of the maximum possible number of points.

4. Results

The conducted interviews indicate that the digitalization of documentation in the administrative area primarily took place within the following processes: finance and accounting, information flow and document management, and HR and payroll (Table 2.). Within the finance and accounting process, the principal change resulting from the digitalization of documentation was the introduction of an electronic invoice workflow, which was implemented in all analyzed hospitals in 2025. In most hospitals, contracts also began to be signed electronically, indicating a systematic shift away from paper-based contracting procedures. These changes were described in detail by the administrative director of a local hospital with high economic efficiency: *Since January 1, we've launched electronic invoice circulation, so all the invoices in the hospital are now handled electronically (...) We also have new contracts that are already being entered into the system, and the circulation of those contracts is electronic as well.*

Another process in which documentation was digitalized in the analyzed public hospitals within the administrative area was information flow and document management. In most of the hospitals included in the study, measures were undertaken to digitalize archival records, which increased document accessibility for authorized entities and improved the flow of information.

These activities were confirmed by the administrative director of a national hospital with high economic efficiency: *That documentation (...) is continuously being digitalized by the document management department.*

Additionally, in some of the analyzed hospitals, within the information flow and document management process, an electronic workflow for both internal and external correspondence was implemented. A department head from a local public hospital with high economic efficiency stated: *All those shorter messages (...) are sent through messaging apps. (...) In the near future, we're planning to implement electronic external and internal correspondence as well.*

Within the HR and payroll process, the digitalization of documentation involved the implementation of solutions enabling the electronic creation, processing, and archiving of employee records. The analyzed hospitals also introduced electronic conclusion of employment contracts and electronic repositories for contractual documentation. An important component of digitalization was the electronic workflow of HR documents, which enabled the automation of processes related to employment administration, including the transfer of documents between administrative departments and department management.

Table 2.
Activities subject to documentation digitalization in public hospitals within the administrative area divided by process

AREA	PROCESS	ACTIVITIES SUBJECT TO DOCUMENTATION DIGITALIZATION
ADMINISTRATIVE	Finance and accounting	• Electronic invoice workflow. • Electronic processing of settlement documents. • Settlement of healthcare services with the payer. • Contracting of healthcare services. • Financial and operational reporting.
	Information flow and document management	• Electronic workflow of administrative documents. • Electronic correspondence workflow. • Electronic internal communication. • Digitalization and archiving of administrative documentation.
	HR and payroll	• Electronic conclusion of contracts. • Electronic repository of contractual documents. • Electronic workflow of HR documents. • Digital storage of documentation.

Source: Own elaboration.

Within the clinical area, in all analyzed hospitals, the digitalization of documentation covered patient registration, including the recording of referral data and patient data, verification of insurance information, and the establishment of Electronic Medical Documentation (EMD). Subsequent processes in which documentation digitalization was implemented in the clinical area included diagnostics and patient monitoring as well as hospitalization and patient discharge (Table 3). Within the diagnostics and patient monitoring process, electronic test orders were introduced in all analyzed hospitals. This was emphasized by a department head from a regional public hospital with medium economic efficiency, who stated *Orders for vaccinations and things like that—we already do all of that in the computer.* In most of the analyzed hospitals, within diagnostics and patient monitoring, paper-based laboratory and imaging test results were also eliminated in favor of electronic formats. This was confirmed in an interview with a department head from a local public hospital with low economic efficiency: *(...) we don't print test results in paper form anymore—it's only available electronically.*

Within the hospitalization and patient discharge process, the digitalization of documentation primarily covered medical orders. This was discussed in detail by a department head from a national public hospital with high economic efficiency: *It applies not only to medical documentation, but also to medical orders issued by physicians.* Similarly, the digitalization of documentation within hospitalization and patient discharge was confirmed in interviews conducted with nursing staff. In most of the analyzed hospitals, chief nurses emphasized: *Nursing care documentation is in the AMS system—it's not printed.* Additionally, a department head from a regional public hospital with medium economic efficiency indicated that digitalization also encompassed medication management, including electronic medication distribution: *Practically the whole hospital—except for two departments—has switched to the electronic medication cart.*

An analysis of the conducted interviews indicates that within the hospitalization and patient discharge process, in some of the analyzed hospitals, medical documentation was maintained simultaneously in both paper and electronic formats. This phenomenon was observed primarily in local public hospitals with low economic efficiency and local public hospitals with medium economic efficiency. It increased the workload of medical staff: *For now, it's basically double documentation. [Department head, a local public hospital with low economic efficiency]; I see a big problem in duplicating documentation (...) we already have electronic systems, but we still write down a lot of things manually. [Chief nurse, a local public hospital with low economic efficiency]*.

The analysis of respondents' statements regarding the simultaneous maintenance of electronic and paper documentation also indicates that printing medical documentation is sometimes necessitated by the need to provide it to entities outside the hospital. For example, a department head from a local public hospital with low economic efficiency commented: *We print it because not everywhere can the EMD version be accessed (...) not every doctor would probably be able to find it.* It can therefore be observed that the additional printing of medical documentation results from the limited accessibility of Electronic Medical Documentation (EMD) outside the hospital.

Table 3.
Activities subject to documentation digitalization in public hospitals within the clinical area divided by process

AREA	PROCESS	ACTIVITIES SUBJECT TO DOCUMENTATION DIGITALIZATION
CLINICAL	Patient registration	• Admission of a patient for hospitalization. • Admission of a patient for an appointment. • Verification of the patient's insurance data. • Patient registration. • Recording of patient data. • Management of patient queues and sending appointment reminder notifications.
	Diagnostics and patient monitoring	• Electronic referrals for diagnostic tests. • Electronic laboratory and imaging test results. • Electronic monitoring of prescription fulfillment. • Electronically maintained patient medical history. • Electronic Medical Documentation (EMD).
	Hospitalization and patient discharge	• Electronic medical orders. • Electronic medication distribution. • Patient movement within the hospital. • Electronic nursing documentation. • Electronic patient discharge summaries. • Electronic hospital discharge information card.

Source: Own elaboration.

An analysis of the interviews conducted with respondents in both the administrative area and the clinical area indicates that the level of advancement of documentation digitalization in the analyzed public hospitals is differentiated. It can be observed that the level of documentation digitalization in hospitals operating at the local and regional levels is lower than in hospitals operating at the national level, regardless of their economic efficiency. However, national-level hospitals differed from one another depending on their level of economic efficiency.

Documentation digitalization in national public hospitals with high economic efficiency was more advanced than in national public hospitals with lower economic efficiency (Figure 1). The intensity of shading in Figure 1 reflects the degree of advancement of documentation digitalization in public hospitals, with a darker shade indicating a higher level of implementation of digital solutions.

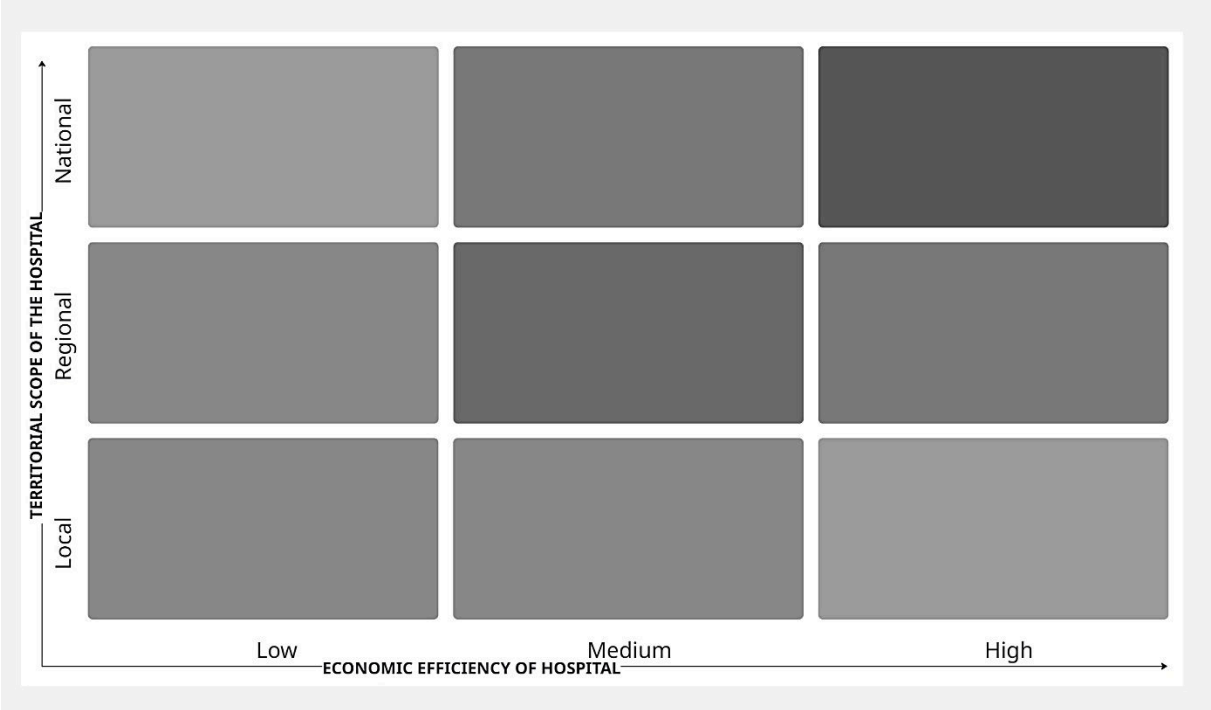

Figure 1. The level of advancement of documentation digitalization in the analyzed public hospitals. Source: Own elaboration.

The interviews conducted for the purpose of this study also facilitated the identification of the main benefits and risks associated with the digitalization of documentation. One of the primary benefits in both the clinical area and the administrative area was the reduced use of paper. This was emphasized by a department head from a national public hospital with high economic efficiency, who considered paper reduction to be one of the most tangible changes. Similar views were expressed in other hospitals, regardless of their scope of healthcare services or level of economic efficiency. The reduction in printing also resulted in lower consumption of toner and energy, as well as decreased costs related to document disposal. The reduction of hospital costs in this regard is reflected in the following statements by respondents: *Toner, electricity (...) disposal of all those things (...) definitely fewer printers; Completely eliminating paper and documentation (...) brings huge financial benefits for the*

hospital; It's (...) a lot of money and (...) a huge saving. [Chief nurse, a national public hospital with high economic efficiency].

Another benefit resulting from the implementation of documentation digitalization in both the administrative area and the clinical area was the acceleration of document circulation. Furthermore, the interviews indicate a reduction in the organizational workload of certain administrative and clinical staff members. An administrative director from a local public hospital with low economic efficiency emphasized: *Introducing digital solutions can also speed up our administrative work and improve the hospital's operational efficiency.* In most hospitals, particularly in national-level hospitals, respondents also pointed to improved internal communication due to the reduced need to distribute information in paper form.

Risks associated with documentation digitalization were also identified in all analyzed hospitals. These risks were particularly emphasized by representatives of the clinical area. Among the primary risks mentioned were failures of IT systems. Interviews conducted with respondents representing the clinical area indicate that they encounter significant difficulties in accessing medical documentation and test orders when IT systems are not functioning properly. A department head from a national public hospital with high economic efficiency stressed that in situations involving disruptions to IT infrastructure, access to key clinical data may be temporarily restricted, thereby affecting the continuity of healthcare service delivery: *(...) when there are system problems, we don't have access to the documentation on the computer. We can't really work then or admit patients. It's even dangerous for their lives.*

Another risk associated with the digitalization of documentation in public hospitals is the insufficient number of devices available for creating and processing medical documentation. It should be noted that in some of the analyzed hospitals, primarily local and regional ones, respondents pointed to infrastructural limitations, particularly a shortage of mobile devices enabling documentation at the patient's bedside. A department head from a local public hospital with medium economic efficiency emphasized: *We don't have that many (...) tablets (...) that's why there's still paper documentation (...) because we simply don't have enough equipment.*

Another risk that may arise in connection with Electronic Medical Documentation (EMD) is the insufficient functionality of IT systems in relation to the needs of medical staff. As indicated by the conducted interviews, in some hospitals the functions available within IT systems were inadequate for delivering certain medical services. For example, modules designed for electronic medication management and distribution were not properly configured: *The medication cart isn't (...) properly set up. [Department head, a regional public hospital with medium economic efficiency]*.

5. Discussion

The analysis of the study results indicates that documentation digitalization in the administrative area was most advanced in the following processes: finance and accounting, information flow and document management, and HR and payroll. A widely implemented solution in this area across public hospitals is the electronic workflow of invoices and contracts, as well as digital repositories of administrative documents. At the same time, within the administrative area, documentation digitalization remained limited in the processes of infrastructure and logistics management. In the clinical area, documentation digitalization in public hospitals occurs primarily in processes related to patient registration, diagnostics and patient monitoring, and hospitalization and patient discharge. However, digitalization has not yet been fully completed in all of these processes. In the analyzed hospitals, ongoing improvements to existing software systems are still being implemented. It is also noteworthy that in some hospitals, paper documentation continues to be maintained alongside electronic documentation.

The obtained results indicate that the level of advancement of documentation digitalization in both the administrative area and the clinical area was highest in hospitals operating at the national level, particularly those with high economic efficiency. In contrast, the lowest level was observed in local hospitals with low and high economic efficiency.

An analysis of the study findings also suggests that legal regulations have had a decisive impact on the development of documentation digitalization in public hospitals within both the clinical area and the administrative area. Since 2011, public hospitals in Poland have been prepared to create and store medical documentation in electronic form, and since 2019, the obligation to maintain medical documentation electronically has been introduced (Dz.U. 2011, nr 113, poz. 657).

The legal foundations for documentation digitalization in the administrative area were established in regulations concerning the informatization of entities performing public tasks, accounting, and employee documentation. Of particular importance was the Act of February 17, 2005, on the Informatization of the Activities of Entities Performing Public Tasks, which enabled the maintenance of documentation in ICT systems and the electronic exchange of data between public institutions (Dz.U. 2005, nr 64, poz. 565). A significant impact on the digitalization of administrative documentation was also exerted by the Regulation of the Minister of Family, Labor and Social Policy of December 10, 2018, on Employee Documentation, which enabled the creation and storage of HR documentation in electronic form (Dz.U. 2018, poz. 2369).

The main benefit resulting from documentation digitalization in public hospitals across both analyzed areas is the reduction in paper consumption. In the administrative area, documentation digitalization has particularly improved processes related to hospital finance and accounting.

In the clinical area, the main benefit of documentation digitalization is reflected in faster access of medical staff to patient information compared to paper-based documentation. It can therefore be concluded that documentation digitalization increases the organizational efficiency of public hospitals and enhances the quality and speed of patient service delivery.

The risks associated with documentation digitalization in both areas can be divided into technological and non-technological risks. As indicated by the conducted study, technological risks primarily include IT system failures and their insufficient functionality. Non-technological risks, in turn, relate to the lack of financial resources for the acquisition of hardware and IT software. The findings of the present study confirm and complement the research of Flis (2020), indicating that many public hospitals also face insufficient digital competencies among staff, infrastructural limitations, and financial burdens associated with the implementation of new tools. The risks associated with documentation digitalization in public hospitals highlight the necessity of ensuring high reliability of IT systems. It is also advisable to maintain a high level of IT system security to prevent unauthorized access to data.

In summary, based on the conducted study, it can be concluded that documentation digitalization in public hospitals requires a process-oriented approach that integrates technological solutions with oversight of key clinical and administrative processes. It is also essential that these efforts take into account the specific characteristics of patient care within the healthcare system.

6. Summary

Documentation digitalization in public hospitals constitutes one of the most important directions of transformation within the healthcare system in Poland. It aligns with the broader digitalization of public services and the development of the e-health system. Digital solutions in documentation management in public hospitals have become the foundation for coordinated patient care, the integration of hospital systems, and greater patient engagement in the treatment process. As demonstrated by the findings presented in this article, documentation digitalization occurs in processes within both the clinical area and the administrative area. As a result of documentation digitalization in public hospitals, there has been a transition from traditional registers, medical charts, and administrative forms to Electronic Medical Documentation (EMD). This development indicates that the digitalization of documentation in public hospitals in Poland has significant implications for the quality of care, patient safety, staff work efficiency, and the overall operational stability of the organization.

By providing information on the processes in which documentation digitalization takes place in public hospitals, as well as the associated benefits and risks, the conducted study may support public hospital managers in making decisions regarding the digital transformation.

This information may also be useful for policymakers responsible for the digitalization of the healthcare sector in Poland.

The findings on documentation digitalization in public hospitals are significant from an academic perspective. Within the management and quality sciences, this research provides new information concerning work organization in the public sector. Thus, the research results extend the knowledge in the field of public entrepreneurship. Future research may be aimed not only at identifying the factors influencing the progress of documentation digitalization in public hospitals.

This study has several limitations. First, due to its qualitative design and the use of semi - structured interviews, the findings cannot be generalized statistically to all public hospitals. Second, the study focused exclusively on public hospitals in Poland, which limits the transferability of the results to private healthcare providers and other national contexts. Finally, the division of hospitals according to territorial scope and economic efficiency, although analytically useful, may not fully capture other relevant organizational differences influencing the implementation of documentation digitalization.

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SELECTED NONPARAMETRIC TESTS ON COSMETIC MARKET CONSUMERS REGARDING CSR

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Purpose: The aim of this article is to present the results of research on consumers' perception of CSR in the Polish cosmetics market, including the impact of CSR on purchasing decisions or the main sources of consumers' knowledge on this topic. The analysis also incorporates selected nonparametric tests (Mann-Whitney U test and Kruskall-Wallis test) to identify statistically significant differences between respondent groups based on gender and age.
Design/methodology/approach: A survey was conducted using the CAWI method to examine how socio-demographic characteristics, including gender, age, and education, affect the evaluation and perception of CSR activities implemented by cosmetics companies. A questionnaire distributed via Google Forms consisted of single-choice and multiple-choice items, as well as questions on a five-point Likert scale. To analyze group differences, two non-parametric tests were applied: the Mann-Whitney U and the Kruskal-Wallis test.
Findings: The results indicate that CSR is a significant aspect for younger respondents, particularly women. The conducted nonparametric tests revealed statistically significant relationships between gender and the perceived importance of CSR, age group and the impact of CSR on purchasing decisions.
Research limitations/implications: The study was conducted over a short period in 2024 and may not capture longer-term trends in consumer perception. Additionally, not all aspects were considered, such as consumers' actual knowledge of CSR practices. Detailed discussion of these limitations and their implications is provided in the Summary section.
Originality/value: This article provides new empirical insights into consumer perceptions of CSR in the Polish cosmetics market, an area where nonparametric tests have been rarely used. The study combines survey data with Mann-Whitney U and Kruskal-Wallis tests to identify significant differences in CSR perceptions based on gender, age, and education. The results are valuable for researchers examining consumer perceptions of CSR in the cosmetics market. The study contributes to the literature by offering quantitative data on the influence of demographic factors on attitudes toward CSR, filling a gap in research on socially responsible practices in the Polish cosmetics market.
Keywords: Cosmetics market, CSR, nonparametric tests.
Category of the paper: Research paper.

1. Introduction

Regarding the Polish cosmetics market, corporate social responsibility (CSR) has emerged as a major area of focus in recent years. Although CSR has a long-standing tradition in the scientific literature, including management and quality sciences or economy, cosmetics companies treat this issue as relatively new, arising primarily from current legal regulations and social expectations. Both academic research and industry reports highlight the growing consumer awareness expressed through the analysis of cosmetic ingredients, the choice of sustainable products (e.g. those with international certifications or biodegradable components), the expectations of transparency and the selection of socially responsible brands.

Previous research on consumer behaviours and preferences in the Polish cosmetics market has focused primarily on the general issues rather than CSR. Most studies sought to identify key determinants, shopping locations, purchase frequency and purchasing strategies (e.g. stockpiling or spontaneous purchases). Several studies have explored consumer behaviour in the natural cosmetics market (Kantor, Hübner, 2019; Bojarczuk, Smalej, 2020; Firek, Dziadkowiec, 2020). Nevertheless, none of them have focused on CSR-related issues. Additionally, the majority of studies are based on survey research, both traditional and CAWI, but they do not employ statistical descriptions or tests, such as nonparametric methods. These observations inspired the present study on consumer perception in the cosmetics market in the context of CSR practices. This article focuses on the Mann-Whitney U test and Kruskal-Wallis tests.

2. Research description

For the purposes of this study a survey was conducted using CAWI method between April 25 and May 31, 2024. The main objective was to analyze the impact of socio-demographic characteristics, such as gender, age and education, on the evaluation and perception of CSR activities implemented by cosmetics companies. A questionnaire was developed for the study and subsequently distributed through Google Forms platform. This survey consisted of two sections and included single-choice and multiple-choice questions, as well as questions using a five-point Likert scale. The main section of the questionnaire addressed the following questions:

- Do you pay attention to CSR activities in the case of cosmetics companies? (Answer: Yes or No).
- Using a 1-5 scale, please rate how important CSR activities are to you in the context of cosmetics companies (1 - not important at all, 2 - rather unimportant, 3 - neither important nor unimportant, 4 - rather important, 5 - very important).
- Which of the following dimensions of CSR do you consider the most important in the context of cosmetics companies? (Select one: environmental, ethical, philanthropic, social, legal).
- Using a 1-5 scale, please indicate to what extent the implementation of CSR activities by cosmetics companies influences your purchasing decisions? (1- does not influence at all, 2 - rather does not influence, 3 - neither influences nor does not influence, 4 - rather influences, 5 - definitely influences).
- Where do you obtain information about CSR in cosmetics companies? (Multiple choice: from the Internet, social media, television, other people, magazines, discussion forums, reports, I do not obtain any information on this topic).

The second part of questionnaire, focusing on demographic information, included the following questions:

- gender (female or male),
- age group (up to 17 years, 18-29 years, 30-39 years, 40-49 years, 50-59 years, 60 years and above),
- education (primary, vocational, secondary, higher),
- place of residence (village, city up to 50,000 inhabitants, city 51,000-150,000 inhabitants, city 151,000-500,000 inhabitants, city over 500,000 inhabitants).

Due to the limited time available for the study, a random sampling method was employed, which is also referred to by other researchers as convenience sampling. This approach is primarily fast and inexpensive to implement and relies on units that are easily accessible and willing to participate (Szreder, 2004). Although random sampling does not guarantee the representativeness of the sample, it can provide a basis for understanding the population (Miszczak, Walasek, 2013, p. 103). In total, the study involved 432 respondents.

3. Description of variables

For the purposes of this study nine variables were used. Each of them is discussed in more detail in Table 1.

Table 1.
Description of variables

Variable	Type of variable	Question type	Example
Gender	Nominal, dichotomous	Single-choice question; selection of one of two options	Female
Age	Ordinal (age ranges)	Single-choice question; selection of the appropriate age range from six options	30-39 years
Education	Ordinal	Single-choice question; four response options	Higher
Place of residence	Ordinal (by range)	Single-choice question; five response options	City over 500,000 inhabitants
Consumer attention to CSR in cosmetics companies	Nominal, dichotomous	Single-choice question; selection of one of two options	Yes
Perceived importance of CSR in cosmetics companies	Ordinal	Five-point Likert scale question	4 - rather important
Key dimension of CSR in cosmetics companies	Nominal	Single-choice question; five response options	Ethical
Impact of CSR on purchasing decisions	Ordinal	Five-point Likert scale question	4 - rather influences
Sources of CSR knowledge	Nominal	Multiple-choice question	Internet, social media

Source: Own study.

Graphical presentations in the form of charts were created for all variables. In addition, two nonparametric tests were applied. To determine the relationship between gender and consumers' assessment of CSR activities undertaken by cosmetics companies, the Mann-Whitney U test was used. When analyzing variables such as the impact of CSR activities on purchasing decisions across different age groups, the Kruskal-Wallis test was employed.

4. Results of variable analysis

As previously mentioned, a total of 432 respondents participated in this study. In terms of gender structure, the vast majority of respondents were women (80,1%), while men accounted for 19,9% (Figure 1). This result may indicate that women continue to show greater interest in the activities of cosmetics companies including the implementation of socially responsible practices.

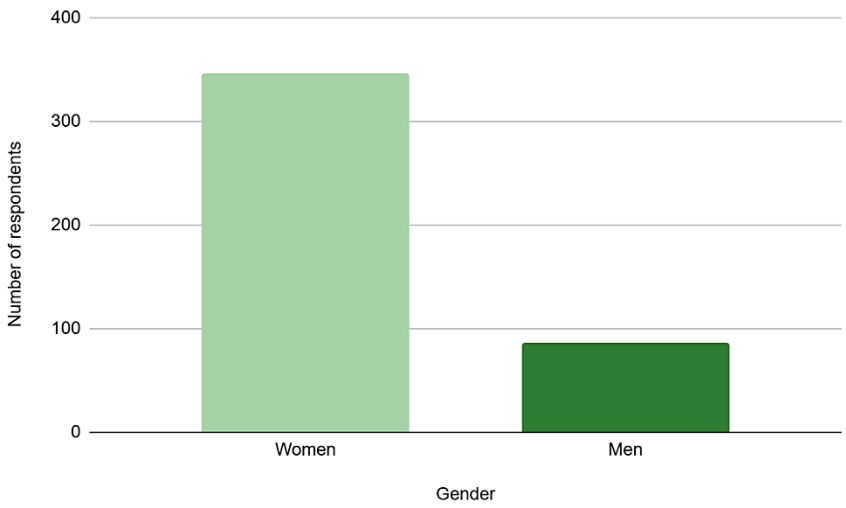

Figure 1. Distribution of respondents by gender.

Source: Own studies.

As presented in Figure 2, the age distribution of respondents was uneven, with a clear predominance of younger consumers. The largest group consisted of individuals aged 18-29 (50,46%). This was followed by the 30-39 age group (21,30%) and the 50-59 (14,35%). Smaller proportions were observed in the 40-49 age group (9,95%) and among those aged 60 and above (3,94%). It should be noted that no respondents under 18 participated in the study.

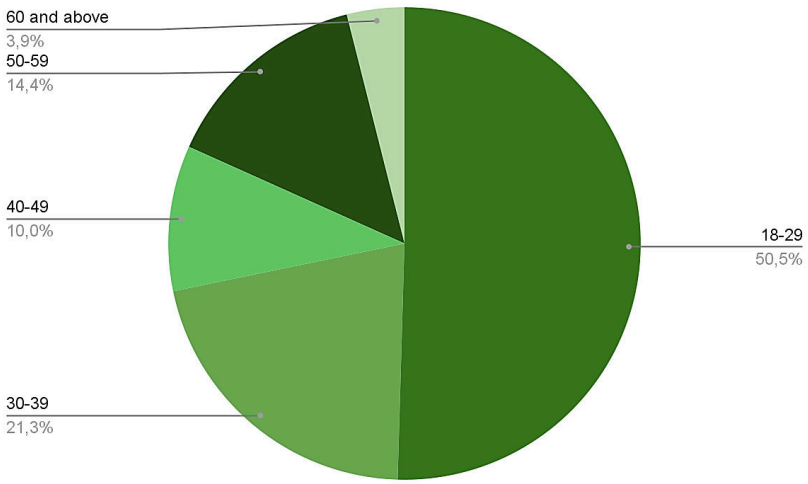

Figure 2. Age distribution of respondents.

Source: Own studies.

Regarding respondents' education, only two groups were represented in the study: those with secondary education (213 respondents, 49.3%) and those with higher education (219 respondents, 50.7%). No respondents with primary or vocational education participated in the survey. This distribution indicates that the sample was relatively well-educated (Figure 3). It may reflect that individuals with at least secondary education are more aware or attentive to CSR issues.

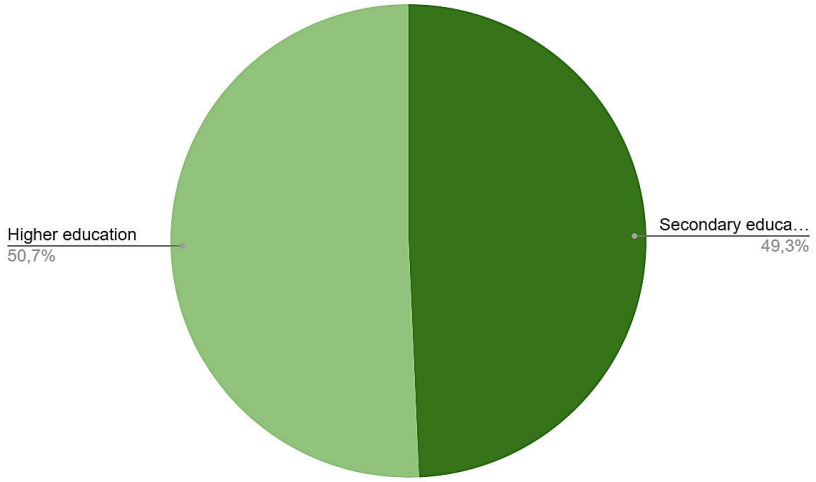

Figure 3. Respondents' education.

Source: Own studies.

The analysis of respondents' place of residence reveals a clear predominance of urban participants (Figure 4). Only a small proportion of the sample lives in rural areas (n = 23) or in small towns up to 50,000 inhabitants (n = 21). A slightly larger group comes from towns of 51,000 to 150,000 residents (n = 48), However, the majority of respondents reside in larger urban centers, with 213 participants living in towns of 151,000 to 500,000 inhabitants and 127 in cities with more than 500,000 inhabitants.

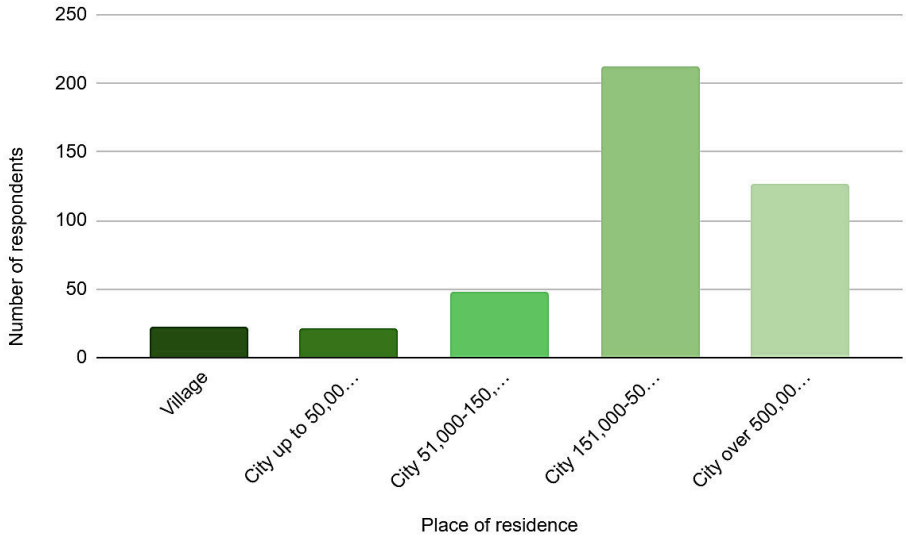

Figure 4. Distribution of respondents by place of residence.

Source: Own studies.

The analysis of respondents' attention to CSR in the context of cosmetics companies indicates that a substantial majority of participants consider CSR to be important (Figure 5). Specifically, 303 respondents reported that they pay attention to CSR initiatives, while 129 respondents stated that they do not. These results may suggest the growing importance of ethical and responsible business practices among consumers in the Polish cosmetics market.

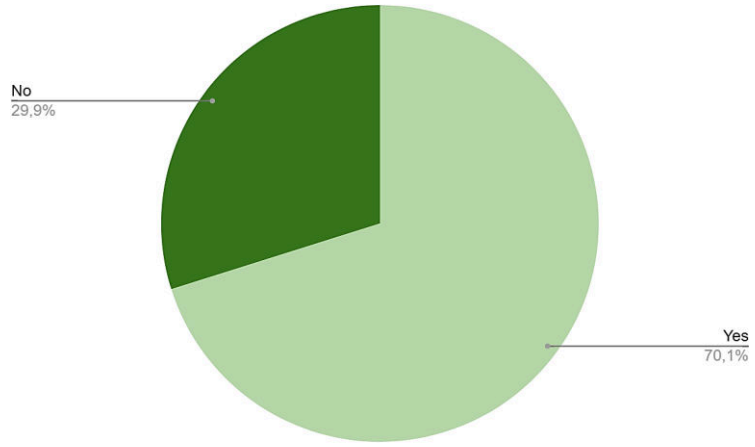

Figure 5. Attention to CSR initiatives in cosmetics companies.

Source: Own studies.

Respondents were also asked to rate the importance of CSR in cosmetics companies on scale from 1-5 where 1 indicated not important at all and 5 very important. The results show that the majority of respondents consider CSR to be significant (Figure 6). 32% of them rated it as 4 and 29% as 5. Lower ratings were less frequent, with 16% of respondents selecting 1 and an equal proportion (16%) selecting 3, while 8% selected 2.

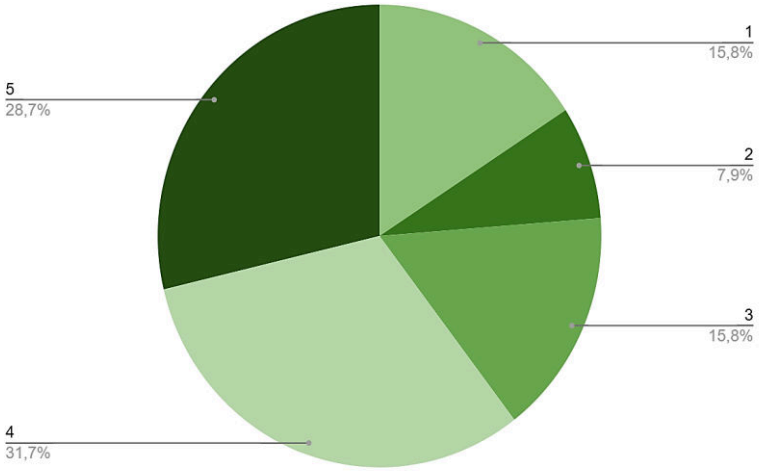

Figure 6. Consumers' ratings of CSR significance in cosmetic companies.

Source: Own studies.

Respondents were asked to indicate which CSR dimension they considered most important. As presented in Figure 7, the ethical dimension was identified as key by 48% of participants. The environmental dimension was identified by 28%, followed by the social dimension (20%). Only 4% of respondents considered the philanthropic dimension the most important, and none identified the legal dimension.

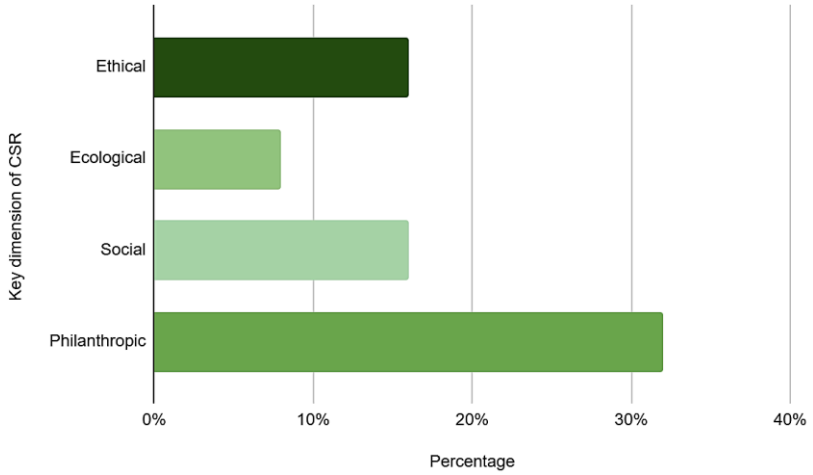

Figure 7. Key dimensions of CSR according to respondents.

Source: Own studies.

Analyzing the influence of CSR on consumers' purchasing decisions in the cosmetics sector (Figure 8), the highest proportions were observed for ratings 4 (30%) and 5 (24%). It indicates that a substantial share of respondents considers corporate social responsibility to be an important factor. On the other hand, lower ratings (1 and 2) together account for 41%, suggesting the presence of a group of consumers for whom CSR is not a significant consideration when purchasing cosmetics. The neutral rating (3) was selected least frequently (5%). Overall, these results reveal clear divisions among respondents in their perception of the importance of CSR.

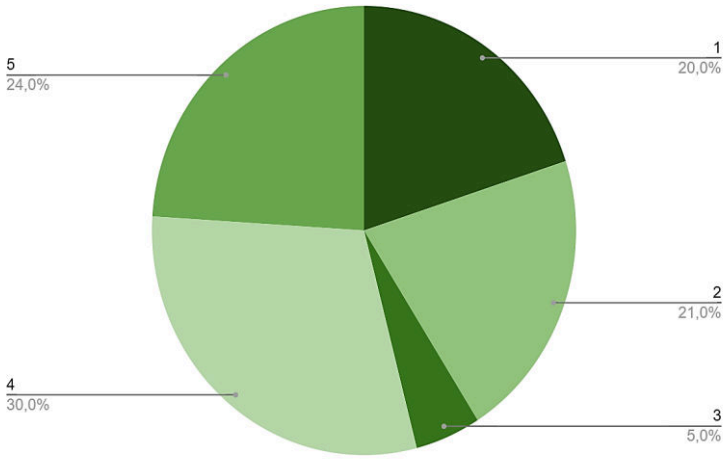

Figure 8. The impact of CSR on consumer purchasing decisions.

Source: Own studies.

In the case of information regarding CSR activities undertaken by cosmetic companies, digital platforms play a central role (Figure 9). In a multiple-choice question, the Internet (n = 272) and social media (n = 213) were the most frequently indicated sources. Notably, 152 respondents stated that they do not seek information about CSR in this context. This suggests that, despite the growing presence of CSR in online communication, there

remains a segment of consumers for whom CSR issues are not important or visible. In this case, a key action for cosmetic companies would be to carry out educational initiatives aimed at raising consumer awareness. Traditional media were mentioned far less often, with television cited by 8 participants and magazines by 3. Surveys were reported by 2 respondents.

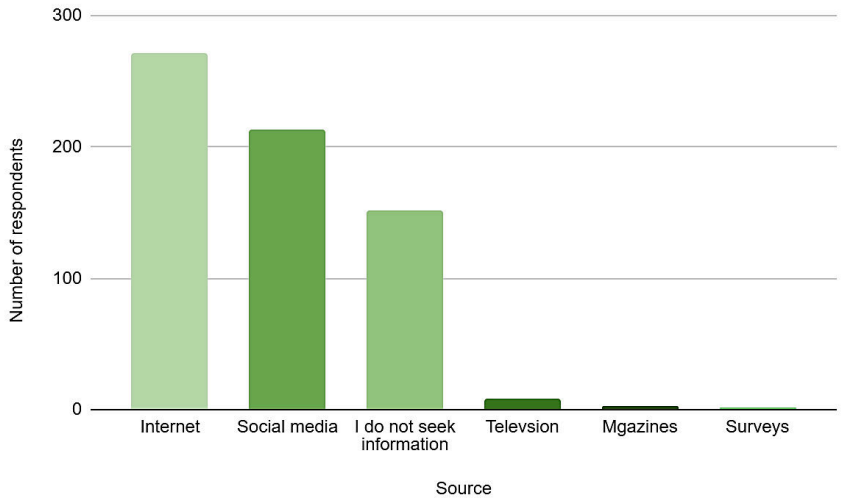

Figure 9. Sources of information on CSR.

Source: Own studies.

The analysis indicates that digital platforms play a central role in the communication of corporate social responsibility (CSR) activities within the cosmetics market. At the same time, 152 respondents reported that they do not actively seek information related to CSR, which suggests a heterogeneous level of consumer engagement in this area. The variables presented in this chapter, along with the overall distribution of responses, provide a necessary foundation for further statistical analysis. In the next stage of the study, the results will be subjected to nonparametric tests in order to determine whether and to what extent socio-demographic characteristics, such as gender and age, differentiate respondents' perceptions of CSR.

5. Nonparametric tests and results

According to Cz. Domański statistics, as a method of extracting information from observed data, serves to make logical decisions under conditions of uncertainty (Domański, 2014, p. 1). Although it is mainly associated with natural and exact sciences, it also has a wide range of applications in the social sciences. The literature highlights that statistical methods can be implemented at almost every stage of research design, from data collection and processing to analysis and interpretation. Consequently, the use of statistical methods in management and quality sciences is becoming increasingly important (Chybalski, 2017, p. 6).

A key aspect is the proper selection of statistical tests. Researchers often consider the use of parametric and nonparametric tests. Parametric tests require certain assumptions to be met, such as a normal distribution of the variable in the population and homogeneity of variance (Kleka, Jasielska, 2008; Kompa, 2014, p. 4). When these conditions are not satisfied, nonparametric tests provide a suitable alternative. Their advantages include ease of calculation, speed, and independence from the shape of the variable's distribution (Donocik, 2013, p. 34). Nonparametric tests are particularly useful in pilot (Chavan, Kulkarni, 2017, p. 41) and survey research. As M. Słowińska notes, statistical analysis constitutes an integral part of survey result interpretation, enabling the verification of previously formulated hypotheses (Słowińska, 2019, p. 37).

The most commonly used nonparametric tests include Chi-Square test, One Sample Wilcoxon Signed-Rank test, Wilcoxon Signed-Rank Paired sampled test, Spearman's Rank Correlation test, Mann-Whitney U test and Kruskall-Wallis test. For the purposes of this study, two nonparametric tests were applied. To determine the relationship between gender and consumers' assessment of CSR activities undertaken by cosmetic companies, the Mann-Whitney U test was used. To analyze the impact of CSR activities on purchasing decisions among different age groups of cosmetic consumers, the Kruskal-Wallis test was employed.

The Mann-Whitney U test is considered a nonparametric equivalent of the independent samples t-Test. Its purpose is to verify the hypothesis that the two analyzed samples originate from different populations (Malska, 2017, p. 114). In this study, the Mann-Whitney U test was used to examine whether there are statistically significant differences in the assessment of the importance of CSR between genders. The significance level was set at $p < 0.05$. The following hypotheses were formulated:

- Null hypothesis (H_0): There are no statistically significant differences in perceived importance of CSR between genders.
- Alternative hypothesis (H_1): There are statistically significant differences in perceived importance of CSR between genders.

The results presented in Figure 10 indicated a statistically significant difference between the two groups ($U = 27{,}552$, $p < 0.001$). Analysis of median scores showed that women assign higher importance to CSR activities, with a median rating of 4, whereas men tend to give lower ratings, with a median of 1. The distribution of ratings among women is concentrated in the higher range (4-5). However, some women gave lower scores, such as 3, indicating slight variability within the group. Men's ratings are more dispersed and shifted toward lower values (1-2). The boxplot also highlights a few outliers among men, indicating that some male respondents rated CSR higher than the majority of their group.

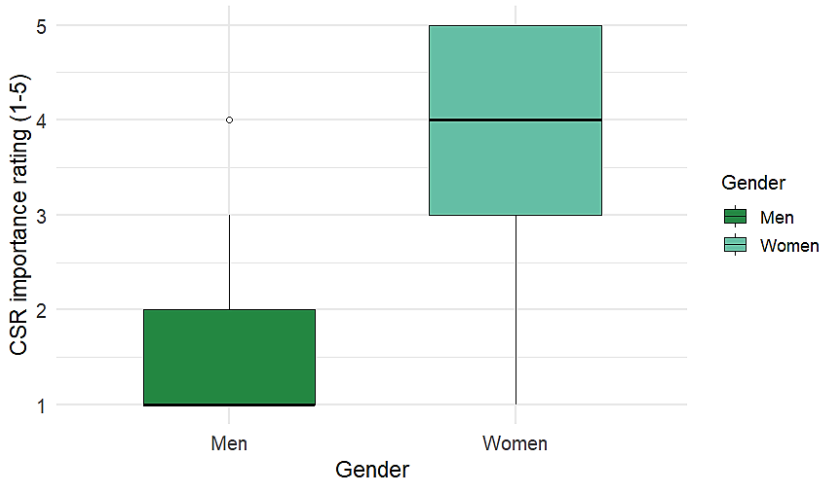

Figure 10. Importance of CSR by gender.

Source: Own studies.

The Kruskal-Wallis test is a nonparametric equivalent of analysis of variance (ANOVA) (Donocik et al., 2013, p. 34). It is applied when the assumption of normality is violated, the subsamples are small, and the variable is ordinary in nature (Wiktorowicz, Grzelak, Grzeszkiewicz-Radulska, 2020, p. 111). The selected variables meet these criteria. Both age (respondents' age groups) and the perceived impact of CSR on consumers' purchasing decisions are ordinary variables. Statistical significance is assumed at $p < 0.05$. In the present study, the Kruskal-Wallis test was used to determine whether the perceived influence of CSR on purchasing decisions in the cosmetics market differs between age groups. The following hypothesis was formulated:

- Null hypothesis (H_0): There are no statistically significant differences in the perceived influence of CSR on consumers' purchasing decisions in the cosmetics market between age groups.
- Alternative hypothesis (H_1): There is at least one age group in which the perceived influence of CSR on consumers' purchasing decisions in the cosmetics market differs significantly from the other groups.

The Kruskal-Wallis test revealed a statistically significant difference in the perceived impact of CSR on purchasing decisions between age groups (chi-square = 244.94, df = 4, $p < 0.001$). Younger respondents (18-29 and 30-39) tended to rate the impact of CSR higher, with most ratings concentrated in the 4-5 range, whereas older respondents (50-59 and 60+) generally gave lower ratings, mainly between 1 and 3. Middle-aged groups (40-49 and 50-59) showed a more dispersed distribution of ratings. A few outliers were observed across all groups, indicating occasional anomalous ratings (Figure 11). These results suggest that age significantly influences how consumers perceive the importance of CSR in the cosmetics market.

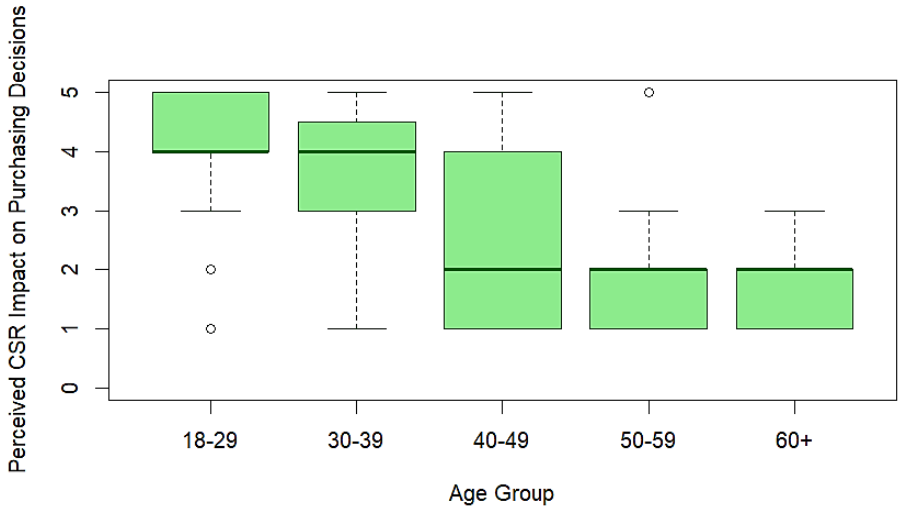

Figure 11. The impact of CSR on purchasing decisions depending on the age group.
Source: Own studies.

The main finding of the analysis is that CSR perception is not homogeneous and varies significantly depending on socio-demographic characteristics. The application of nonparametric statistical tests enabled empirical verification of the research hypotheses and addressed a gap in the existing literature, where quantitative methods are still relatively underutilised in this field.

6. Summary

Although consumer preferences, attitudes and opinions constitute the primary focus of research on the cosmetics market, there is still a lack of publications in which assumptions regarding relationships between specific variables are supported by appropriate statistical tests. Based on the conducted research, the following conclusions can be drawn:

- Gender and age are significant determinants of CSR perception, with women and younger consumers (18-39 years) assigning higher importance to CSR-related activities.
- A considerable proportion of respondents does not actively seek information about CSR, indicating limited consumer engagement despite generally positive attitudes.
- The ethical dimension of CSR is perceived as the most important compared to environmental and philanthropic aspects.

To further explore this topic in future research, the following criteria should be considered:

- purposive sampling,
- increasing the sampling size,

- ensuring representativeness,
- including questions in the survey to assess consumers' knowledge of socially responsible practices implemented by cosmetics companies (e.g. tests on recognizing certifications),
- taking into account actual purchasing behaviours (i.e., whether purchasing CSR-compliant cosmetics is real or merely declared),
- extending the duration of studies,
- the use of additional nonparametric or parametric tests.

In conclusion, the study provides valuable insights into consumer perceptions of CSR in the cosmetics market and demonstrates the usefulness of nonparametric statistical methods in analysing such relationships. Although the results should be treated as preliminary due to the applied sampling method and limited time frame, they indicate clear patterns in how different demographic groups perceive CSR. The findings may serve as a foundation for more comprehensive and methodologically advanced future research in this area.

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CIRCULAR MANAGEMENT OF MUNICIPAL BIO-WASTE IN THE CONTEXT OF KRAKOW'S SMART CITY STRATEGY

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Purpose: The purpose of article is to present the concept of municipal bio-waste circularity within the framework of Krakow's smart City strategy and to evaluate the energy potential of bio-waste based on conducted simulations.
Design/methodology/approach: A research process based on Desk Research analysis, utilizing existing data from the Marshal's Office of the Małopolska Region and the Krakow Development Strategy 2030. The assessment of smart city implementation in Krakow was conducted based on the Smart City Index. Furthermore, the article provides a review of the relevant literature.
Findings: The study shows that Krakow is successfully executing actions, fostering a city ecosystem aligned with sustainable development goals.
Research limitations/implications: The theoretical biogas production potential was estimated based on 2024 data regarding the volume of kitchen (code 20 01 08) and green (code 20 02 01) bio-waste collected in Krakow. The calculated energy potential of kitchen waste indicates a high return on investment, representing the missing link in Krakow's circular economy model.
Practical implications: The calculations have a practical application in the design of urban energy systems. Determining the energy potential of the kitchen and green waste enables the identification of specific zones, including residential complexes and public utility buildings, capable of achieving partial energy autonomy by integrating circular economy technologies.
Social implications: The study shows that smart city actions in the field of circular economy require social acceptance and resident participation to be successful. It should be clearly shown that waste is repurposed into clean energy, helping to decrease air pollution in Krakow while curbing the ever-increasing expects associated with waste management.
Originality/value: The novelty of this study consists in establishing a direct correlation between smart city strategies and the recovery of energy from kitchen waste as a core element of the circular economy. The novelty of this study lies in demonstrating a direct correlation between smart city strategies and energy recovery from kitchen waste as a key element of the circular economy. The analysis combines a case study typical of a management article with practical energy simulations demonstrating the potential of kitchen waste utilization.
Keywords: smart city, circular economy, municipal biogas plant.
Category of the paper: Research paper.

1. Introduction

The urban environment is shaped by physical elements that satisfy the needs of residents, such as residential and public buildings, shopping centers, roads and energy infrastructure. Development is achieved through the expansion of infrastructure, which leads to the consumption of natural resources and energy, and consequently to the emission of pollutants into the atmosphere and the generation of waste. It is estimated that cities consume around 75 per cent of the world's energy and generate as much as 70 per cent of global CO_2 emissions (Energy 101, 2022). For these reasons, measures are being taken to optimize energy consumption and reduce waste, with a view to ensuring the sustainable development of urban communities.

The world's largest cities and Polish cities alike must solve the same problems that make life difficult for their residents. These include a lack of housing, inefficient public transport, traffic congestion, healthcare, waste management and others. In order to address these issues in a comprehensive manner, the concept of a smart city was developed. It should be adapted to the geographical, economic and social conditions of each city. Transforming existing urban organisms to make them compatible with this concept takes time, financial resources and, most importantly, the participation of residents in the creation of programs and their involvement in their implementation. As economic and social conditions change, as do the demands of city inhabitants, it seems that the process can never be considered complete. The integration of circular economy within the smart city ecosystem enables advanced energy recovery models. By applying energy simulations to urban biodegradable waste streams, a smart city can optimize its local energy balance and reduce reliance on external power sources.

This article describes the origins of the concept of sustainable development, the circular economy model and the components of the smart city model. The main part of the publication consists of our own research on the implementation of the smart city| concept in Krakow and an indication of possible further actions in the area of municipal waste management.

The aim of article is to present the concept of municipal bio-waste circularity within the framework of Krakow’s Smart City strategy and to evaluate the energy potential of bio-waste based on conducted simulations.

The present study aim to test the hypothesis that waste management activities in Krakow should be expanded to include the construction of a municipal biogas plant, which is an installation implementing the assumptions of the circular economy and smart city.

2.1. Research gap

Despite the extensive literature on smart city development and the circular economy, there is a noticeable lack of simultaneous assessment of the implementation efficiency of both concepts within a city. There is a lack of research in which the assessment of smart city

initiatives is conducted based on the Smart City Index survey, used to evaluate such activities among the residents of Krakow. The majority of scholarly works evaluate smart city initiatives and the circular economy as separate entities. Previous studies smart city initiatives have relied on mathematical modeling tools to identify key activities across the six core dimensions of a smart city (Kauf et al., 2025). Existing literature, such as the work of Winkowska, has explored the smart environment dimension, with a particular emphasis on waste management practices in Kielce and Gdynia. Although several smart city rankings are described, the study identifies a gap in linking Smart City Index survey results with actual urban projects in a Polish city (Winkowska, 2021). Pech et al. performed a comparative analysis of two cities using smart city applications to drive circular economy transitions. The author's focus was limited to the analysis of isolated technical solutions implemented in cities (Pech et al., 2021). Regions in Context III. Principles of circular economics in regional management leading to increased efficiency of systems). Research concerning circular economy activities in the context of waste was conducted by Rolewicz-Kamińska and Wesołowska. The authors analyzed how waste morphology influenced the efficiency of waste collection (Rolewicz-Kalińska, Wesołowska, 2025). The publication by Czerwionka et al. presents the "Sztum Circular Economy" project. This publication shows that selective waste collection, green purchasing, and education are key drivers for circular economy implementation in smaller urban areas (Czerwionka et al., 2025). There is a notable absence of energy modeling that showcases the practical implementation of circular economy and smart city initiatives in urban environments.

None of the studies include simulations on producing energy from city-generated biodegradable waste. The findings indicate a clear need for integrated development of circular economy practices and smart city initiative.

2. Literature review

2.2. The concept of sustainable development in cities

The natural environment of modern humans is cities, where more than half of the world's population lives. According to UN data, more than half of the world's population (55%) currently lives in urban areas, and by 2050 this figure is expected to rise to as much as 68% (Desa, 2014). Urban agglomerations have specific living conditions resulting from high population density and housing needs, as well as the need to commute from home to work and school, to go shopping, visit the doctor, run errands or enjoy entertainment. A large percentage of residents use private transport, which means they have to spend a lot of time in traffic jams (Mierzejewska, 2015). This phenomenon occurs in agglomerations with millions of inhabitants

and in cities with up to 100,000 inhabitants, which is also observed in Poland. These problems have given rise to the idea of sustainable cities, which aim to comprehensively address the institutional, environmental, social and economic challenges resulting from rapid urbanization, population density, and inefficient resource management. issues. The main goal is to create urban spaces that are friendly to people and the environment, meeting the needs of current residents without limiting the opportunities of future generations (Rzeńca, 2016). In the world's most popular development strategy, Agenda 2030, there are 17 Sustainable Development Goals and 169 related actions to be achieved by all parties. They take into account economic, social and environmental aspects. Agenda 2030 was adopted in 2015 by 193 UN member states, unanimously, through the resolution "Transforming our world: the 2030 Agenda for Sustainable Development". These goals relate to eradicating poverty and hunger, ensuring a good quality of life, health, education, economic development, clean energy and innovation, as well as environmental and climate protection. For urban development, Goal 11 – Sustainable cities and communities – is the most important (Cele zrónoważonego rozwoju). The aim is to create inclusive, safe, resilient and environmentally friendly spaces. Implementation is based on integrating ecological, social and economic aspects. Key management concepts that implement these objectives in cities include smart city and circular city based on the circular economy.

2.3. Circular economy in cities

The circular economy in sustainable cities is a resource management model that aims to eliminate waste and pollution and keep products and materials in use through repair and reuse. It replaces the linear economy model (take – make – use – dispose), which consumes large amounts of raw materials and pollutes the environment (Dincă et al., 2022). The circular economy is seen as a driver for sustainable development worldwide. In comparison to sustainable development, it is a newer approach that focuses primarily on minimizing inputs, strengthening and protecting natural resources, as well as managing limited resources efficiently and reducing overall risk (Lakatos et al., 2021). The circular economy is "a model of production and consumption that involves sharing, consuming, reusing, repairing, refurbishing and recycling existing materials and products for as long as possible" (Kirchherr et al., 2017; Gospodarka o obiegu zamkniętym, 2023). This approach extends the life cycle of products, which in practice means less waste will be generated. The concept of circular economy is based on minimising the environmental impact of manufactured products through the selection of components and design that enable their reuse (Imperatives Strategic, 1987). The concept of cradle-to-cradle is related to the circular economy. It is a way of designing and manufacturing objects in accordance with the concept of sustainable development. After they have been used, they can be reintroduced into circulation (Bakker et al., 2011). In the circular model, there is no waste, only raw materials that become resources. This economic model

makes resource management more efficient and reduces the risk of depletion. Well-managed waste becomes a raw material that re-enters the product life cycle.

In the first place, the principles of the circular economy should be based on a hierarchy of resource management based on the 3xR principle, i.e. reduce, reuse, recycle (Kirchherr et al., 2017; Wysokińska, 2018). The circular economy is seen as a sustainable economic system in which economic growth is independent of the consumption of resources such as fossil fuels, minerals, metals and biomass (MacArthur, 2013; Ghisellini et al., 2016). It focuses on sustainable development in areas such as industrial ecology, waste management, renewable energy, recycling and smart cities. By reusing and recycling municipal waste, the global demand for raw materials used in the production of materials and energy resources is reduced. This results in a reduction in greenhouse gas emissions into the atmosphere (Aceleanu et al., 2019). Over the years, technological advances have led to the development of waste-to-energy (W2E) technologies, which have become more affordable and efficient. In addition, waste can be used to manufacture various products which, when properly designed, can be used for a long time. Therefore, municipal waste in the circular economy is treated as a resource rather than waste (Musti, 2020). In addition to guidelines and waste management schemes, the European Union also promotes the circular economy among the general public through education. The aim is to raise awareness among citizens and businesses in order to reduce waste generation and greenhouse gas emissions. These areas of education include: selective waste collection, energy saving and waste reduction in households and businesses (Kowalska et al., 2020). According to European Union guidelines, the value of products, materials and resources should be maintained for as long as possible and waste generation should be minimized. This is the basis for the development of smart cities (Closing the Loop, 2015).

2.4. Smart city concept

A modern city consists of many elements, making it an open, complex socio-economic system, and its development depends on the connections between its individual elements (Sikora-Fernandez, 2013). There is no clear definition of a smart city in the literature. Komnimos attempted to define a smart city. According to it, a smart city is defined as an area with a high capacity for learning and innovation, creativity, research and development institutions, higher education, digital infrastructure and communication technologies, and well-developed governance (Komnimos, 2002, p. 1). According to Bakici et al., a smart city should connect people and information, using new technologies to create a sustainable, more ecological, competitive and economically innovative organism in order to improve the quality of life there (Bakıcı et al., 2012). Barrionuevo et al. defined a smart city as the use of all available information, technologies and resources in an intelligent and coordinated manner by integrating them (Barrionuevo et al., 2012). According to Nan and Pardo, the information collected helps identify problems and demonstrate how they can be solved. This facilitates rapid action in the event of natural disasters, the need for optimal resource utilization decisions,

and cooperation between various city authorities (Nam, Pardo, 2012). Zygiaris defined the roles of smart cities as cities:

- green – referring to urban infrastructure, environmental protection and reduction of CO_2 emissions,
- connected – related to the broadband economy revolution,
- intelligent – stating the ability to generate added value information in real time from sensors and actuators (Zygiaris, 2013).

According to Żukowska and Chmiel, the concept of a smart city refers to an ultra-modern city that meets the needs of businesses, institutions and all citizens. The concept is characterized by a holistic approach to urban development and the use of solutions based on communication technologies ICT – Information and Communication Technologies (Żukowska, Chmiel, 2022). A smart city focuses on implementing sustainable development principles in the social, economic and environmental spheres, without compromising the interests of future generations (Żukowska, Chmiel, 2022a). Characterized by modern administration or offices that provide new public services based on user-friendly information and communication services in local government (Gonzales, Rossi, 2011; Ferro et al., 2013).

These definitions show that advanced information and communication technologies (ICT) have a dominant role in the development of modern cities. Lazaroiu and Roscia indicate that the term smart city should refer to a city where available and new resources and possible investments are optimized. These goals can be achieved with the support of advanced information and communication technologies, particularly in areas such as energy, technological infrastructure, public safety, waste management and transport (Lazaroiu, Roscia, 2012). Modern cities require large amounts of energy and water to function, which must satisfy the needs of increasingly populated cities. Residents play a key role in the smart city ecosystem, as their activities influence the processes taking place in the city related to the flow of energy and matter. The primary sources of energy are fossil fuels and renewable energy, while matter comes in the form of waste generated from the production and consumption of products (Ba, 2017). The smart city concept seems to be the best for managing cities, as in addition to saving energy and water, it solves the problem of waste management and air protection (Musti, 2020; Aceleanu et al., 2019). The problems with establishing a single definition stem from the different perceptions of the smart city concept in different countries. In the European Union and its strategic documents, the emphasis is on clean energy, energy savings and reducing CO2 emissions into the atmosphere. In the US, smart cities are perceived as those that have human and social capital, transport and communication technologies, their development is in line with sustainable development, and the authorities ensure a better quality of life. In Australia, the concept of a smart city focuses on creative industries and digital media (Sikora-Fernandez, 2013). Despite the lack of a clear definition of a smart city, six main areas can be identified that make up the idea of ‘smart’. The elements of a smart city include: smart mobility, smart economy, smart people, smart living, smart governance and smart environment (Glinka, 2017;

Khatoun, Zeadally, 2016). The intelligence of cities is measured using six components, comprising 28 factors presented in Table 1.

Table 1.
Six smart components and factors for measuring urban intelligence

Component	Factors for measuring urban intelligence
Smart economy	Spirit of innovation, entrepreneurship, economic image and trademarks, productivity, labor market flexibility, international cooperation
Smart people	Level of qualifications, lifelong learning, ethnic pluralism, creativity
Smart governance	Participation in public life, public and social services, transparency of governance
Smart mobility	Local, national and international accessibility, IT infrastructure accessibility, sustainability of the transport system
Smart environment	Environmental conditions, air quality, environmental awareness, sustainable resource management
Smart living	Cultural facilities, health conditions, safe communities, housing conditions, educational facilities, tourist appeal, economic prosperity

Source: (Baraniewicz-Kotasińska, 2017).

In order to make a city more resident-friendly, measures must be introduced to protect the environment and use natural resources more efficiently. A smart city that cares about the environment should implement measures in line with the circular economy, which increases its economic, social and environmental value (Dincă et al., 2022). From an ecological perspective, a concept has been developed that describes this area of smart city functioning in greater detail. One such concept is the green city, according to which a city takes politically and socially responsible actions to achieve high environmental quality, which contributes to human well-being (Pace et al., 2016). Another concept is the eco-city, according to which expenditure (resources) and production (waste) are minimised. Residents agree to the construction of an eco-city and commit to living in harmony with the biosphere (Rudloff, 2018).

Polish cities are implementing elements of the smart city concept into their urban management processes. This is indicated by the global Smart City Index ranking, which focuses on the economic and technological aspects of smart cities and on the human dimension of smart cities, i.e. quality of life, environment and integration. In 2025, the two largest Polish cities, Warsaw and Krakow, were included in the ranking.

This holistic approach will allow us to assess whether Krakow is actually becoming a smart city or whether it is just individual innovations.

3. Methods and research

This article presents a detailed analysis of the case of Krakow. This choice is dictated not only by the city's high ranking but, above all, by the continuation of previous research on this metropolis, which allows for a more in-depth, retrospective assessment of the changes implemented (figure 1).

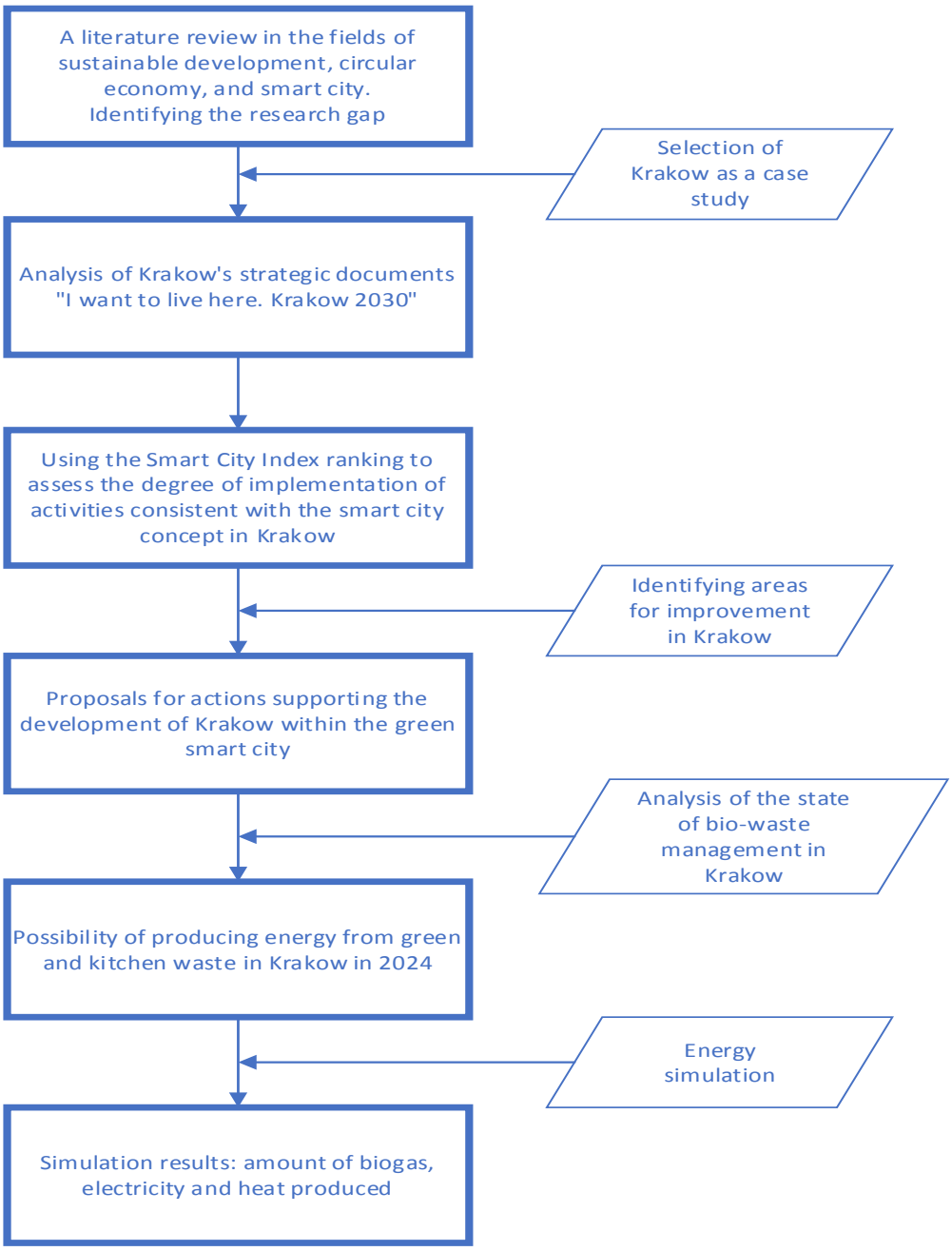

Figure 1. Methodologies of the research.

3.1. Objects analysis

Krakow is an example of a city modernized according to the smart city and circular economy model. Located in the Vistula River Valley and surrounded by hills, it lies at the intersection of the A4 motorway and the S7 expressway. Due to its numerous historical monuments, it is a center of domestic and international tourism. Residents from across the Małopolska Voivodeship and neighboring voivodeships come to Krakow to work, study, and shop. It is a dynamically developing city, as evidenced by the increase in its population from 761,000 in 2015 to over 806,000 in 2024 (Bank Danych Lokalnych, 2025). Krakow was chosen as a case study due to previous research interests in the city and favorable conditions

for conducting systematic research. Based on the city's development strategy, the degree of implementation of smart city and circular economy initiatives was assessed, and the potential for biogas production from biodegradable waste was calculated based on datBaraniewicz-Kotasińskaa provided by the Marshal's Office of the Małopolska Voivodeship. Striving to become a modern urban center combining a high standard of living with cutting-edge technology and a resident-friendly environment, Krakow is committed to implementing the principles of a smart city and a circular economy.

3.2. Krakow's activities within the smart city framework

In 2018, the Krakow City Council adopted the city development strategy titled 'This is where I want to live. Krakow 2030,' developed in accordance with the smart city model. Its goals are achieved through strategic programs and non-program tasks, including independent projects across various management fields (Kraków przyszłości, 2024).

Among the most important projects implemented in line with smart city components are:

- *Smart economy* – Virtual assistant, which is a free mobile application. Using text and voice commands, users can obtain information regarding business services as well as other procedures carries out by organization units. This tool allows for the handling of official matters at various times of the day and from any location. It provides particular support for busy people and with disabilities.
- *Smart mobility* – It is implemented through a modern, eco-friendly fleet consisting of trams, electric buses, and vehicles powered by compressed natural gas (CNG) that meet Euro 6 emission standards. Smart traffic management systems are in operation. An integrated and secure transport system creates a high-speed network through a traffic control system that grants priority to public transport at intersections. The Agglomeration Fast Rail links central Krakow with the international airport and a number of neighboring communes. Discounts for individuals registered or paying taxes in Krakow who hold a Krakow City Card serve as an incentive to encourage the use of public transportation (Uchwała nr XCIV.2449/18 Rady Miasta Krakowa, 2018).
- *Smart environment* - Refers to waste to energy plants and the management systems for water supply and sewage networks. Biogas plants at two of Krakow's wastewater treatment facilities produce electricity and heat in a cogeneration process. The development of urban green areas and parks provides the city with 'green lungs' and creates a haven for wild birds, hedgehogs, and rodents. Pocket parks and green transit stops are being developed to cater to residents seeking a connection with nature a place to unwind. As part of Krakow's ongoing battle against smog, air quality monitoring devices and information displays providing real-time pollution data have been set up in numerous high-traffic locations. Measures are being implemented to decrease urban energy consumption. The transition to energy-efficient LED street lighting was finalized in 2016. The smart lighting control system cut energy consumption by 63%, significantly

lowering the city's electricity bills. Reducing CO_2 emissions into the atmosphere is an additional benefit (Uchwała nr XCIV.2449/18 Rady Miasta Krakowa, 2018).

- *Smart governance* – This field focuses on the monitoring of restricted traffic zones using specialized camera systems. The cameras verify vehicles entering restricted areas. It helps city guards monitor and enforce prohibited entry zones. This all aids in protecting the environment, adapting to climate change, and ensuring the safety of the local community (Uchwała nr XCIV.2449/18 Rady Miasta Krakowa, 2018).

The efficiency of municipal initiatives is enhanced by consecutive rounds of the citizen budget, where residents leverage their knowledge of local issues and needs through high levels of engagement. Mobile applications that enable the reporting of local issues, such as road damage or water utility failures, are also gaining popularity.

3.3. Evaluation of Krakow's activities within the smart city framework

Krakow and Warsaw stand as the sole Polish cities featured in the prestigious Smart City Index ranking, established by the Switzerland-based International Institute for Management Development (IIMD). It encompasses key sectors, including mobility, health, safety, data management, and sustainability. The index assesses how cities utilize technology and innovation to enhance the quality of life for their inhabitants and manage key infrastructure, including transport, energy, safety, and sustainability. The ranking is based in the subjective opinions of city residents regarding how their cities function. Responders choose 5 out 15 priority areas of city functioning. The assessment utilizes the Human Development Index (HDI), which evaluates factors such as health and longevity, education, and standard of living (Smart City Index, 2025).

In the first edition of the index, published in 2019, Krakow ranked 69th out of 102 cities evaluated. The priority areas of city functioning for residents were air pollution (75%), traffic congestion (60.8%) and affordable housing (50.8%). For those surveyed, areas such as citizen engagement, social mobility/inclusiveness, and corruption /transparency (picture 3). In 2025, Krakow ranked 70th out of 146 cities evaluated. In this edition, the majority of respondents stated that the priority areas in cities, are affordable housing (61.5%), air pollution (57.8), and road congestion (47.9%). Following these were security, fulfilling employment, health service, green spaces, and broad-based urban services (Smart City Index, 2024, 2025).

Comparing the importance of priorities in the three key areas addressing basic human needs across both edition, it can be concluded that efforts to improve air quality have yielded results, but for 57.8% of residents, the improvements is insufficient. Comparing the importance of priorities in three key areas responding to basic human needs from both editions, it can be concluded that efforts to improve air quality have brought results, but for 57.8% of residents the improvement is insufficient. The reduced severity of traffic congestion is a results of the construction of new tram lines and expressways, such as the Łagiewnicka Route, yet nearly half of the residents remain dissatisfied with the situation. The problem of affordable housing

availability has not been resolved; instead, it is escalating. The sense of security has decreased followed by issues with water, waste, and education.

Analyzing the data shown in Figure 2, it can be hypothesized that current efforts should focus on implementing the "Green Smart city" concept, namely environmental production.

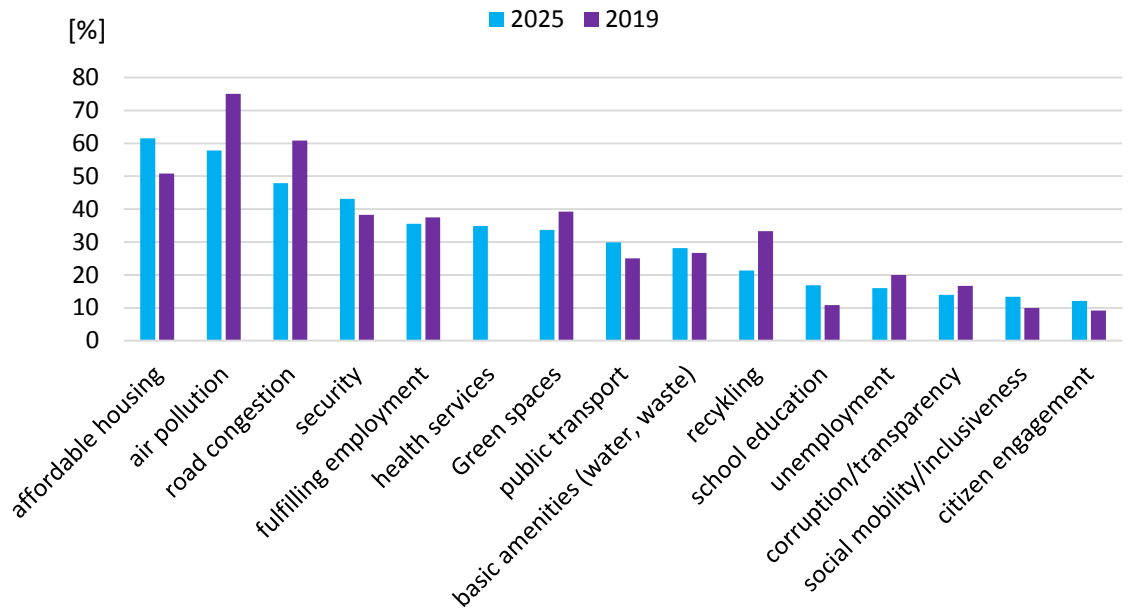

Figure 2. Priority areas selected by Krakow residents in the 2019 and 2025 Smart City Index. Source: (Smart City Index, 2019, 2025).

3.4. Recommendations for further measures in the field of Green Smart City development

The realization of the green smart city vision necessitates the construction of affordable housing, the reduction of Green House Gases (GHG) and particulate matter emissions, the mitigation of traffic congestion, the expansion of public transit, and enhanced waste management systems.

Krakow has experience in implementing large-scale infrastructure projects in waste management and environmental protection. These include a thermal waste treatment plant and two modern wastewater treatment plants equipped with facilities for biogas production and co-generation combustion. The thermal waste treatment plant processes more than 200,000 megagramms (Mg) of waste per year, producing electrical energy and thermal power. In 2024, it generated over 69,000 MWh of electricity and more than 1.3 million GJ of heat per year. The biogas installation at the "Płaszów" sewage treatment plant generates about 12,000 MWh of electrical energy and more than 43,000 GJ of heat per year (Oczyszczalnia ścieków Płaszów…, 2024). The biogas plant at the "Kujawy" wastewater treatment facility has an annual production of approximately 12,000 MWh of electricity and over 38,000 GJ of thermal energy (Energia ze źródeł odnawialnych…, 2023). These facilities solve the problem of managing mixed waste and sewage sludge. The challenge of managing separately collected

biodegradable waste (bio-waste) remains to be addressed, specifically green waste (code 20 02 01) and kitchen waste (code 20 02 08). The introduction of separate municipal waste collection in 2013, in accordance with the Waste Act (Ustawa o odpadach, 2012), has led to a steady increase in the volume of segregated bio-waste collected by Krakow residents, as shown in Figure 3.

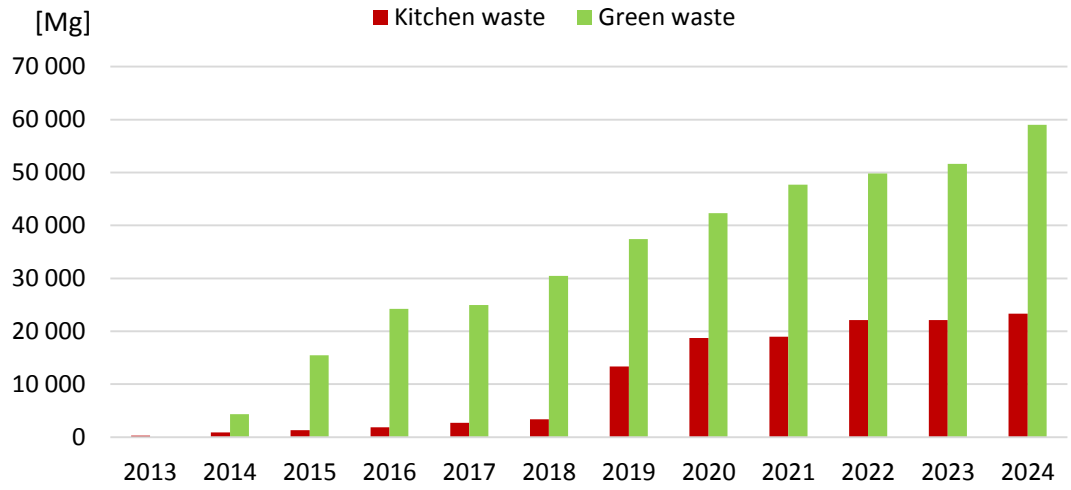

Figure 3. The amount of green waste and kitchen waste collected from residents of the Municipality of Krakow in 2013-2024.

Source: Based own: (Analiza stanu gospodarki odpadami…, 2013-2024).

Biodegradable waste under code 20 02 01 includes grass, leaves, and shredded branches. These originate from private gardens and municipal green areas (parks, cemeteries, and roadsides). In 2024, over 63,000 Mg of green waste were collected and pecked up. Almost all green waste, collected under the selective waste collection program and received at the municipal selective waste collection point, was recycled through composting at the "Barycz" green waste composting plant, owned by the Municipality of Krakow. The cost expenditure for waste treatment at this composting facility amounted to over 20 million PLN in 2024. Only about 100 megagrams (Mg) of green waste were treated in another installation (Analiza stanu gospodarki odpadami…, 2024).

Biodegradable kitchen waste (code 20 01 08) from households and companies is collected in brown bags or bins. In 2024, over 23,000 Mg of biodegradable kitchen waste was collected from the residents of Krakow. All collected waste was entirely treated at municipal processing plants. More than 20,000 Mg of waste was treated in processing plants situated outside the city of Krakow. Long-distance ccollection and transport of green and kitchen waste generate significant costs, which in 2024 amounted to over 14.6 million PLN (Analiza stanu gospodarki odpadami…, 2024).

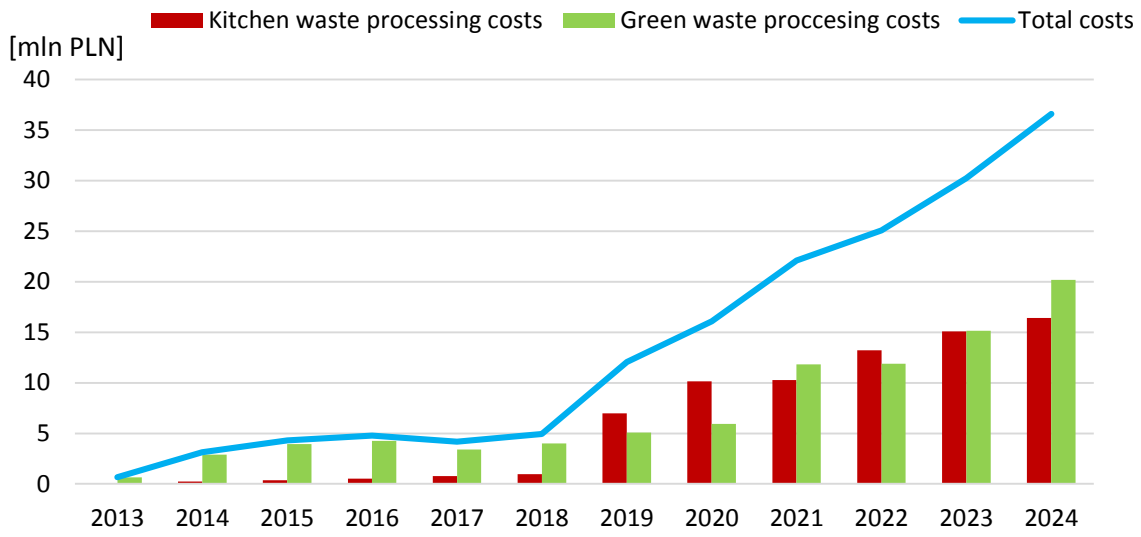

Figure 4. Costs of processing green and kitchen waste collected in households of the Municipality of Krakow in 2013-2024.

Source: Based own (Analiza stanu gospodarki odpadami…, 2013-2024).

The data presented in Figure 4 shows that the costs of processing waste collected in Krakow have exhibited a strong upward trend since 2013. In 2024, the total costs of their processing amounted to over 36.5 million PLN, which accounted for more than 13% of the total costs municipal waste collection, transport, recovery, and disposal in Krakow (Analiza stanu gospodarki odpadami…, 2024). Reducing these costs, or even generating a profit from waste management, could be achieved by utilizing the waste for green energy production in municipal biogas plants.

3.5. The possibilities of generating energy from biodegradable waste collected in Krakow

Data provided by the Marshal's Office of the Małopolska Region shows that the amount of bio-waste collected from both fractions is increasing year by year, it show Table 2. In 2021, approximately 50,000 Mg of green waste and about 19,000 Mg of kitchen waste were collected. In 2022, the volume of green and kitchen waste collected rose by about 2000 Mg. A significant increase in the volume of green waste collected occurred in 2023. At that time, over 59,000 Mg of green waste was collected, while the mass of collected kitchen waste was slightly higher than the previous year. In 2024, the highest volume of bio-waste among the analyzed years was collected, amounting to over 63,000 Mg of green waste and more than 23,000 Mg of kitchen waste. The data shown in the Figure 3.

Table 2.
Volume of green waste (code 20 02 01) and kitchen waste (code 20 01 08) collected in Krakow, 2021-2024

Year	Waste code	
	20 02 01	**20 01 08**
2021	49826.00	19003.03
2022	51659.07	22116.72
2023	59040.72	22140.79
2024	63335.65	23347.73

Based on data from Marshal's Office of the Małopolska Region regarding the volume of waste collected within the Municipality of Krakow in 2024, calculations were initiated to determine the potential production of biogas, biomethane, electricity and heat. For this purpose, a simulation was conducted showing, the potential for biogas production from kitchen bio-waste (code 20 01 08) and green waste (code 20 02 01) generated by the residents of Krakow. The calculations were performed for the total mass of waste in order to obtain information on the maximum possible energy production and to determine whether this would be a profitable investment for Krakow.

The data collected on biodegradable waste in Krakow for 2024 did not include information regarding the dry matter content of the feedstock for the biogas plant; therefore, biogas yields per 1 Mg of fresh matter were adopted for the calculations. For waste code 20 02 01, the biogas yield V_{bg} was assumed to be 150-200 Nm^3, and for waste code 20 01 08, the assumed biogas yield V_{bg} was 200-500 Nm^3. The specified biogas yield were adopted from the literature (Biogaz. Produkcja i wykorzystanie, 2021). The biomethane C_{bm} content in cubic meters (show in Table 3) was calculated based on the following formula (1).

$$V_{bm} = V_{bg} \cdot \frac{C_{bm}}{100} \tag{1}$$

Assuming the calorific value of biomethane W = 9.3 kWh/Nm^3, the total energy E_t, generated from 1 Mg of waste was calculated using formula (2).

$$E_t = V_{bm} \cdot W \tag{2}$$

The electric energy E_e and thermal energy E_h obtained from 1 Mg of bio-waste were calculated according to formulas (3) and (4).

$$E_e = E_t \cdot \frac{\eta_e}{100} \tag{3}$$

$$E_h = E_t \cdot \frac{\eta_t}{100} \tag{4}$$

where:
η_e - electricity yield,
η_t - heat energy yield.

The electric power of the generator P_e was calculated from formula (5).

$$P_e = \frac{E_e}{T_w} \tag{5}$$

The values used to calculate the potential for producing biogas, biomethane, electricity and heat in 2024 are presented in Table 3.

Table 3.
Values used to calculate energy production in a municipal biogas plant

Item	Unit	Waste code	
		20 02 01	**20 01 08**
Biogas yield	Nm^3	150-200	200-500
Biomethane content in biogas	%	55	60
Calorific value of biomethane	kWh/Nm^3	9.3	9.3
Electrical energy yield	%	35	35
Thermal energy yield	%	55	55
Generator operating time	hour/year	8000	8000

Source: Biogaz. Produkcja, wykorzystanie, 2005.

4. Results

To calculate the annual biogas, biomethane, electricity, and heat yields for the municipal biogas plant, the values from Table 3 were used, along with data on the amount of waste collected for 2024 (Table 2). The simulation began by calculating the amount of biogas and biomethane produced, which are the energy carriers in the biogas plant. Next, the total amount of electricity and heat produced was calculated, as well as the amount of heat used for the biogas plant and for sale to consumers. The obtained results are for the minimum and maximum biogas yields from green waste (code 20 02 01) and kitchen waste (code 20 01 08). The simulation results are presented in Table 4 and Figures 6 and 7.

Table 4.
Amount of biogas, biomethane, electricity, and heat produced from bio-waste collected from Krakow residents in 2024

Item	Unit	Yield	Waste code	
			20 02 01	**20 01 08**
Amount of waste	Mg/year	-	63 335.65	23 347.73
Total biogas yield	m^3/year	Min	9 500 347.5	4 669 546.0
		Max	**12 667 130.0**	**11 673 865.0**
Total biomethane yield	m^3/year	Min	5 225 191.1	2 801 727.6
		Max	**6 966 921.5**	**7 004 319.0**
Total electricity generation	MWh	Min	17 008.0	9 119.6
		Max	**22 677.3**	**22 799.1**
Total thermal energy generation	MWh	Min	26 726.9	14 330.8
		Max	**35 635.8**	**35 827.1**
Internal heat consumption	MWh	Min	8018.1	4299.3
		Max	**10690.7**	**10748.1**
Exportable heat	MWh	Min	18 708.8	10 031.6
		Max	**24 945.1**	**25 079.0**
Biogas plant electric power	MW	Min	2.1	1.1
		Max	**2.8**	**2.8**

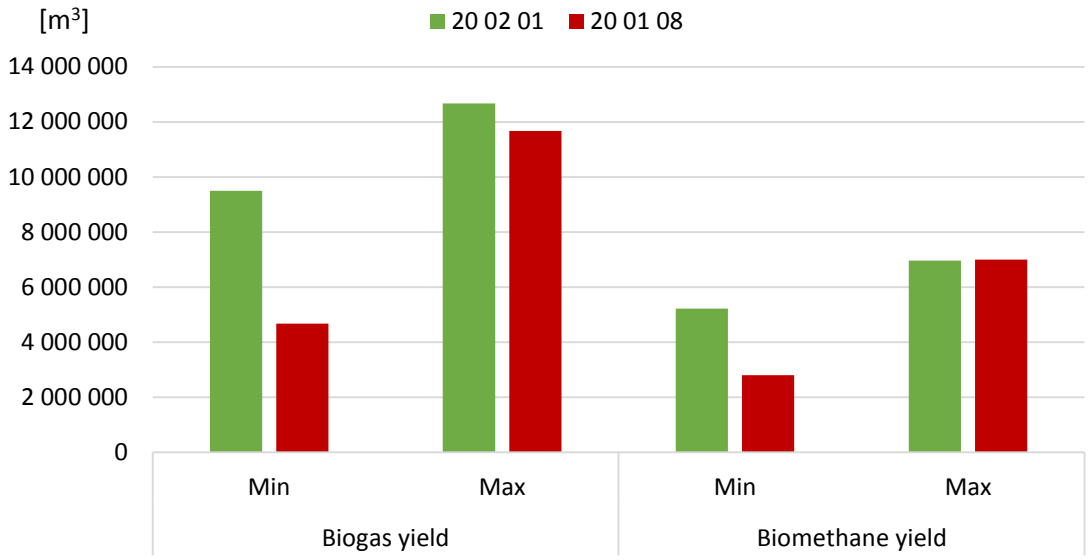

Figure 5. Minimum and maximum amounts of biogas and biomethane that can be obtained in 2024 from biodegradable municipal waste.

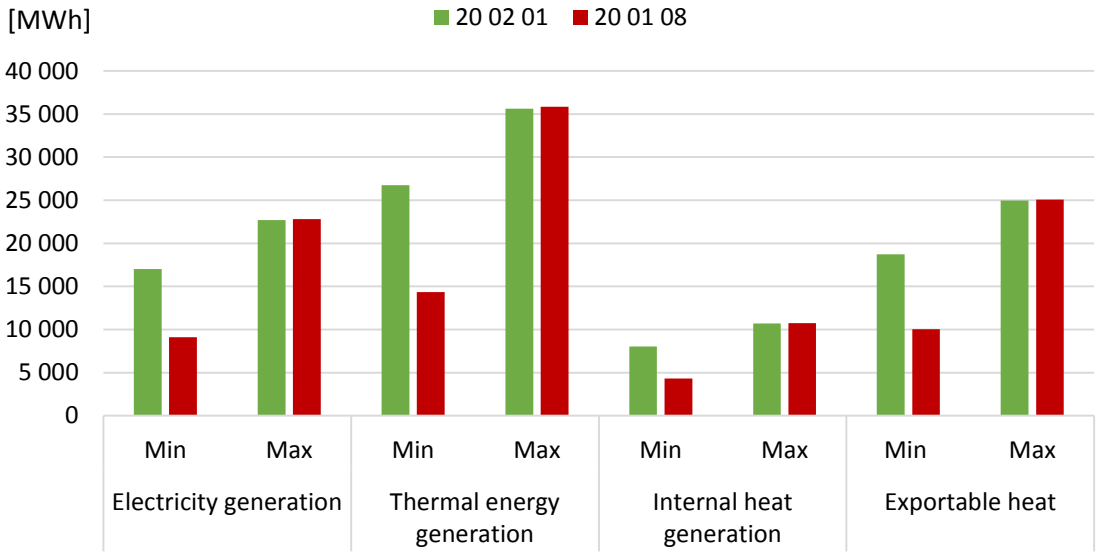

Figure 6. Minimum and maximum amounts of electricity and heat that can be produced in 2024 from biodegradable municipal waste.

From approximately 14 million m^3 to over 24 million m^3 of biogas V_{bg} can be produced annually from the given biodegradable waste. It contains between 55 and 60% methane V_{bm}, which is burned in cogeneration units in a biogas plant. This results in the generation of electrical energy E_e and thermal energy E_h. This allows for the production of electricity E_e which will be sold consumenrs in amounts from over 26,000 to over 45,000 MWh and thermal energy E_h in amounts from approximately 41,000 to over 71,000 MWh. Of the produced thermal energy E_h, 30% must be allocated to maintaining the fermentation process in the fermentation chambers. The remaining heat E_h can be sold or transferred to the Krakow district heating network.

5. Discussion

The biogas quantities presented in the table could be achieved by utilizing 100% of the biodegradable waste collected in 2024, provided it is supplied regularly to the fermentation chambers. Meanwhile, green waste (20 February 2020) is collected from households only between April and October. Preparing grass silage could ensure some regularity of deliveries (Szyba, Mikulik 2023). 1 Mg of such silage can yield 170 to 200 Nm^3 of biogas (Biogaz, Produkcja, Wykorzystanie, 2023). Preparing silage incurs additional costs. These costs seem unnecessary, as the disposal of this waste fraction is carried out in a composting plant. One ton of grass silage yield between 170 and 200 Nm^3 of biogas (Biogaz, Produkcja, Wykorzystanie, 2005).

The collection of kitchen waste (code 20 01 08) is continuous, with only minor seasonal fluctuations. The variations in feed quantities and the differing rations of carbohydrates, proteins, and fats do not pose an obstacle to maintaining the fermentation processes. The viability of this approach is demonstrated by performance of municipal biogas facilities in Sweden, Denmark and Austria (Olsson, Fallde, 2015; Raven, Gregersen, 2007; Nowak et al., 2015). The primary issue regarding the collection of this waste lies in the frequency of removal from the points of origin. In the summer, extended lead times lead to waste decomposition, resulting in unstable anaerobic digestion inside the digesters. Pre-decomposed kitchen waste generates an excessive amount of volatile fatty acids. Their accumulation leads to a rapid drop in pH within the biogas plant, which kills methanogenic bacteria and halts energy production (Zhang et al., 2007). Increasing the waste collection frequency will raise costs and reduce profitability. A potential solution could be collection of waste in households using hermetically sealable paper bags, a practice already established in Sweden. Studies conducted by Bernstad and la Cour Jansen confirm that paper packaging not only facilitates waste separation but, above all, prevents the premature rotting bio-waste. This results in a more stable fermentation process and higher methane production compared to waste collected in plastic bags (Bernstad, la Cour Jansen, 2012). Due to the year-round availability of kitchen waste in consistent volumes, and the steadily increasing amount of this fraction collected in Krakow, the construction of municipal biogas plant utilizing exclusively kitchen bio-waste should be considered. Preparing grass silage to ensure a consistent year-round supply would incur additional costs and labor. Green waste would continue to be processed at that the “Barycz” composting plants as it has been to date.

The development of a municipal biogas plant does not entail substantial adverse effects on the local population or the surrounding environment. In the long-term perspective, the operation of a municipal biogas plant will contribute to the improvement of local air quality by partially displacing the combustion of fossil fuels as an energy source. This will result in a reduction of CO_2 emissions into the atmosphere (Al-Wahaibi et al., 2020).

Failure to build municipal biogas plants will hinder the implementation of Poland's Energy Policy until 2040 in the field of renewable energy development and the achievement of the target set out in Directive 2009/28/EC of the European Parliament on the promotion of the use of energy from renewable sources (Polish Energy Policy until 2040).

To achieve the aforementioned Sustainable Development Goals and the goals of EU and Polish policies, society must engage in their implementation. This begins with the basics: proper segregation of bio-waste and the creation of a system that will enable its collection and disposal at a biogas plant.

6. Conclusions

In Krakow, a waste collection system is in place for the following fractions: plastic and metals, paper, glass, biodegradable waste and mixed waste of the latter; of the latter, more than 48% was collected in 2024. Mixed waste can contain approximately 32.7% of green and kitchen waste (Pawnuk et al., 2022). In 2024 green waste accounted for 14.7% and kitchen waste for 5.4% of the total amount of all waste fractions collected. Currently, their disposal poses a significant burden on the city's waste management system. Biodegradable waste can be processed and converted into electricity and heat in municipal biogas plants, and the revenue from energy sales can bolster the city's budget.

Green waste is collected from March until the end of November, and the volume gathered depends on the intensity of the growing season. This waste fraction in successfully treated at the "Barycz" composting facility, resulting in the production of organic compost. Kitchen waste is collected from households throughout the entire year, with quantities remaining relatively stable regardless of the season. The study presents a simulation demonstrating the potential for biogas production from biodegradable municipal waste collected in Krakow during 2024. Due to the year-round availability of food waste, the collected amount would allow for the production of approximately 4.6 to 11.6 million m^3 of biogas with a methane content of 60%. The significant discrepancy in the results is due to the variable composition of food waste; only a detailed analysis would allow for the determination of the approximately composition of these wastes. The biogas produced through cogeneration would yield both electricity and heat, as well as digestate, which serves as an excellent organic fertilizer for the green areas in Krakow.

The building of a municipal biogas plant would allow for a reduction in food waste disposal costs, which in 2024 amounted to nearly 16.4 million PLN in Krakow. High disposal costs are driven, among other factors, by the transport of these wastes to facilities located up to 300 km from Krakow, which currently lacks its own treatment plant for this specific waste fraction.

Building a municipal biogas plant in Krakow is possible. This will reduce the costs of disposing of kitchen bio-waste (code 20 01 08) and increase the share of renewable energy sources in Krakow's energy mix. Together with two biogas plants at the sewage treatment plant and the Waste to Energy, the share of renewable energy sources in Krakow's energy mix will be strengthened. The municipal biogas plant aligns with the circular economy concept supported by the European Commission and implements the UN Sustainable Development Goals: Goal 7 – Affordable and Clean Energy; Goal 11 – Sustainable Cities and Communities. This research confirms the hypothesis posed in the introduction of this article (Cele zrównoważonego rozwoju).

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HOFSTEDE'S CULTURAL MODEL IN SHAPING POLAND-PERU TRADE RELATIONS

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Purpose: The purpose of this paper is to analyze how cultural differences between Poland and Peru, as explained by Hofstede's cultural dimensions, influence managerial practices and business cooperation, while addressing the research gap in studies on Polish–Peruvian trade relations.
Design/methodology/approach: The study uses a structured literature review based on the SALSA method, analyzing academic sources to examine Hofstede's cultural dimensions in the context of Polish–Peruvian business relations.
Findings: The study finds that despite similar Hofstede scores, cultural dimensions in Poland and Peru are interpreted differently, leading to significant differences in managerial practices, particularly in communication, hierarchy, trust-building, and approaches to uncertainty, which may cause misunderstandings in cooperation.
Research limitations/implications: The study is limited by its reliance on a literature review without empirical data and the general nature of Hofstede's model, which may oversimplify cultural differences. Future research should include empirical studies, such as interviews with managers, and expand the analysis to other sectors and countries.
Practical implications: The study provides guidance for managers by highlighting the need to adapt communication styles, respect hierarchical structures, and prioritize relationship-building in Polish–Peruvian cooperation, which can improve negotiation effectiveness and reduce the risk of misunderstandings in international business.
Social implications: The study promotes greater intercultural understanding and awareness, which can improve cooperation between societies, reduce cultural misunderstandings, and support more responsible and respectful international business practices.
Originality/value: The paper offers analysis of Polish–Peruvian business relations, a rarely studied context, by reinterpreting Hofstede's model at the managerial level. It provides value to researchers and practitioners by linking cultural theory with practical business interactions and highlighting context-specific differences in interpreting cultural dimensions.
Keywords: Hofstede's cultural dimensions; cross-cultural management; Polish–Peruvian trade relations; managerial practices.
Category of paper: Literature review.

1. Introduction

The modern global economy is undergoing a period of change. After many years of dominance by traditional growth centers in the United States and the European Union, there is a noticeable trend toward the growing importance of developing countries (Estevadeordal et al., 2025). Countries that were not associated with innovation or the building of a stable economy in the 20th century are becoming increasingly important in the global market. As the balance of power shifts, so do supply chains. Companies operating in the EU are looking to expand into new markets. Peru, as a developing country, is taking advantage of the current situation by opening its economy to international cooperation, making it an attractive, albeit culturally challenging, partner for Polish companies (Investment Climate Statements: Peru, 2025). At the same time, global challenges such as geopolitical conflicts, pressure to diversify supplies, and the importance of friendshoring remain significant (Javorcik, Yıldırım, 2023). These challenges underscore the importance of building trade relations with non-obvious partners outside the traditional area of cooperation. To fully exploit this potential, it is necessary to understand cultural differences and how business contacts are formed. Analyzing the above, Hofstede's model is an important tool both scientifically and in practice.

Previous research on cultural issues in business has been based mainly on general models of cultural differences, such as Hofstede's cultural dimensions (Hofstede, 1980), Hall's communication context theory (Hall, 1976), and Gesteland's relational-transactional approach (Gesteland, 2012). The scientific literature describes both Latin American culture and its characteristics, which manifest in relationality, high-context communication, and the importance of hierarchy in decision-making. However, an important issue is the differences between countries, which can shift perspectives. One limitation is that the research focuses on economic relations between the largest economies in Europe and LATAM. The studies (e.g., Arditto et al., 2020) described show a trend towards analyzing the most economically significant economies in the region, i.e., the Mercosur countries or Mexico. Peru is treated marginally in the studies described (Arditto et al., 2020). The selection of Poland and Peru is motivated by the limited academic attention given to CEE–LATAM business relations, as well as the analytical value of comparing culturally and economically distinct environments. Based on the literature review, no empirical studies have been identified that directly analyze how specific dimensions of organizational culture translate into the actual effectiveness of business cooperation between Poland and Peru. Existing studies focus on individual countries or other pairs of countries (e.g., Torres, Jones, 2010). An additional aspect is the lack of research on the micro-level perspective of the topic from a managerial perspective, which would provide a view of the issue at the enterprise level. A comparison of Poland and Peru makes it possible to identify interpretative differences in cultural dimensions within a bilateral context that has hitherto been little studied.

Although Hofstede's cultural dimensions have been widely applied in international management research, empirical and conceptual studies focusing on business relations between Central and Eastern Europe and Latin America remain scarce (Arditto et al., 2020). In particular, Polish–Peruvian business cooperation has received little scholarly attention, despite the growing economic relevance of emerging Latin American markets. There is a lack of research in the literature on how cultural differences affect specific aspects of business (McGrath, O'Toole, 2014). The negotiation process, building partnerships, and technical issues related to finalizing deals between Poland and Peru have not been explored. This research gap underscores the need for an in-depth analysis grounded in Hofstede's model, which considers both the practical context and entrepreneurs' real experiences (Chaudhry, Shafiullah, 2021). This raises the research question: How are cultural differences between Poland and Peru, as described by Hofstede's dimensions, interpreted in the literature in relation to managerial business practices and cooperation mechanisms?

The aim of this article is to examine how these cultural differences are reflected in managerial practices by conducting a structured literature review. The study does not rely on primary empirical data; instead, it reconstructs dominant patterns of interpretation, behavior, and adaptation strategies attributed to managers engaged in Polish-Peruvian business relation. The analysis was conducted primarily from the perspective of Polish managers entering into business partnerships with Peruvian counterparts. This justifies the detailed focus on the Peruvian context as an external business environment.

The study is based on a structured literature review conducted using the SALSA method (Search, Appraisal, Synthesis, and Analysis). This approach enabled a systematic identification, critical evaluation, and synthesis of relevant academic sources on cultural models and cross-cultural business communication, ensuring methodological transparency and analytical consistency. The starting point for the discussion is the research question posed. Thanks to the proposed approach, it is possible to organize existing knowledge and identify unexplored areas, which contribute to the development of research on economic cooperation between Poland and the LATAM countries. This article makes three types of contributions to the literature on the subject. First, it extends Hofstede's cultural model to a relatively unexplored geographical context: Polish-Peruvian business relations. Second, it offers practical insights for managers engaged in cross-cultural cooperation with Latin American partners. Third, by reviewing the available scientific literature, the paper organizes the findings on the study's subject and offers a new analytical framework for future research.

2. Theoretical framework

2.1. Culture as a determinant of business behavior

Culture is one of the most important factors influencing organizational functioning in an international environment (Sowińska-Domagała, Wolniak, 2025). It shapes both perceptions of reality and interpretations of interpersonal signals, ultimately influencing the building of business relationships. In international management, culture is understood as shared values, norms, and patterns of behavior cultivated within a given social group (Bartosik-Purgat, Rakowska, 2023). When coming into contact with people outside our cultural circle, to communicate effectively, it is necessary to understand the code in which "strangers" operate. A lack of understanding of social norms, differences in communication, or interpretation of hierarchy can lead to misunderstandings, tensions, and hinder cooperation.

Researchers such as Adler (2008) note that culture influences every stage of international interactions. Its influence is visible from the first contact, through the exchange of information and the finalization of the agreement, to the maintenance of relations (Adler, 2008). Translating the above into practice, cultural differences have real effects beyond the symbolic. In a business environment, culture translates into the form, timing, and manner of negotiations, the interpretation of a partner's intentions, and the attitude toward risk. Control mechanisms, argumentative styles, and forms of communication are shaped by a given culture. Equally important are expectations regarding the pace and dynamics of discussions (Bartosik-Purgat, Guzek, 2024).

Trompenaars and Hampden-Turner (2012) point out that economic interactions are based on different "logics" of relationship building. Some cultures operate transactionally, prioritizing tasks and results. Other cultures are relational, prioritizing trust in other people and emotional harmony before proceeding with formalities. In economic practice, these logics imply, among other things, expectations regarding the pace of work, the degree of directness in communication, the interpretation of silence, resistance, and the manner of negotiation (Trompenaars, Hampden-Turner, 2012).

Hofstede (1980), Adler (2008), and Trompenaars (2012) all emphasize the continuous influence of culture on communication and ultimately on decision-making. Culture creates a kind of framework for managers' actions, which means that cooperation between managers from different cultural circles requires the ability to correctly read the codes of one's partner. Ignoring differences resulting from cultural context can lead to misinterpretations of a partner's intentions, delays in negotiations, loss of trust, and, in extreme cases, even the failure of a business relationship. Culture is not just a backdrop; it is often a key factor influencing international business.

2.2. Hofstede’s cultural dimensions in international management

In the literature on the subject, the dominant tool for analyzing cultural issues is G. Hofstede's multidimensional approach (Chaudhry, Shafiullah, 2021). The origins of the model date back to the 1960s and 1970s, when a large-scale research project was conducted at IBM. The study involved thousands of respondents from over 50 countries, allowing Hofstede to analyze a large dataset and identify recurring patterns of behavior across specific national cultures (Torres, Jones, 2010). The survey results revealed four cultural dimensions: power distance, individualism–collectivism, uncertainty avoidance, and masculinity–femininity. Over time, the model has been updated by subsequent researchers with two additional dimensions: indulgence and long-term orientation (Chaudhry, Shafiullah, 2021). The presented methodology provides an analytical framework for identifying mental patterns that shape perceptions of hierarchy, the role of the individual in the group, attitudes towards risk, and forms of communication. From a business perspective, interpreting behavior based on the model allows for a deeper understanding of a partner's approach to negotiations, building interpersonal relationships, and finalizing transactions (McGrath, O’Toole, 2014). Thanks to its ability to interpret cultural issues, it becomes possible to adapt managerial practices to local conditions, and Hofstede's tool remains one of the most frequently cited in international cultural management research to this day. Despite the model's widespread influence on the literature on the subject, it is often criticized for its limitations. Researchers emphasize that the model is based on data from only one corporation (IBM) and assumes relatively homogeneous national cultures (McGrath, O’Toole, 2014). In economic practice, each culture is more complex and changes dynamically with the progress of globalization, migration, and cultural mixing. Another related criticism of the tool is that it oversimplifies cultures, making it difficult to understand local context. Despite these reservations, the model remains one of the most widely used tools in research on cultural differences, useful for studies in management, intercultural communication, and negotiations.

3. Methodological approach

The study was based on a systematic review of the available literature on the subject. To conduct an in-depth and methodologically consistent analysis of the topic, the SALSA (Search, Appraisal, Synthesis, Analysis) method was employed, a commonly used approach in narrative and structured literature reviews within management sciences. The use of this method enabled a transparent organization of sources and facilitated the identification of patterns, relationships, and research gaps in the existing literature. In the Search phase, academic databases such as Scopus and ScienceDirect were queried using combinations of keywords

including “Hofstede”, “cross-cultural management”, “Latin America”, “Peru”, “Central and Eastern Europe”, and “international business culture”. The initial search yielded approximately 85 publications, which constituted the preliminary pool of sources for further examination. I revised and expanded the methodology section to clarify the selection procedure. The final set of sources was selected based on several criteria: a direct connection to intercultural management and Hofstede’s framework, a focus on Latin American or Central and Eastern European contexts, academic quality, and conceptual contributions to understanding managerial practices and business interactions. Publications were excluded if they were not directly related to the research topic, lacked scientific rigor, or focused on unrelated geographical contexts. Furthermore, the most recent literature was preferred, and foundational works were retained where necessary for theoretical justification. In the subsequent Appraisal phase, the identified materials were screened based on their thematic relevance, academic quality, and publication type. Peer-reviewed journal articles and academic books comprised the core material, while practitioner-oriented reports served as contextual supplements. After screening abstracts and full texts, approximately 20 sources were included in the final analysis. The third stage, Synthesis, involved categorizing the selected literature according to Hofstede’s cultural dimensions and their managerial implications, allowing for a structured comparison of conclusions derived from different cultural models, with particular emphasis on Hofstede’s framework. The final stage, Analysis, focused on interpreting these findings in the specific context of Polish–Peruvian business relations and provided the analytical foundation for the subsequent sections of the article. Overall, the application of the SALSA method ensured a transparent and systematic research procedure, enhancing the methodological credibility of the study and enabling the development of an analytical framework tailored to the case at hand.

4. Cultural profiles of Poland and Peru

The comparison between Poland and Peru is a scientifically fresh and valuable case for intercultural analysis. The economies in question are located in two different geographical areas and also differ in terms of their stage of economic development, communication traditions, and organizational traditions. Poland is a leader and one of the fastest-growing economies in Central and Eastern Europe, increasingly seeking to expand beyond the EU. Peru, on the other hand, is a dynamic Latin American economy that bases its economic growth on the raw materials, food, and services sectors, and its relational business model directly influences cooperation with foreign partners (Investment Climate Statements: Peru, 2025). The combination of CEE and LATAM, using Poland and Peru as examples, allows us to examine the impact of cultural differences on management practices in a relationship that is poorly described in the literature, but at the same time has growing practical significance for

entrepreneurs. The cultural profile and comparison of the cases discussed can be carried out using Hofstede's (1980) cultural dimensions. The infographic presentation of the results provides information on how the individual dimensions are shaped in both countries. The recorded results are a starting point for further consideration.

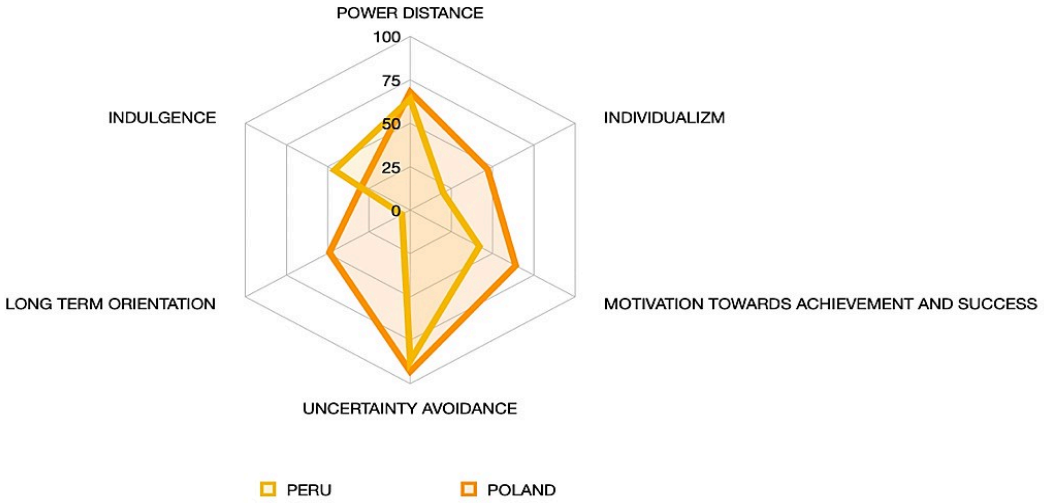

Figure 1. Cultural profiles of Poland and Peru**.**

Source: Based on data from The Culture Factor (n.d.).

The following analysis is based on data published by The Culture Factor Group in 2023, which regularly presents the values of individual cultural dimensions for different countries. These values are measured on a scale from 0 to 100, where higher scores indicate a stronger intensity of a particular cultural dimension in the analyzed society (The Culture Factor, n.d.). The study's results indicate similarities and differences between Peru and Poland across various cultural aspects of Hofstede's model. While some results may be similar, their interpretations may differ, which should significantly influence the behavior of Polish managers. The following analysis summarizes the cultural aspects, highlighting the key differences in interpretation between Poland and Peru.

5. Managerial decision-making practices

5.1. Power distance – strong hierarchical relationships and centralized decision-making

Peru belongs to a group of countries characterized by high power distance. In practice, this manifests as society accepting a clear division between decision-makers and subordinates. Social groups at the bottom of the hierarchy accept this social arrangement and do not oppose the established order (Hofstede, Bond, 1988). Members of society translate the country's social rules into the rules governing business operations. In Peru, decisions are rarely delegated to

lower-level employees, resulting in a high degree of centralization of decision-making (Torres, Jones, 2010). The person delegated by the company to conduct negotiations should have sufficient status. In practice, if a Polish manager wants to conduct negotiations efficiently, they should expect to talk to higher-level managers. The process of initial interactions is prolonged due to the high-power distance. Before moving on to specific commercial arrangements with decision-makers, managers should be prepared for a longer negotiation process than in Europe. In cultures with low power distance, such as Poland, it is more common to delegate to employees and to participate in discussions. Peruvian managers, on the other hand, expect personal contact at the same hierarchical level (Doney et al., 1998; McGrath, O'Toole, 2014).

The distance between authority figures and subordinates is also evident in the formality of behavior and the importance placed on ceremony. Hierarchy affects not only decision-making but also how people address their partners and greet each other (Gesteland, 2012; *IOR Peru*, 2026). In Peru, titles, functions, and status are also strongly emphasized in interpersonal contact. During negotiations, a person's origin, network of contacts, and social position influence their status as much as their professional competence. This means that social status translates into the perception of professional competence (Wright, 2024). Another important issue is the position of the boss ("jefe") and the expectation of strong leadership. The leader is seen as a figure who should give clear instructions and make final decisions. The management style is more directive than participatory (McIntosh, 2012).

This finding suggests that similar power distance scores in Hofstede's model may mask fundamentally different organizational functions of hierarchy (Hofstede, 1980, 2001). While in Poland hierarchy primarily serves as an administrative and coordination mechanism, in Peru it plays a relational and symbolic role, conditioning access to authority through social capital. This distinction highlights the need to move beyond numerical indices toward context-sensitive interpretations of cultural dimensions.

5.2. Individualism – the primacy of personal relationships over formal structures

Collectivism is a characteristic feature of Peruvian society (Radziszewska, 2025). Loyalty to the team, family, or organization is seen as more important than the interests of the individual. Relationships and personal trust are more important than contracts and formal agreements, which in turn lead to strong social bonds (Fuentes, 2024; Meyer, 2014). Saving face is also an important issue – avoiding embarrassment, criticism, and open confrontation is important to many South American citizens. This also translates into the importance of harmony over directness. A gentler style of communication and the pursuit of mutual agreement are preferred (Byczyk, 2025). These issues allow all individuals to feel comfortable in a group (*IOR Peru*, 2026). Because decisions must be made by consensus within the group, decision-making processes take longer.

In a country characterized by a "collective" approach to problems, recommendations, and prior contacts are key to establishing further cooperation. Building personal relationships makes it easier to obtain new contacts or referrals. Conversations in Peru begin with building relationships; meetings where you can get to know a potential contractor better and present yourself and your values are important. Peruvian citizens are cautious about new partners they have not met through their social network. Cooperation is mainly verified through personal relationships. The negotiation process only begins after trust has been established, and moving quickly to commercial terms may be perceived negatively. Negotiations cannot be too aggressive or too fast, and Polish assertiveness and a tough approach to talks may be interpreted negatively (*Managing In Peru – Management Style & Workplace Culture*, 2016).

5.3. Motivation to succeed – focus on balance between relationships and results

In terms of the cultural aspect of striving for success, Peruvian society does not show above-average results. Its position below the middle of the scale indicates that this is a country with a moderate focus on success. There is no culture of competition in this country, and results are important but do not constitute the dominant goal in life. A visible aspect is the balance between work results and interpersonal relationships. Group and individual achievements are important, but they are not more important than the quality of cooperation with colleagues. Harmony is important and acts as an element of effective action. Compromise is preferred over confrontation, and excessive pressure to achieve results is avoided (Gesteland, 2012; Torres, Jones, 2010). Importantly for Polish managers, this implies that, in the broader context of this region's business culture, the tendency to engage in aggressive negotiations is reduced. Cooperation becomes more important than domination, and loyalty to one's partner is a priority. Success in this aspect of Hofstede's model in Peru can also be understood as stability in relationships. Saving face and psychological comfort become more important than unequivocal "winning" in negotiations (*Managing In Peru – Management Style & Workplace Culture*, 2016).

5.4. Avoiding uncertainty – relational security over rigid procedures

Avoiding uncertainty in Peru manifests itself in a strong need to reduce interpersonal fears. Relational security is more important to Peruvians than legal and procedural security. Uncertainty is minimized by frequent contact with the contractor, conversations, and direct presence (Fuentes, 2024). Therefore, conducting remote negotiations is a difficult challenge. While there is a noticeable need to build trust while maintaining caution in direct and indirect contacts, there is also visible flexibility in procedures. Negotiations in Peru are not characterized by the formalism typical of Poland. The initial stage of the actual talks focuses on maintaining harmony and avoiding premature hard declarations. The partner is expected to adapt to changing circumstances. Pushing a rigid schedule may result in resistance from the Peruvian side, as they are sensitive to time pressure (*IOR Peru*, 2026).

Procedural flexibility translates into gradual decision-making based on interactions with a known business partner. Contract documentation is finalized later than in Poland and is relatively fluid. Flexibility in negotiations is interpreted as a tool for building comfort in interpersonal relationships, rather than a sign of unprofessionalism (*Managing In Peru – Management Style & Workplace Culture*, 2016). Importantly, in Peru, renegotiations and returns to previous agreements are common practice in the process. In Poland, this could be considered chaotic, but in Peru, it is not. A contract or agreement, even after it has been signed, is considered a "living document." The formal contractual framework is seen as the final safeguard of the negotiation process, not the starting point (*IOR Peru*, 2026).

5.5. Long-term orientation – focus on immediate benefits

Peru is characterized by an extremely low long-term orientation. This translates into a strong focus on achieving the desired results "here and now". The immediate benefits that Peruvians can achieve by entering into a contract are more important than a profitable long-term cooperation strategy with a several-year horizon (Gesteland, 2012). In business, this translates into a preference for quick financial results immediately after signing a contract. Decisions regarding potential cooperation are most often made in light of the current macroeconomic situation. There is significant flexibility in the approach to long-term plans. In Peru, there is little pressure to plan for long-term investment, and projects are primarily evaluated on short-term returns (Arditto et al., 2020). The current financial liquidity of the company and the potential partner is of great importance, which, in theory, is supposed to guarantee a low risk of unsuccessful cooperation.

The society in question is characterized by caution towards long-term projects and frequent changes in strategy as the context changes. Along with changes in the environment, there is also a flexible approach to goals, susceptibility to market impulses, and situational opportunities that arise on the market (Fuentes, 2024). Business relationships are maintained as long as they bring immediate benefits, and, as the above findings show, the usefulness of cooperation is expected to be immediate (so-called situational loyalty). Peru is the opposite of strongly long-term cultures, such as Japan, which is noticeable in the divergent strategic approach based on patient accumulation of effects (Oh, Yoo, 2022).

5.6. Tolerance – balanced expression beneath a formal exterior

Peruvian culture lies between the extremes of tolerance and restraint. Compared to other South American countries, Peru could be described as more restrained than overly comfortable. There is a visible acceptance of pleasure in the country, but within social norms. Interpersonal communication is emotional and expressive, and body language is lively, full of natural gestures. Direct communication is characterized by cordiality, warmth, and showing sympathy towards others (Chaudhry, Shafiullah, 2021). From a business perspective, personal relationships are important because they shape an individual's perception in the business world.

As part of building interpersonal relationships, which are the foundation of transactions, social gatherings, such as lunches or dinners, are an established custom (Fuentes, 2024). In the capital of Peru, Lima, there are many restaurants of the highest international standard, where such social gatherings with a business undertone are the norm. As a result, networking in Peru is based on recommendations (word of mouth) and networks of acquaintances.

At the same time, it should be remembered that despite its geographical location, which might suggest above-average informality, business in Peru is dominated by formalism. The dress code for business meetings is conservative. Elegant attire is required, understood as classic, dark suits and classic outfits without excessive extravagance. In business contacts, especially at the very beginning of an acquaintance, titles, functions, and the participants' hierarchy are emphasized. When making initial contact, it is better to approach conversations too formally than too casually. This should not be understood as avoiding a relaxed atmosphere during the meeting — despite the expressive communication style characteristic of Latin American cultures, business interactions in Peru remain embedded in a formal protocol that emphasizes hierarchy, titles, and appropriate attire (Wright, 2024). Similarly, it is good practice to warm up the relationship with humor and small talk (a Polish manager should focus first on building a relationship — only then can they move on to contractual arrangements) before transitioning to the main topic. In the case of invitations to less formal meetings outside working hours, this may signal the contractor's acceptance and trust. Managers from procedural cultures should not interpret the expressiveness of Latin Americans as a lack of discipline. In practice, formal attire, respect for hierarchy, and the essence of etiquette can coexist with expressiveness, creating a new image of business practice (*Managing In Peru – Management Style & Workplace Culture*, 2016; Wright, 2024).

Due to cultural differences, cooperation between CEE and LATAM countries is prone to misunderstandings. The conclusion of a deal between partners from Poland and Peru will not be determined solely by strictly business considerations, but also by intercultural understanding. The correct interpretation of behavior and adaptation to a given society's requirements can be just as important as other factors influencing a company's success in an international environment. The following analysis identifies some of the most important areas of misunderstanding, understanding which will enable appropriate adaptation to the cultural context.

6. Key areas of interpretative divergence and adaptation

The comparative analysis of Polish and Peruvian cultural profiles identifies several key areas of interpretative divergence that most frequently lead to misunderstandings in bilateral business cooperation. These areas concern communication styles, relationship-building

mechanisms, decision-making hierarchy, perceptions of time, formalization of agreements, and approaches to risk. Understanding these differences is essential for developing effective adaptation strategies in Polish–Peruvian managerial interactions.

Communication styles and contextual differences – Communication style and a proper understanding of the context in which information is conveyed are key to effective communication with foreign partners. Poland is a low-context culture, so communication is direct. Polish literalness may be perceived as passive-aggressive and rude in other cultures. In Peru, indirect communication prevails, and the main emphasis in communication is on politeness and avoiding confrontation (Gesteland, 2012; *IOR Peru*, 2026). Given these differences, there is a noticeable risk of misunderstandings. Polish managers may not notice signs of disagreement with certain arrangements because they are not communicated directly, while Peruvian partners may interpret the Polish side's statements as confrontational. To make the agreement between Polish and Peruvian partners more effective, adaptations are necessary. The Polish side must pay closer attention to non-verbal communication and polite phrases, while the Peruvian side should improve the clarity of the information they convey.

Trust and relationship-building – In the Peruvian business model (and beyond), trust in a contractor is crucial. Unlike in Poland, interpersonal relationships are more important than formal cooperation. Competence, offer, and the importance of a company's efficiency are priorities in Poland, which is different in LATAM countries (Meyer, 2014). Polish managers participating in bilateral talks with the Peruvian side may view the initial stage of preliminary talks as a waste of time. The Peruvian side, in turn, may interpret the Polish side's task-oriented approach as a sign of disrespect or coldness, which Latin Americans dislike (Fuentes, 2024). To achieve agreement on communication, an important tip for the Polish side would be to include small talk at the initial stage of the talks. It may also be important to reserve more time than for similar meetings in Europe and to approach the talks with respect, but in a slightly less formal manner. Another important tip is to include informal meetings in the delegation's schedule, which would help them get to know their future business partners better.

Decision-making hierarchy and access to authority – Peru is characterized by limited access to higher-level individuals (decision-makers). To resolve an issue, it is necessary to communicate with decision-makers, and meeting with them requires building relationships and trust (Gesteland, 2012). As a result, the entire process may take longer than a similar procedure in Poland, where more decisions are delegated to lower-level personnel. The lack of a direct response, resulting from the lack of decisiveness on the part of Peruvian interlocutors, may be interpreted by the Polish side as a reluctance to cooperate. Peruvians, in turn, may perceive attempts to speed up the process negatively. To adapt culturally, the Polish delegation should accept the longer decision-making process and respect the hierarchy in the Peruvian business environment.

Approach to time – Polish entrepreneurs conducting business talks expect the other party to be punctual and to carry out activities in accordance with the agreed schedule. Peruvian practices differ, being more polychronic, with greater acceptance of change and the postponement of prior arrangements (Hall, 1976). Poles may interpret this behavior as a lack of professionalism and respect. Peruvians, on the other hand, may consider excessive attachment to time and strict adherence to schedules to be overly rigid (Meyer, 2014). The cultural adaptation required on the Polish side is to increase flexibility and prepare in advance for potential changes in the schedule. Peruvians, on the other hand, should clearly state deadlines for individual tasks to better communicate with Poles.

Formalization of agreements – in Peru, signed agreements or concluded arrangements are treated as living documents that can be renegotiated later as the relationship develops (Katz, 2006). This is a different practice from that in Poland, where managers treat signed agreements as final documents that fully regulate cooperation. Due to the above, there is a risk of misunderstandings, which the Polish side may interpret as disloyalty, while the Peruvian side may interpret the rigidity of the arrangements as a lack of trust. For both parties to feel secure not only at the initial stage but also at later stages of cooperation, it is worth introducing contract provisions that regulate the renegotiation mechanism and include flexibility.

Risk assessment – although both countries exhibit a high level of uncertainty avoidance, these results should be interpreted slightly differently. Poles regulate uncertainty through appropriate contractual provisions and formalization of procedures in their cooperation. Peruvians, on the other hand, try to mitigate potential risks by managing relationships and personal trust in the contractors with whom they enter into deals (*Cultural Considerations for Partner Selection in Peru*, 2025; Morgan, Hunt, 1994). Possible misunderstandings may arise from Polish expectations of a precise framework for action and formalization of procedures, while the Peruvian side may prefer continuous adaptation to current circumstances. To enable managers from both countries to reach a long-term agreement, it would be advisable to define clear expectations regarding the predictability and limits of flexibility in the arrangements.

7. Discussion

Based on the analysis of Poland and Peru cases regarding the impact of cultural differences on managers' behavior, several key differences have emerged. Their proper interpretation can translate into an easier process of reaching agreements and real profits for companies. The results presented in the article are consistent with classic approaches to cultural models, but attention should be paid to the interpretation of certain elements that have not been widely presented in the literature on the subject to date.

The first conclusion that can be drawn from the article is that it emphasizes the importance of personal relationships in the Peruvian business model. Confirming Hall's observations (Hall, 1976), Latin American countries characterized by a high context of communication prefer indirect communication. In contrast to Central and Eastern European countries, which are characterized by a task-oriented and formal culture, there is a confrontation between two opposing approaches. This results in difficulties in adapting to the style of business conversations and negotiations and creates a practical challenge. This is also consistent with Gesteland's research on relational and transactional cultures (Gesteland, 2012). The examples of Poland, with a transactional culture, and Peru, with a relational culture, also illustrate a particular sensitivity to differences in the perception of contracts. For the Polish side, this is the point at which the arrangements are finalized, whereas for the Peruvian side, it is only a framework for cooperation subject to further negotiation (Katz, 2006). Another key point is the correct interpretation of power distance, which in both countries scores high in classic models, but is interpreted differently. The functional significance of the hierarchy in question is different in both cases. In Poland, the hierarchy primarily serves to stabilize organizational structures, while in Peru it fulfills a social and relational function, concentrating decisions at the highest levels and making access to decision-makers conditional on the development of social capital (Meyer, 2014). The presented interpretative distinction (resulting from the analysis of a specific topic – business) is not available in Hofstede's research. The article shows that despite similar PD results, they do not mean the same things for given societies and organizational practices, which is an important theoretical observation. The approach to uncertainty is also worth noting. According to classic interpretations of Hofstede's model (Hofstede, 1980, 2001), a high level of UAI should suggest a similarly cautious, rule-based approach to stability and formalization, but the analysis offers different insights. In Poland, when formal threats arise, the parties protect themselves through contracts, a precise structure of activities, or other formalities, whereas in Peru, uncertainty is offset by trust in personal relationships, flexible arrangements, and ongoing adjustments (Katz, 2006; Morgan, Hunt, 1994). This conclusion is consistent with Luhmann's theory (Luhmann, 2017), which holds that trust can, in certain circumstances, replace formal control mechanisms, whereas Hofstede's classical theory (Hofstede, 1980, 2001) stands in opposition to this. A high UAI in Peru does not lead to increased formalization, but rather to its opposite, namely flexibility and adaptability. Another topic worth highlighting is the issue of mono-/polychronicity, which affects not only the widely discussed issue of punctuality and schedules (Hall, 1976), but also the very definition of “progress in negotiations.” The Polish side often expects continuity of work, while Peruvians see successive stages as fluid and overlapping implications (Meyer, 2014). The interpretative ambiguity of the described behavior model affects communication between managers and the success of cooperation.

The key conclusion that emerges from the discussion is that Polish-Peruvian business relations are fraught with a high risk of misinterpretation of behavior. Interpretation errors result not so much from economic differences as from differing models of communication, hierarchy, and uncertainty management. The article emphasizes the essence of classical models of culture and their contribution to the literature on the subject, while also highlighting the importance of interpreting the results.

8. Conclusion

The analysis presented in this article clearly shows that cultural differences and the appropriate interpretation of specific behaviors influence managers' decision-making processes in business relationships. The cultural dimensions described by Hofstede's model indicate which aspects differ most significantly between Poland and Peru. Power distance, individualism, uncertainty avoidance, and time orientation in economic practice influence different approaches to communication, negotiation style, and the form of building trust with potential partners. The study's results indicate that Peru's business culture differs from Poland's. Peruvian relationality, indirect communication, and hierarchy contrast with Polish formalism, task-orientedness, and direct communication. As a result, proper preparation for bilateral talks between contractors from Peru and Poland determines not only the course of the talks but also the effectiveness of the cooperation. Understanding the cultural conditions of a given society is key to effective, long-term cooperation between managers from both countries.

The research conducted and the conclusions drawn from it make a significant contribution to the development of cultural management science from a managerial perspective in a narrow comparative approach between Poland and Peru. The article indicates that the models used in the literature on the subject, such as Hofstede or Hall, are useful tools for conducting this type of research, but their imperfections and the need for clarification in each case should be borne in mind. The analysis showed that even very similar values should be interpreted differently in some cases, which should subsequently influence managers' behavior during business negotiations. The article presents a new perspective on the subject from the point of view of countries whose comparison in the described context is very poorly described. Both extending the analysis to include comparisons of new regions and examining the subject from a specific (managerial) perspective expand and organize the knowledge gathered so far. The article also confirms Luhmann's theory on the importance of trust and suggests a different interpretation than the classic high UAI. In Peru, as the study showed, trust serves as a substitute for formal mechanisms, thereby reducing uncertainty. Finally, the article serves as a bridge between the macroeconomic perspective (national dimensions of culture) and the microeconomic

perspective (managerial practices in specific business situations), showing that real conclusions come not so much from indices as from their interpretation.

Based on the results, the identified cultural differences can be translated into practical management guidelines. Managers should begin with an interpretive diagnosis, recognizing differences in communication, hierarchy, trust, and time perception. A relational communication approach is essential, requiring greater directness, greater attention to indirect and nonverbal cues, and a stronger focus on building relationships. Negotiations should be viewed as a process based on trust, which will allow for more time to be devoted to them and help avoid undue pressure. Effective cooperation also requires respect for hierarchical structures and access to decision-makers. Finally, a flexible contractual approach should be adopted, treating agreements as evolving frameworks open to adaptation. These frameworks combine cultural interpretation with practical management practices.

This study has several limitations that should be considered when interpreting the results. The method used to analyze the data for this article was a review of the available literature on the subject. The article does not include empirical data from interviews or real-life cases, nor does it draw directly on managers' experiences. This limitation may affect the interpretation of the results described and omit nuances relevant to the research topic. Another limitation is the high level of generality of Hofstede's model used in the research, which may lead to oversimplification. Although this typology can be an extremely useful analytical framework, it is difficult to use to identify the dynamics of change, the impact of institutional factors, or sectoral differences. Thirdly, the interpreted results and guidelines for managers are of little value when generalized to a larger region, e.g., CEE vs. LATAM. When analyzing the impact of cultural differences on specific aspects of business, despite certain similarities, the noticeable differences are so subtle that each country in the region should be interpreted individually. The results of the study of relations between Poland and Peru cannot be fully representative of Central and Eastern Europe or South America as a whole. It is worth noting that the article primarily focuses on the managerial perspective. Differences arising from individual sectors, industry differences, or the macroeconomic and geopolitical context have been omitted. These limitations point to the need for more advanced empirical research that will enable a more complex comparative approach.

The results of the study suggest further directions for analyzing the subject of the article. First, it would be reasonable to conduct qualitative research, e.g., in-depth interviews with managers from Poland and Peru, who could provide important nuances regarding economic practice. Both broadening the discussion's perspective and examining adaptation strategies in real interactions could expand the scope of information currently available in the literature on the subject. Future research could enable the operationalization of cultural dimensions using measurable indicators, such as the duration of negotiations, trust-building indicators, contract stability, or partnership success indicators, which would allow for the empirical validation of the relationships identified in this study. Next, it would be worthwhile to expand the analysis

to include other variables, such as specific sectors of the economy. A sectoral comparison may reveal different effects of cultural differences on cooperation in the raw materials, agri-food, technology, and service sectors. Thirdly, future research could expand the geographical scope of the considerations and examine other LATAM countries, such as Chile, Mexico, or Colombia. The aim of expanding the research could be to identify broader regional patterns and to check which characteristics are specific to Peruvian society and which are also repeatable in other countries. Another recommendation for future research is to include additional cultural models in the analysis, such as Erin Meyer's cultural map, Trompenaars' model, or Hall's concept of contextuality, which could not only supplement the research results with new information but also refine Hofstede's classic model's conclusions. Finally, future research could also take into account contextual factors arising from geopolitical factors, history, or institutional issues. Building a broader picture based on context can provide a comprehensive comparative overview of relations between Poland and Peru and serve as a model for further research in this area.

By demonstrating that identical cultural dimension scores may yield divergent managerial practices depending on their social interpretation, this article contributes to refining Hofstede's framework and supports calls for a more interpretative, context-sensitive application of cultural models in international management research.

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SMART CITIES IN THE AGE OF ARTIFICIAL INTELLIGENCE: TOWARDS DATA-DRIVEN URBAN MANAGEMENT

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Purpose: The purpose of this publication is to analyse the potential of data driven urban management.
Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases connecting with researched topic.
Findings: The findings indicate that AI-driven Smart Cities are not defined by individual technologies but by the degree of integration across layered digital infrastructures and data-driven management models. The evidence suggests a gradual shift from fragmented, sector-specific applications toward more interconnected and platform-based systems, where real-time data processing and predictive analytics enable adaptive urban governance. At the same time, this transformation remains uneven, as technological advancement is frequently constrained by data quality issues, institutional fragmentation, and unresolved challenges related to transparency, accountability, and system interoperability.
Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage analysed scientific problem.
Keywords: Artificial intelligence; smart cities; data-driven urban management; urban sustainability; predictive analytics; digital infrastructure; data governance.
Category of the paper: literature review.

1. Introduction

The increasing incorporation of artificial intelligence into organizational settings has begun to reconfigure—rather than simply extend—the analytical foundations of management sciences. This is particularly visible in the domain of People Analytics, where the use of employee-related data is no longer limited to descriptive reporting but is progressively oriented toward predictive, behaviorally informed inference. Earlier forms of human resource analytics tended to rely on retrospective indicators—turnover rates, absenteeism, performance scores—

aggregated and interpreted after the fact. That logic now appears insufficient. Contemporary approaches move toward continuous, multi-source data processing, often integrating digital trace data, interaction patterns, and contextual variables. The objective shifts: from describing what has occurred to anticipating what might emerge. Not always cleanly (Alfaidi et al., 2026; Dey et al., 2026; Han, 2026).

This transformation reflects a broader epistemological reorientation within organizational research. Data-driven reasoning, supported by algorithmic models, increasingly supplements—or in some cases displaces—traditional hypothesis-driven approaches. Artificial intelligence, in this context, does not function merely as an auxiliary analytical instrument. It becomes embedded within the analytical architecture itself, shaping how problems are framed, how variables are selected, how relationships are inferred. The distinction between method and theory begins to blur. At least partially. Models detect patterns that are not always anticipated by existing theoretical frameworks, and this introduces both opportunity and tension.

The expansion of AI-driven People Analytics therefore raises a set of theoretical and methodological questions that are not easily resolved. The relationship between inductive pattern discovery and established theories of organizational behavior becomes less stable. Should models be guided by theory, or should theory adapt to model outputs? There is no straightforward answer. Additionally, the issue of contextual interpretation becomes more pronounced. Data extracted from organizational systems—emails, workflows, digital interactions—are inherently situated, shaped by culture, structure, informal norms. Without careful interpretation, algorithmic outputs risk becoming decontextualized abstractions.

The goal of this paper is to analyse the potential of data driven urban management.

2. Theoretical and Technological Foundations of AI-Driven Smart Cities

The concept of Smart Cities has not evolved in a linear or entirely coherent manner; rather, it has shifted—sometimes unevenly—from a predominantly infrastructure-oriented paradigm toward a more integrated configuration in which artificial intelligence (AI) operates as a coordinating, almost mediating layer. Earlier interpretations tended to equate “smartness” with the deployment of information and communication technologies (ICT), sensor arrays, and digital platforms designed to enhance operational efficiency. That framing, while technologically grounded, often privileged hardware and connectivity over systemic integration. Something was missing there. More recent perspectives, increasingly influenced by urban informatics and systems-oriented thinking, begin to treat the city as a complex adaptive system—loosely bounded, continuously evolving—where data streams, institutional logics, and behavioral patterns intersect in ways that are not always predictable. Within this reframed

context, AI does not simply augment existing infrastructures; it alters the underlying logic of coordination itself, enabling forms of prediction, adaptation, and partial autonomy that were previously out of reach (Polydoros et al., 2026; Chawla et al., 2026; Masud et al., 2026; Dissanayake et al., 2026).

From a theoretical point of view, the incorporation of AI into urban systems resists explanation through any single framework. The Technology–Organization–Environment (TOE) perspective offers an initial structure, situating AI adoption at the intersection of technological maturity, organizational readiness, and external pressures—regulatory, societal, sometimes geopolitical. Yet, TOE remains somewhat descriptive. It captures conditions, less so dynamics. The Resource-Based View (RBV) extends the analysis by positioning data as a strategic asset and analytical capability as a differentiating factor in urban performance. Cities, in this sense, begin to resemble data ecosystems rather than purely administrative entities. Still, RBV has its own limits—it tends toward static equilibrium assumptions. This is where Dynamic Capabilities theory becomes analytically useful, emphasizing the capacity of urban institutions to reconfigure resources under conditions of uncertainty and rapid change. Not always smoothly. The combination of TOE, RBV, and Dynamic Capabilities does not produce a fully unified theory, but it does allow for a more layered interpretation—one that acknowledges both structure and motion in the embedding of AI within governance systems.

At the technological level, AI in Smart Cities functions as an upper-layer capability built upon a stratified digital architecture. At the base, the Internet of Things (IoT) provides the sensory substrate: distributed sensors embedded across transport networks, energy infrastructures, environmental monitoring systems, public utilities. These devices generate continuous streams of heterogeneous data, often noisy, sometimes incomplete. Transmission occurs through communication networks—frequently leveraging high-bandwidth solutions such as 5G—toward centralized or distributed data environments. The intermediate layer, where cloud and edge computing intersect, becomes critical here. It is not just about storage, but about latency, responsiveness, and control. Centralized processing offers scale; decentralized architectures provide resilience and, in some cases, greater alignment with data sovereignty requirements. The trade-offs are structural, not merely technical (Hussein et al., 2026; Dorostkar, 2026; Kumar et al., 2026; Rosak-Szyrocka, Wolniak, 2025b).

Above this infrastructural base, AI techniques—machine learning, deep learning, reinforcement learning—are deployed to extract patterns and inform decisions. Machine learning models are widely used for relatively well-defined tasks: traffic optimization, demand forecasting, anomaly detection. Deep learning extends analytical capacity into domains characterized by unstructured data—images, video streams, complex sensor outputs—enabling applications in surveillance, infrastructure diagnostics, public safety. Reinforcement learning remains less pervasive, but conceptually significant; it introduces adaptive control logics that evolve through interaction with dynamic environments. Not always stable, though. What becomes increasingly relevant is not the isolated use of these techniques,

but their integration into decision-support systems that operate in near real time, sometimes with minimal human oversight.

This layered technological configuration supports what is often described as data-driven urban management. The shift, however, is not abrupt—it unfolds gradually, and not uniformly across domains. Decision-making moves away from periodic, retrospective evaluation based on aggregated indicators toward more continuous, forward-oriented optimization processes. Traffic flows are adjusted dynamically; energy systems respond to fluctuations in demand and supply; service allocation becomes, at least in principle, predictive. Yet this transformation introduces new dependencies. Data quality becomes a constraint. Model calibration matters more than is often acknowledged. Interoperability issues—between systems, between institutions—can generate friction that offsets potential efficiency gains. Sometimes the system works, but not quite as intended.

The human dimension complicates this picture further. While the technological narrative emphasizes efficiency, optimization, responsiveness, the social embedding of AI-driven systems remains uneven, occasionally fragmented. Human-centered approaches—often associated with the notion of "Smart City 3.0"—attempt to reintroduce balance by foregrounding participation, transparency, inclusivity. But tensions persist. Algorithmic decision-making, especially when based on opaque or highly complex models, raises questions of accountability and explainability. Who is responsible for a decision generated by a model? Can it be contested? Trust becomes an issue—not abstract, but operational. And not easily resolved (Daovisan, 2026; Orduño-Osuna et al., 2026; Jonek-Kowalska, Wolniak, 2021, 2023).

AI-driven Smart Cities should not be conceptualized as purely technological constructs. They are better understood as socio-technical configurations, shaped by the co-evolution of infrastructure, institutional arrangements, and human practices. Their effectiveness depends on more than computational capacity or data availability; it is contingent upon organizational learning processes, regulatory alignment, and cultural acceptance. Some urban systems achieve high levels of technological sophistication yet encounter resistance at the institutional or societal level. Others proceed more incrementally—slower, perhaps, but with greater alignment between technological deployment and social expectations. There is no single developmental trajectory. Instead, multiple pathways emerge, conditioned by local constraints, governance models, and strategic priorities. Not entirely predictable, and not easily standardized.

The table 1 presents a layered architecture of AI-driven Smart Cities, linking each technological stratum with its core components and corresponding system functions. It highlights the sequential yet interdependent nature of urban digital infrastructure, where data acquisition, transmission, processing, and analytics collectively enable adaptive and real-time urban management. At the same time, it underscores that technical performance is contingent upon supporting layers such as cybersecurity, governance frameworks, and user interaction mechanisms, which ensure system reliability and societal integration.

Table 1.
Technological Foundations of AI-Driven Smart Cities

Technological Layer	Core Technologies	Functions and System Role
Data Acquisition Layer	IoT sensors, cameras, GPS, mobile devices	Continuous collection of real-time, heterogeneous urban data; foundation for all higher-level analytics
Communication Infrastructure	5G networks, LPWAN, fiber-optic systems	High-speed, low-latency data transmission; enables real-time system responsiveness
Data Storage and Processing	Cloud computing, edge computing, data lakes	Scalable storage and distributed processing; balance between centralization and local responsiveness
Data Integration and Management	Urban data platforms, APIs, interoperability frameworks	Integration of heterogeneous datasets; supports cross-domain data exchange and system coordination
Artificial Intelligence and Analytics	Machine learning, deep learning, reinforcement learning	Pattern recognition, prediction, optimization, and adaptive control of urban systems
Simulation and Modeling	Digital twins, system dynamics models	Scenario analysis, forecasting, and virtual testing of urban policies and interventions
Decision Support Systems	AI-driven dashboards, optimization algorithms	Support for policy-making and operational decisions; transition toward semi-automated governance
Cybersecurity and Data Protection	Encryption, anomaly detection, blockchain	Protection of data integrity, privacy, and system resilience against cyber threats
User Interface and Interaction	Smart applications, dashboards, chatbots	Communication between systems and users; enables monitoring, control, and citizen engagement
Governance and Control Layer	Data governance frameworks, regulatory technologies (RegTech)	Ensures compliance, accountability, and ethical use of AI systems in urban environments

Source: Author's own work.

3. Applications of AI-Driven People Analytics in Understanding Organizational Behavior

The application of artificial intelligence within urban systems has not progressed in a strictly linear fashion; rather, it has expanded from relatively isolated, domain-specific deployments toward more integrated—though still imperfect—configurations in which multiple subsystems are connected through shared data infrastructures and analytical logics. This shift reflects something broader than simple technological upgrade. It signals a transition from digitization, understood as the conversion of analog processes into digital form, toward datafication, and further into what might be described as algorithmically mediated governance. In this setting, AI ceases to function merely as an auxiliary analytical instrument. It becomes embedded—structurally—in urban management architectures, influencing both operational routines and higher-order strategic choices. The range of applications is extensive, but unevenly distributed; some domains display relatively high levels of maturity, others remain fragmented, exploratory, not fully stabilized.

Urban mobility constitutes one of the most developed application areas, although even here coherence is not guaranteed. AI-based traffic management systems draw on real-time inputs from heterogeneous sources—sensor networks, video feeds, GPS traces, mobile applications—

to regulate flows and mitigate congestion. Machine learning models extrapolate from historical and current datasets, generating short-term forecasts that allow for dynamic signal control or route optimization. In more advanced configurations, reinforcement learning introduces adaptive control mechanisms, where traffic systems effectively "learn" from ongoing conditions. Yet the effectiveness of these solutions is highly contingent. Data completeness is rarely achieved. Integration across administrative boundaries—particularly in metropolitan regions composed of multiple jurisdictions—often proves difficult. The system works, but only within certain limits (Koshy et al., 2026; Garai et al., 2026; Li et al., 2026; Sungheetha et al., 2026; Wolniak, Stecuła, 2024; Rosak-Szyrocka, Wolniak, 2025a).

In the energy domain, AI applications are closely entangled with the evolution of smart grids and the growing share of renewable energy sources. Urban energy systems are no longer centralized in the traditional sense; they become distributed, variable, sometimes unstable. This introduces the need for more sophisticated coordination mechanisms. AI models support load forecasting, demand-side management, and distribution optimization, enabling more responsive balancing of supply and demand. Predictive analytics can anticipate peak loads, while anomaly detection tools identify inefficiencies or technical faults within the grid. At the same time, the proliferation of distributed energy resources—rooftop photovoltaics, localized storage units—adds layers of operational complexity. AI facilitates coordination, yes, but it also exposes new vulnerabilities. Questions of resilience, of cybersecurity, do not disappear; they intensify (Shrivastava et al., 2026; Pawar et al., 2026; Skotnicka-Zasadzień, Wolniak, 2026).

Public safety and urban security represent another field of rapid AI deployment, particularly through the use of computer vision and predictive analytics. Automated video analysis allows for object detection, crowd monitoring, behavioral pattern recognition—functions that would otherwise require extensive human oversight. Predictive models attempt to estimate spatial or temporal concentrations of risk, informing allocation of policing resources. But this domain remains deeply contested. Issues of privacy, algorithmic bias, and potential discrimination are not peripheral—they are central. Training data may encode existing inequalities; model outputs may reinforce them. In this sense, public safety applications illustrate a recurring asymmetry: technological capacity advances quickly, while regulatory and ethical frameworks struggle to keep pace. Sometimes significantly.

Environmental monitoring and urban sustainability form another domain in which AI is increasingly embedded. Sensor infrastructures generate continuous streams of environmental data—air quality indices, acoustic levels, thermal variations, pollutant concentrations. Machine learning techniques process these inputs to detect trends, forecast risks, and support policy interventions. For example, models can simulate pollutant dispersion patterns across urban morphologies, enabling more targeted mitigation strategies. In water systems, predictive algorithms assist in leak detection, distribution optimization, stormwater management. These applications gain particular relevance under conditions of climate

instability, where adaptability becomes a functional requirement rather than a policy preference. Yet, again, a gap appears. Analytical insight does not automatically translate into effective intervention. Institutional fragmentation, limited administrative capacity—these factors intervene.

Beyond sector-specific implementations, a more structural transformation becomes visible through the emergence of integrated, data-driven urban management models. These models attempt to transcend individual domains, linking data flows and decision processes across the urban system as a whole. The notion of the "urban data platform" captures this idea: a centralized or federated environment where heterogeneous datasets are aggregated, standardized, and made interoperable. In principle. In practice, achieving interoperability remains difficult. Data standards differ, ownership structures are contested, technical architectures are not easily aligned. The platform exists, but often in a partial or segmented form (Alourani et al., 2026; Nagpal et al., 2026; Khan et al., 2026).

A related development—more advanced, but also more demanding—is the concept of the digital twin. Here, the city is represented as a dynamic virtual model, integrating real-time data with simulation capabilities. Digital twins allow planners to test scenarios, evaluate interventions, anticipate system responses before changes are implemented in the physical environment. Traffic systems can be simulated under alternative infrastructure configurations; energy transitions can be modeled under different policy assumptions. The incorporation of AI enhances these models, introducing predictive and adaptive dimensions. Still, the resource requirements are substantial. Not only computational, but organizational. Many cities lack the institutional capacity to sustain such systems over time.

Algorithmic governance represents a further step, where decision-making processes are partially—sometimes extensively—delegated to AI systems. This may involve automated service allocation, dynamic pricing mechanisms, real-time optimization of public resources. The potential gains in efficiency and responsiveness are evident. But so are the risks. Accountability becomes diffuse. Decision pathways are not always transparent. Who, precisely, is responsible for an outcome generated by an algorithmic system? And how can such systems be audited, contested, corrected? These are not abstract concerns. They shape the legitimacy of governance arrangements (Archana Reddy et al., 2026; Bodade et al., 2026; Gkikas, Gkikas, 2026).

The transition toward data-driven urban management does not follow a uniform trajectory. Cities differ—economically, institutionally, technologically—and these differences produce distinct implementation pathways. Some adopt comprehensive, top-down strategies, investing in integrated infrastructures and large-scale AI deployments. Others proceed incrementally, focusing on pilot projects or specific functional domains. Hybrid configurations also emerge, often involving public–private partnerships that redistribute both capability and control. Each pathway entails trade-offs. Flexibility versus coordination, scalability versus governance complexity. There is no optimal model, only context-dependent configurations.

The table 2 synthesizes the principal domains of AI application in urban systems by linking them with corresponding data-driven management models and their functional implications. It illustrates a transition from sector-specific implementations toward more integrated, platform-based and algorithmically coordinated forms of urban governance, where data interoperability and real-time analytics play a central role. At the same time, the table highlights that technological capabilities are accompanied by systemic constraints, including data quality dependencies, institutional fragmentation, and emerging ethical and accountability challenges.

Table 2.
AI Applications and Data-Driven Urban Management Models: Domains, Architectures, and System Implications

AI Application Domain	Data-Driven Urban Management Model	Key Functions and Implications
Urban Mobility (traffic, transport systems)	Real-time adaptive traffic management systems	Dynamic signal control, congestion prediction, route optimization; dependence on high-frequency data streams; sensitivity to data gaps
Energy Systems (smart grids, RES integration)	Predictive energy management platforms	Load forecasting, demand-response optimization, distributed energy coordination; increased system complexity and cybersecurity exposure
Public Safety and Security	Predictive policing and video analytics systems	Pattern recognition, risk mapping, automated surveillance; ethical risks (bias, privacy), governance challenges
Environmental Monitoring	AI-supported urban sustainability platforms	Air quality prediction, climate risk modeling, resource optimization; supports evidence-based policy, but requires institutional integration
Water and Waste Management	Smart resource management systems	Leak detection, consumption optimization, waste flow prediction; efficiency gains with relatively low visibility to citizens
Healthcare and Social Services	Predictive service allocation models	Identification of vulnerable populations, demand forecasting; risk of exclusion due to data bias or incomplete records
Urban Planning and Infrastructure	Digital twin-based planning models	Scenario simulation, infrastructure optimization, long-term forecasting; high data and computational requirements
Governance and Administration	Algorithmic decision-support systems	Automation of administrative decisions, resource allocation; issues of transparency, accountability, and legitimacy
Cross-domain Urban Management	Integrated urban data platforms	Interoperability across sectors, centralized or federated data governance; technical and institutional coordination challenges
Citizen Interaction and Participation	AI-enhanced civic engagement platforms	Chatbots, sentiment analysis, participatory data input; potential to increase responsiveness, but uneven adoption across groups

Source: Author's own work.

4. Conclusion

The integration of artificial intelligence into People Analytics should not be interpreted as a marginal enhancement of existing analytical routines. It is closer to a structural reconfiguration—one that alters how organizational behavior is observed, interpreted, and, eventually, translated into managerial action. The analytical lens shifts. Instead of static, descriptive snapshots of workforce phenomena, AI-driven approaches enable dynamic, multi-level representations in which behavior is understood as an emergent property of interacting elements: individual decisions, relational structures, institutional contexts. Not always neatly separable. Within such a framework, employee behavior appears less as a set of attributes and more as a process—evolving, contingent, sometimes unstable.

This transformation extends both the explanatory and predictive reach of organizational research. AI-based models allow for the identification of complex behavioral configurations associated with engagement, turnover, collaboration patterns, leadership dynamics, or well-being trajectories. These configurations are not isolated variables; they form interdependent structures that unfold over time. The temporal resolution of analysis increases—what was previously observed in aggregated intervals can now be tracked as a sequence of micro-adjustments. Subtle shifts, small deviations. At the same time, analytical granularity deepens, enabling the detection of patterns that remain obscured under conventional statistical approaches. Yet, increased precision does not necessarily imply increased understanding. Not automatically.

The findings suggest that the value of AI-driven People Analytics is not intrinsic to the technology itself but depends on its theoretical and epistemological embedding. Artificial intelligence does not displace established frameworks of organizational behavior. Rather, it repositions them. Theory moves away from a strictly model-specifying role toward a more interpretative function—one that situates algorithmically identified patterns within broader explanatory narratives. This creates a hybrid analytical logic, combining inductive pattern discovery with deductive reasoning. Productive, but also tension-laden. Questions of causality become less straightforward; interpretability varies across models; generalizability remains uncertain, especially when context-specific data dominate the analysis. Without a sufficiently robust conceptual grounding, there is a risk of reducing complex human phenomena to abstract data regularities—precise in form, limited in meaning.

Also the expansion of AI within People Analytics introduces a set of ethical and normative dimensions that cannot be treated as secondary considerations. They are constitutive of the analytical process itself. Issues of privacy, transparency, fairness, and employee autonomy shape not only the acceptability of AI applications but also their operational viability over time. Systems perceived as opaque or intrusive tend to generate resistance, which in turn affects data

quality and model performance. A feedback loop emerges—technical and social factors intertwine. Not always predictably.

The further development of People Analytics depends on the capacity to align computational sophistication with forms of ethical governance and contextual awareness. It is not enough to build more accurate models. The challenge lies in embedding these models within organizational settings in ways that preserve trust, maintain interpretability, and respect the complexity of human behavior. A theoretically informed, ethically grounded approach does not resolve all tensions, but it allows organizational research to retain explanatory depth while adapting—sometimes unevenly—to the increasing data intensity and structural complexity of contemporary work environments.

From the findings of this analysis, it is evident that it would be useful for organizations to implement AI-powered People Analytics in a strategic and theoretically informed way, thus making sure that technology is implemented based on organizational behavior theories rather than the availability of data alone or novel ways of using analytics. This suggests the necessity for organizations to implement integrated analytical architectures through which behavioral data from various sources could be analyzed based on theoretical constructs, which would make it possible not only to predict certain outcomes but to interpret employee-related phenomena as well. On the other hand, the use of People Analytics should go hand in hand with investments in analytical capabilities and governance to enable responsible applications of technology. Specifically, special emphasis should be placed on embedding certain ethical considerations, such as the protection of personal privacy, into People Analytics solutions. Otherwise, the analytical benefits provided by AI could be overshadowed by lack of trust and limited applicability of insights gained through analytics.

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OPTIMIZATION OF ORGANIZATIONAL SYSTEMS OF SOCIAL WELFARE UNITS. THE CASE OF POLAND

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Purpose: The aim of the article is to diagnose the level of optimization of the organizational structures of social welfare units in Poland in the context of challenges determining the change in the approach to the management of social services.
Design/methodology/approach: Using the *Participatory Action Research* method, a diagnosis of organizational structures was made in 2,573 OPS and 328 PCPR local government social welfare organizations in Poland. Using formative indicators, a research framework was developed to diagnose and assess the occurrence of organizational learning, as well as the implementation of programs to manage organizational culture change.
Findings: The diagnosis revealed a lack of internal communication systems and the existence of extensive personnel accountability systems. The problem of overly complex organizational structures and a lack of awareness of the organization's mission among managers and employees was identified.
Research limitations/implications: The study results indicate the need to extend the research to European countries that have carried out extensive public sector reforms in order to conduct comparative analyzes with other welfare models.
Practical implications: An inherent element of the rationalization of organizational structures within units remains their flattening and reduction in employment, primarily at the highest and lowest levels.
Social implications: Rationalizing organizational structures should be a response to the implementation of social services based on relationships, technology, collaboration, and design "from below" rather than being imposed centrally.
Originality/value: Managing social welfare units in an entrepreneurial manner requires changes in organizational culture through rationalization of structures. Without rationalizing organizational structures, it is not possible to implement social services.
Keywords: public management, organizational structures, social welfare organizations, social services.
Category of the paper: Research paper.

1. Introduction

Dynamic economic, political, and demographic changes, and above all the effects of the Covid-19 pandemic, are giving rise to new and increasingly complex problems of various kinds, which a significant part of society is unable to cope with (Quantin, Tubert-Bitter, 2022). These changes require an improvement of the organizational structures of social welfare to optimize the effectiveness of new tasks. The new challenges facing these organizations are forcing them to engage in increasingly frequent cross-sectoral and inter-institutional cooperation and to involve clients in the creation and implementation of social strategies and programs (Cataldi, 2024). Multifaceted cooperation can make a real contribution to solving social problems and bring significant value to improving the living conditions of people in need of assistance. Central and local authorities should focus their attention on optimizing the potential of public entities and strengthening the links between them (Zelek, Strzępek, 2024). Attention is drawn to the management need to improve the quality within organizations and cooperation between public policy stakeholders, as well as the political and social dimension of management (Pestoff, 2012). In an era of globalization and dynamic change, it is important how a specialized state should coordinate cross-sectoral cooperation with other entities such as large corporations, international organizations, non-governmental organizations, or data cloud management organizations, while gaining legitimacy as one of the main characteristics determining the relationship between the organization and its environment (Suddaby et al., 2017). A review of the literature points to an increasingly clear universalization of management theories, concepts, models, and methods, and after appropriate adaptation, there is a real possibility of applying them to achieve the adopted goals, both in the private, public, and social sectors (Frączkiewicz-Wronka, 2009; Aguinis, Burgi-Tian, 2023). The literature on the organizational structures of social welfare units is poor in its scientific output, creating a research gap, which motivates a greater interest in this area (Zelek, 2023). The importance of optimizing organizational systems in social welfare units is increasing due to the growing complexity of social problems and the need for more adaptive public service delivery models (Cataldi, 2024; Quantin, Tubert-Bitter, 2022). Contemporary approaches to public management emphasize cross-sectoral collaboration, co-production, and relational service design, which require more flexible and responsive organizational structures (Pestoff, 2012; Cottam, 2022). However, despite the development of management concepts and their applicability across sectors, empirical research focusing on the internal organizational structures of social welfare units remains limited (Frączkiewicz-Wronka, 2009; Aguinis, Burgi-Tian, 2023). In particular, there is insufficient evidence on how structural characteristics influence the effectiveness and adaptability of these organizations in practice (Zelek, 2023). This creates a research gap concerning the relationship between organizational design and the implementation of modern social services in public welfare systems.

2. Organizational Systems of Social Welfare Units

Social welfare management requires a qualitatively different approach to the organization of its mission and objectives, introducing the concept of dignified management (Sharma, Mukhejri, 2011). This approach is an attempt to combine efficiency and effectiveness with the maintenance of humanistic goals in the organization of social welfare (Furman et al., 2020). It requires managers of units to combine managerial and interpersonal skills with the ethical quality of assistance activities (Zelek, 2025). The concept of active social policy, implemented in the Polish social welfare system from Western European countries and the US, means redirecting assistance based on broad social transfers towards empowerment and strengthening empowerment (Kam, 2020) through the professional activation of beneficiaries, which presents social welfare services with new tasks. In an era of advancing digitalization, globalization, migration, and dynamically changing socio-economic conditions, attention should be paid to the benefits of implementing innovation and entrepreneurship in the design and coordination of social services for both clients and state budgets (Wodecka-Hyjek, 2023). P.F. Drucker believes that every public utility institution must be as entrepreneurial and innovative as any company, if not more so (Drucker, 1985). Social links with the environment in which social welfare organizational units operate are of great importance for the quality of management in the social welfare system. Until 1989, social welfare systems in CEE countries were subject to the total domination of communist ideology and a policy of strict control over society and the economy, blurring the boundaries between politics and administration (Hajnal et al., 2021). The accession of CEE countries to the European Union (EU) initiated a process of aligning social welfare service standards with those in leading EU countries (Adiukaite, Navicke, 2022). The Polish administration is based on a bureaucratic model derived from the continental (mainly German) tradition, which is dominated by legalism, hierarchy, and organizational formalism. Strongly rooted in law, decision-making processes are formalized and often cautious, which affects the pace of change and the capacity for innovation (Izdebski, 2021). A new approach to social service delivery is currently being proposed: transformation design based on relationships, technology, cooperation, and bottom-up service design rather than centrally imposed (Cottam, 2022). This is also in line with the "need for cross-sectoral collaboration" between three entities (public, private, non-profit civil society) to ensure service delivery (Butcher, Gilchrist, 2016). The specific nature of local government social welfare organizations in the context of building inter-institutional and cross-sector partnerships requires a qualitatively different approach to these issues by involving clients in the processes of designing and coordinating social services (Clarke, 2020). M. Grewiński's original diagram of a modern, forward-looking social policy model, called the Daisy of Prosperity (Grewiński, 2009), shows that social policy is implemented in three sectors: public, civic, and market. The low financial potential of non-governmental organizations means that they are not significant partners for district and

municipal social welfare organizations (Golczyńska-Grondas, Błaszczyk, 2020). There is also a lack of partnership activities between units and cooperation between public entities in the field of social welfare (Eck et al., 2024). The lack of cooperation within the social welfare system is the cause of organizational chaos, which arises as a result of unclear areas of competence and the dispersion of responsibility for the implementation of tasks in the commune and district (Krzyszkowski, 2008). Traditional social welfare derives its legitimacy from values based on compliance with law, justice, effectiveness, and the achievement of results through specific tools, with economic efficiency in the end (Froy, Giguère, 2010). In new approaches, it is a pursuit of quality improvement based on the commissioning of social services (Szarfenberg, 2011). Proper management of planned activities should meet the needs of the individual, bringing their situation in line with that of other members of society (Kulesza, Sześciło, 2013).

2.1. Streamlining Organizational Structures

Changes in organizational culture are brought about by rationalizing organizational structures and promoting the use of social communication techniques, including, for example, implementing communication strategies, appointing spokespersons, and social communication departments in institutions (Gruening, 2001; Wade, Laloux, 2014). In the era of widespread digitization, communication skills are gaining in importance, as they form the basis for activities carried out in entities using information and communication technologies (Maurer et al., 2023). Furthermore, rationalization of organizational structures is reflected in a reduction in employment, mainly in senior and entry-level positions (Cooper et al., 2014; Schmidt et al., 2017). The reduction in employment affects to the least extent employees in middle management positions and specialists who have been recognized as the pillars of the efficient functioning of the organization (Khaw et al., 2022). The rationalization of organizational structures is based on the postulate of implementing quality management in the public sector (Wolniak, Sułkowski, 2016).

The modernization of organizational structures in public sector entities, which took place in the 1980s and 1990s in the United Kingdom (Hood, Dixon, 2015); Scandinavia (Lapsley, Knutsson, 2017); the United States (Denhardt, Denhardt, 2015); Australia (Johnston, 2000) and New Zealand (Boston et al., 1996), including the transformation of public services (Osborne et al., 2026), including social services (Nielsen, Hammerslev, 2024), was carried out in the reforms of the spirit of the *New Public Management* concept. Rationalization of organizational structures in the public sectors of these countries has led to job cuts, mainly in senior and entry-level positions (Hood and Dixon, 2015).

Exercising power in an entrepreneurial manner requires necessary changes in organizational culture (Errida, Lotfi, 2021). This relationship has stimulated interest in the use of organizational culture change management programs and the implementation of the concept of a learning organization and good management models in administration (Ward, 2017).

The widespread use of social communication techniques has also contributed to the practical implementation of instruments of democratization, customer orientation, and improvement of public service delivery (Gruening, 2001). Key skills play a special role in the learning process; they are essential for people to achieve social goals and are used particularly in managerial positions (Roszyk-Kowalska, Kraśniak, 2020).

These analyzes constitute a research problem that led to a diagnosis of the adaptation of the organizational systems of social welfare units in Poland, that is, the social welfare centers (OPS) and the district family assistance centers (PCPR), to dynamically changing needs in terms of matching social services to the needs of the clients. The following research hypotheses were adopted in the article:

H1: OPS and PCPR implement organizational culture change management programs, increasing adaptation to new conditions.

This hypothesis assumes that organizational culture change is already institutionalized within social welfare units. It reflects the growing importance of adaptability and learning in public organizations facing dynamic environmental conditions.

H2: OPS and PCPR have defined missions, strategies, and goals that increase the effectiveness of services.

This hypothesis emphasizes the strategic maturity of organizations as a determinant of service effectiveness. Clearly defined missions and goals are treated as key elements of performance-oriented public management.

H3: OPS and PCPR implement internal and social communication systems that increase the accessibility of supervisors to employees.

The hypothesis highlights the role of communication systems as a critical infrastructure supporting organizational efficiency. Effective communication is assumed to enhance coordination and accessibility within hierarchical structures.

H4: OPS and PCPR have an extensive system of personal responsibility that prevents the efficient operation of organizational structures.

This hypothesis addresses the potential dysfunctions of excessive formalization and accountability systems. It suggests that overly rigid control mechanisms may reduce organizational flexibility and decision-making efficiency.

H5: OPS and PCPR operate in a highly centralized system that prevents adaptation to dynamically changing needs of clients.

The hypothesis reflects the tension between centralization and adaptability in public sector organizations. It assumes that high levels of centralization limit responsiveness to local and rapidly changing client needs.

3. Research Methods

The study used the *Participatory Action Research* (*PAR*) method (Eden, Huxham, 1996), which was subjected to a more in-depth analysis at the end of the 1990s, particularly with regard to the opportunities it offers for solving organizational problems (Kafel, 2016). When considering research methods in action separately, the following approaches can be identified: *action research* (Greenwood, 1998), *community action research* (Senge, Scharmer 2001), and *PAR* (Karlsen, 1991). However, it is the PAR method that best utilizes scientific achievements in solving practical social problems, with the broad participation of those affected by the problem (Cornish et al., 2023). The basic assumption of the research process based on the *PAR* method is scientific consulting, also known as research strategy or action research (Heron, 1996). Participants in the study become their full subjects (Brydon-Miller, 2020). The subjects are co-participants in the research process in all areas of research (Karlsen, 1991).

The study covered all social welfare organizations at the municipal (OPS) and county (PCPR) levels, which constitute the basic element of the social welfare system in Poland. Using the cooperative research method through a set of formative indicators (statements) for the construct 'organizational structure', the scales were given a multi-index form recorded in electronic diagnostic forms adopted under the names *OPS-OpenIndex* and *PCPR-OpenIndex*. The statements were identical for both groups of organizations. Units received an email with a link to a survey questionnaire, which managers and employees were asked to complete. Access to the surveys was only possible through two direct links, created separately for each tool in a Google form.

Table 1.
A summary of the statistical data

Type of organization	Total		%
	Questionnaires sent	Complete surveys received	
OPS	2573	1959	76.1%
PCPR	328	242	75.7%

Source: own study.

The responses obtained were exported to MS Excel and then subjected to statistical analysis in Statistica 13. The following tools were used to perform the descriptive statistical analysis of the research results:

- *Cronbach's α* coefficient to assess reliability (internal consistency of constructs).
- *Cramér's V* coefficient to examine the relationship between qualitative variables.
- *Kendall tau* coefficient to assess the correlation between respondents' responses to statements on a 5-point Likert scale.

A test probability value (p) less than 0.05 provided grounds for rejecting the null hypothesis. The strength of the relationship was then examined using *the Cramer V* coefficient. The latter takes values from 0 to 1 from a closed interval. The higher its value, the stronger the relationship between the variables.

4. Results of the Research

The purpose of the study within the organizational structure construct was to diagnose the occurrence of organizational learning and to determine whether organizational culture change management programs are being implemented. An attempt was made to determine whether the units have logos, defined missions, strategies, and goals, an internal and social communication system, the availability of supervisors to employees, and the complexity of the organizational structure at the management levels. Questions were asked about the training and staff development system and the implementation of quality management. An attempt was made to examine the degree of advancement in the use of information technology and the possibility of giving greater autonomy to units.

The construct measuring organizational structures within OPS and PCPR consisted of 15 statements. The numbering of the statements was not kept in chronological order to ensure the reliability of the responses (Table 2).

Table 2.
Statements for the construct "organizational structure"

No	Statement
21	I have the opportunity to take advantage of additional training, conferences, courses, studies, business trips, expert meetings, advisory meetings, and industry meetings.
50	Employees understand the expectations for the effective performance of their mission.
43.	Working in the unit, I feel like a "co-owner" of the projects and activities in which I participate and take responsibility.
19.	Continuous learning and professional development are expected in my job.
2.	The unit has developed them and uses logos on documents.
1.	The unit has its own website.
55.	The unit is managed according to its stated mission and developed strategy.
40.	I provide information quickly and efficiently to those who need it.
67.	The entity uses electronic communication systems between employees.
7.	Managers can make important decisions without consulting their superiors.
72.	There are too many people in managerial positions in the unit.
35.	The unit focuses on increasing awareness of the services it offers.
32.	The unit does not limit itself to performing its statutory duties.
77.	The entity implements projects aimed at expanding the scope and quality of its services.
3.	The unit has a high degree of autonomy and is not dependent on other entities.

Source: own study.

The study covered all social welfare organizations at the municipal (OPS) and county (PCPR) levels, which constitute the basic element of the social welfare system in Poland. Using the cooperative research method through a set of formative indicators (statements) for the construct "organizational structure", the scales were given a multi-index form recorded in electronic diagnostic forms adopted under the names *OPS-OpenIndex* and *PCPR-OpenIndex*. The statements were identical for both groups of organizations. Units received an email with a link to a survey questionnaire, which managers and employees were asked to complete. Access to the surveys was only possible through two direct links, created separately for each tool in a Google form.

4.1. OPS results

The construct is reliable, as confirmed by *Cronbach's alpha* coefficient of 0.74. The distribution of the responses of the OPS respondents is presented in Table 3. As a rule, respondents have the opportunity to take advantage of additional training, conferences, and other types of trips (Statement 21). This opinion was confirmed by 76.42% of the surveyed group, including 43.85% who moderately agreed with it. The aggregated results showed that 47.01% of the respondents strongly disagreed and 38.39% moderately disagreed with Statement 50, indicating that it is not clear to employees what expectations the unit must meet to effectively carry out its mission. Respondents working in the unit generally feel that they are "co-owners" of the projects and activities in which they participate (Statement 43), which was moderately confirmed by 44.05% of respondents, while 22.72% strongly agreed.

A high level of agreement was observed in response to Statement 19, with 44.61% of respondents moderately agreeing and 37.83% strongly agreeing that continuous learning and professional development are expected in their work. The aggregated responses of the respondents to Statement 2, that entities most often have logos that they use on documents, clearly indicate that 49.06% of the respondents confirmed the statement. More than 76.21% of the respondents strongly confirmed that the entity has its own website (Statement 1).

Table 3.
Responses of OPS respondents within the organizational structure construct (in %, N = 1959)

Specification	S. 21	S. 50	S. 43	S. 19	S. 2	S. 1	S. 55	S. 40	S. 67	S. 7	S. 72	S. 35	S. 32	S. 77	S. 3
	in %														
Strongly disagree	5.97	47.01	7.50	2.60	14.70	5.46	2.40	25.98	17.82	13.63	3.32	44.31	3.57	3.27	19.45
I rather disagree	12.30	38.39	15.77	6.84	7.81	2.60	5.87	34.66	28.18	29.66	8.93	26.49	9.49	8.93	34.81
No opinion	5.31	8.32	9.95	8.12	10.62	3.01	5.31	9.90	18.48	16.64	49.62	11.94	20.83	23.43	15.93
I rather agree	43.85	4.34	44.05	44.61	17.82	12.71	51.30	22.31	24.35	30.99	29.35	12.20	41.04	42.16	21.39
Strongly agree	32.57	1.94	22.72	37.83	49.06	76.21	35.12	7.15	11.18	9.09	8.78	5.05	25.06	22.21	8.42

Source: own study based on research results.

High scores were observed among the aggregated survey results for statement 55. 51.3% of the respondents moderately agreed that the entity is managed in accordance with its stated mission and the strategy developed to solve social problems in the municipality (Statement 55). Furthermore, another 35.12% of the respondents strongly agreed with this statement.

The respondents expressed negative opinions about the speed and efficiency of information transfer to interested parties (Statement 40), which was observed among 34.66% of the respondents, although, on the other hand, 22.31% of them moderately agreed that there were no communication problems. A moderate 28.18% of the respondents maintained that their units did not use electronic communication systems between employees (Statement 67), but slightly fewer, 24.35%, disagreed.

High ratings were recorded for Statement 7. 30.99% of the respondents moderately agreed and 29.66% disagreed with this statement, suggesting that in some units, managers can make many important decisions without consulting their superiors, while in others the decision-making process is longer. 49.62% of the respondents did not express a clear opinion when answering the statement on whether there are too many people in managerial positions in the unit (Statement 72), although 29.35% of the respondents moderately agreed with this opinion. According to the respondents, the units do not focus on increasing the customer's awareness of the importance of the services offered (Statement 35). 44.31% of the respondents strongly disagreed with this opinion, and 26.49% expressed moderate agreement. 41.04% of the respondents moderately agreed with statement 32, indicating that the entity does not limit itself to performing statutory tasks resulting from applicable regulations and legal acts.

A moderate correlation was confirmed by 42.16% of the respondents, who stated that their unit implements projects aimed at expanding the scope of services and improving their quality (Statement 77), while another 22.21% believed that it fully implements such projects. There was a moderate belief among the respondents that the unit does not have much autonomy and is dependent on other entities (Statement 3), which was agreed with by 34.81% of the respondents. On the other hand, 21.39% of the respondents confirmed the existence of dependence to a moderate degree.

The construct contained 15 statements; therefore, the range of possible results was between 15 and 75 (Table 4).

Table 4.
Descriptive statistics for the organizational structure construct in the OPS sample

N of important	Arithmetic mean	Median	Minimum	Maximum	Range	Deviation std.
1959	49.42	50.00	19.00	74.00	55.00	7.89

Source: own study based on research results.

The minimum response was 4 units higher than the lower limit of the construct, while the maximum was 1 unit lower. A high mean and median of 50.0 and a standard deviation of 7.9 were recorded.

There was a weak and statistically significant positive correlation between Statements 3 and 7, with (p) below 0.05 and *Kendall tau* at 0.29. This means that people who agreed that the unit has a high degree of autonomy and is not dependent on other entities generally also believed that managers in the unit can make many important decisions without having to consult their

superiors. The relationship between Statements 7 and 67 was statistically significant ($p < 0.05$), positive, and weak (*tau* coefficient = 0.28). Respondents who expressed the opinion that managers in the unit can make many important decisions without consulting their superiors were also generally of the opinion that the unit uses electronic communication systems between employees. A not very strong, positive (*tau* = 0.36) and statistically significant ($p < 0.05$) correlation was found for the pair of Statements 19 and 21. Respondents for whom continuous learning and professional development were expected in their work generally maintained that they had the opportunity to take advantage of additional training, conferences, etc. The correlation between Statements 43 and 55 was statistically significant ($p < 0.05$) positive and not very strong (*tau* coefficient = 0.35), which means that people working in the unit who feel that they are "co-owners" of the projects and activities in which they participate generally believed that the unit was managed according to its stated mission and strategy for solving the municipality's social problems.

4.2. PCPR results

The distribution of the responses of the PCPR respondents is presented in Table 5. The construct is reliable according to the *Cronbach alpha* coefficient of 0.72. More than 44.63% moderately agreed with Statement 21 on the possibility of using additional training and conferences, while 40.91% of PCPR respondents strongly agreed with this Statement. Similarly, the opposite situation occurred for Statement 50. 85.54% of the respondents confirmed that employees do not understand what expectations an entity must meet to effectively carry out its mission. As a rule, the respondents felt that they were "co-owners" of the projects and activities in which they participated (Statement 43), with 43.8% agreeing to a moderate extent. Similarly, they believed that continuous learning and professional development is expected in their work (Statement 19), which was strongly supported by 41.74% of the surveyed group.

Table 5.
Responses of PCPR respondents within the organizational structure construct (in %, N = 242)

Specification	S. 21	S. 50	S. 43	S. 19	S. 2	S. 1	S. 55	S. 40	S. 67	S. 7	S. 72	S. 35	S. 32	S. 77	S. 3
	in %														
Strongly disagree	3.31	51.65	6.61	2.89	8.68	4.96	1.24	22.31	12.81	15.70	2.07	43.80	4.55	1.24	20.25
I rather disagree	5.37	33.88	14.05	3.31	5.37	1.24	3.31	31.40	30.17	26.45	9.50	29.75	6.61	6.20	29.34
No opinion	5.79	7.44	11.16	5.37	6.61	0.00	4.96	9.50	19.01	21.07	44.21	11.57	14.88	13.22	14.88
I somewhat agree	44.63	4.13	43.80	46.69	17.36	4.13	48.76	28.10	19.42	30.99	32.64	12.40	40.08	38.43	24.79
Strongly agree	40.91	2.89	24.38	41.74	61.98	89.67	41.74	8.68	18.60	5.79	11.57	2.48	33.88	40.91	10.74

Source: own study based on research results.

Similarly to OPS, PCPR employees clearly confirmed that their units have developed and use logos on documents (Statement 2) and that they have their own website (Statement 1). The percentage of "strongly agree" responses for these two Statements was 61.98% and 89.67%, respectively. A significant majority of affirmative responses were recorded for Statement 55. However, 48.76% of the respondents moderately agreed that the unit is managed

according to its stated mission and developed a strategy to solve social problems in the municipality, while another 41.74% strongly confirmed this relationship.

A summary analysis of the survey results for Statement 40 showed that respondents did not agree that they provide information quickly and efficiently to those who need it, with 31.4% moderately disagreeing and 28.1% strongly disagreeing. 30.17% of the respondents moderately disagreed that the unit uses electronic communication systems between employees (Statement 67), while 31.4% of the respondents expressed a moderate opinion that the unit managers can make many important decisions without consulting their superiors (Statement 7). 44.21% of the respondents were generally unable to determine whether the entity employs too many people in managerial positions (Statement 72), while 32.64% of the respondents expressed positive responses.

The aggregated results of the survey for Statement 35 in the responses of 73.55% of respondents indicated critical comments in the context of the statement that the unit focuses on raising customer awareness of the importance of the services offered. A total of 43.8% of respondents strongly disagreed with this statement, while 29.8% disagreed to a moderate extent. On the contrary, respondents expressed the opinion that the entity does not limit itself to performing statutory tasks resulting from applicable regulations and legal acts (Statement 32), which was strongly confirmed by 33.88% of respondents, and moderately confirmed by another 40.08%. Similar responses were recorded for Statement 77. 79.34% of the respondents strongly agreed that their unit implements projects aimed at expanding the range of services and improving their quality. Only 7.44% of the surveyed group disagreed with this. The respondents were undecided whether the unit has a high degree of autonomy and is not dependent on other entities (Statement 3). Moderate dependence in this regard was confirmed by 24.79% of the respondents, but 29.34% of them presented a different opinion and another 20.25% of the respondents strongly disagreed with this statement (Table 6).

Table 6.
Descriptive statistics for the organizational structure construct in the PCPR sample

N of important	Arithmetic mean	Median	Minimum	Maximum	Range	Deviation std.
242	51.68	52.00	27.00	70.00	43.00	7.37

Source: own study based on research results.

The minimum response was significantly higher than the lower limit of the construct and amounted to 27.0. The PCPR sample had a slightly higher median and mean compared to the OPS, which amounted to 52.0. The standard deviation was lower and was 7.4.

The relationship between Statements 21 and 43 was statistically significant ($p < 0.05$), positive, and moderately strong (*tau* coefficient = 0.47), which means that people who declared the possibility of using additional training, conferences, etc. were generally of the opinion that, working in the unit, they felt like "co-owners" of the projects and activities in which they participated and for which they took responsibility. There was also a correlation between

Statements 32 and 77, which was statistically significant ($p < 0.05$), positive and not very strong (*Kendall's tau* coefficient = 0.36). Respondents who believed that the unit was not limited to performing statutory tasks resulting from applicable regulations and legal acts also expressed the opinion that the unit implements projects aimed at expanding the scope of services and improving their quality.

A statistically significant ($p < 0.05$), positive and not very strong correlation (*Kendall tau* = 0.39) was found for Statements 55 and 72. Respondents who believed that the unit was managed in accordance with its stated mission and strategy for solving social problems in the municipality also generally maintained that there were too many people in management positions in the unit.

5. Discussion and Conclusions

Based on the analysis of statistical data, key areas requiring improvement in the organizational structures of social welfare centers were identified, namely: (1) lack of clear expectations that entities must meet in order to effectively carry out their missions; as many as 47% of respondents strongly disagreed with this statement, and 38.4% moderately disagreed; (2) lack of speed and efficiency in communicating information to interested parties, with 34.7% of respondents seeing problems in this area; (3) lack of electronic communication systems between employees, with 28.2% of respondents expressing this opinion; (4) managers' inability to make important decisions without consulting their superiors; approximately 30% moderately agreed and disagreed with this statement; considering the number of questionnaires received, this result should be considered a negative phenomenon; (5) too many people employed in managerial positions, 29.4% of respondents moderately agreed with this opinion; (6) lack of raising customer awareness of the importance of the services offered, 44.3% of respondents strongly agreed with this statement, while 26.5% of respondents expressed moderate agreement; (7) lack of autonomy of individuals and dependence on other entities, which was agreed with by 34.8% of respondents.

Areas requiring improvement in the organizational structures of PCPR include: (1) lack of electronic communication systems between employees, which was confirmed by almost 1/3 of respondents to a moderate degree; (2) too many people employed in managerial positions, with 32.6% of respondents leaning towards a positive answer; (3) a lack of focus on raising customer awareness, with 43.8% of respondents expressing this opinion and 29.8% agreeing to a moderate extent; (4) lack of autonomy of individuals and dependence on other entities, which was confirmed to a moderate degree by 29.3% of them, and another 20.3% strongly confirmed the dependence; (5) too slow and inefficient transfer of information to those who need it, with 31.4% of respondents expressing moderate dependence in this regard.

Table 7.
Identified problems and proposed solutions within the organizational systems of OPS and PCPR – verification of the adopted hypotheses

Identified problems	Verification of the hypothesis	Proposed solutions	Ways to solve problems in the organizational systems of OPS and PCPR
Lack of awareness of the condition organization's mission	H1 rejected H2 rejected	Organizational culture change management programs	- organizing and participating in regular team meetings, - conferences, meetings, and training sessions on the directions of activities.
Lack of internal communication systems	H3 rejected	Implementation of information technology	- electronic internal communication systems.
Extensive system of personal responsibility	H4 confirmed	Flattening of organizational structures	- delegation of tasks and powers to lower-level managers and team coordinators.
Extensive organizational structure		Reducing employment	- reduction of employment at the highest level (merging departments with similar competences), outsourcing services to external entities, - outsourcing.
Strong dependence on local authorities	H5 confirmed	Increased autonomy of OPS and PCPR	- decentralization of management, - limiting the role of county councils, city presidents, mayors, and commune heads to supervisory functions.

Source: own study.

As indicated by the results of the research and the assumptions developed on their basis, to improve the organizational culture of social welfare units, it is necessary to develop and implement complete solutions in the area of social communication strategy and to promote the use of information technology. An integral part of rationalizing the organizational structures of these units remains their flattening and the reduction of employment, mainly at the highest and lowest levels. An important determinant for the introduction of changes in this area, as indicated by the respondents, is the achievement of greater autonomy by municipal and county social welfare organizational units in their day-to-day activities.

Managing social welfare units in an entrepreneurial manner requires changes in organizational culture through the rationalization of structures. This relationship becomes the main determinant when implementing organizational culture change management programs and the idea of a learning organization. The widespread use of social communication techniques will also contribute to the practical implementation of instruments to improve the provision of public services. As a result of the analyses carried out, an important conclusion should be drawn, namely that without rationalizing organizational structures, it is not possible to implement modern social services.

The obtained results are consistent with previous studies emphasizing the limitations of bureaucratic structures in the public sector (Izdebski, 2021; Hood, Dixon, 2015) and the need for more flexible, communication-oriented organizational models (Gruening, 2001; Maurer et al., 2023). The identified deficits in communication systems and organizational autonomy confirm earlier findings on the barriers to effective cross-sectoral collaboration (Butcher,

Gilchrist, 2016; Van Eck et al., 2024). At the same time, the persistence of hierarchical structures reflects the institutional legacy of administrative systems in Central and Eastern Europe (Hajnal et al., 2021). These results reinforce the argument that structural rationalization is a prerequisite for implementing modern social service models based on co-production and innovation. A key limitation of the study is its focus on a single national context, which restricts the generalizability of the findings and indicates the need for comparative international research.

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THE TRANSFORMATION OF SOCIAL WELFARE MANAGERS' ROLES: AN EMPIRICAL DIAGNOSIS

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Purpose: The aim of this article is to diagnose the managerial roles of people managing social welfare organizations at the local government level in Poland in the context of changing approaches to the provision of social services.
Design/methodology/approach: The theoretical part draws on the literature on *new public management* and one of its instruments – 'managerial management'. The empirical part uses the *Participatory Action Research* method in 2573 local social welfare organizations (OPS) and 328 local social welfare organizations (PCPR) in Poland. Using formative indicators, the extent to which managers are able to clearly formulate goals and tasks and enforce their implementation was determined. An attempt was made to determine whether managers have the authority to choose how to perform tasks.
Findings: The diagnosis revealed a lack of autonomy in decision making and a lack of influence on setting the vision for the organization's development. Managers are employed on the basis of employment contracts.
Research limitations/implications: The results of the study indicate the need to redefine managerial roles and raise awareness among social welfare organizations of new challenges. Local authorities should also consider increasing the autonomy of social welfare managers.
Practical implications: An inherent element of the rationalization of organizational structures within units remains their flattening and reduction in employment, primarily at the highest and lowest levels.
Social implications: Social welfare managers should be given greater operational autonomy, but at the same time be held more accountable for achieving measurable results. In a modern approach to public service management, the manager becomes primarily a results manager, strengthening decision-making roles.
Originality/value: Managers should present their vision by taking a broad view of social issues, anticipating, and building visions for the practical application of scientific achievements, as well as entering new areas of interpersonal relations by undertaking new ventures and contributing to the building of trust, which is an essential element of social capital.
Keywords: public management, managerial management, social welfare organizations, social services.
Category of the paper: Research paper.

1. Introduction

There is no consensus in the literature on the roles of managers in the public sector. The reason for this is, on the one hand, the existence of different models of public service in different countries and, on the other hand, the varying degrees of public management mechanisms. Another problem is the lack of adequate decentralization of management, which results in the depreciation of the position of senior managers in organizations. A positive development that should be taken into account is the emergence of a new perspective on the role of organizational leaders. Managers are expected to outline a vision for the development of the organization and determine how to implement it. Leaders are not expected to implement the vision on their own, but to find ways to convince the organization's employees of the need for change and to obtain from them the tools necessary to carry it out (Hartley, 2021). In an era of globalization and dynamic change, it is important how social services will be managed in cross-sectoral cooperation with other entities such as large corporations, international organizations, nongovernmental organizations, or data cloud management organizations, while at the same time gaining legitimacy as one of the main characteristics determining the relationship between the organization and its environment (Suddaby, Bitektine, Haack, 2017). H. Mintzberg proposed one of the most significant concepts describing the actual roles performed by managers in organizations. He showed that management is not just about planning, organizing, and controlling, but is a set of interrelated roles, often performed under time pressure, fragmentation, and discontinuity of activities (Mintzberg, 1973). The article analyzes 'managerial management' as one of the instruments of the *New Public Management* (*NPM*) concept (Hood, 1991) in the context of new challenges facing social welfare systems (Nielsen, Hammerslev, 2024). The adoption of a market orientation within the *NPM* concept was intended to increase the efficiency of public sector entities (Lynn, 1998), lead to rationalization of expenditure, improve management in the public sector, and improve cooperation between all sectors of the economy (Ferlie et al., 1996). In the context of public services, and more specifically social services, citizen participation in the design of support is gaining in importance. Citizens, social organizations, and local communities cocreate public value, jointly define needs, create solutions, and share responsibility for their implementation. The role of the administration should undergo a transformation from a dominant role to a moderating role (Bryson et al., 2014). In view of this, this article diagnoses managerial roles in local government social welfare organizations in Poland in the context of changes caused, among other things, technological development, migration, negative demographic processes, and the need to rationalize public spending.

This study adopts a mixed methodological approach combining a critical literature review with Participatory Action Research (PAR), enabling both theoretical grounding and empirical validation (Chevalier, Buckles, 2019; Eden, Huxham, 1996). The main objective of the article

is to diagnose the roles of managers in social welfare organizations at the local government level in Poland within the framework of New Public Management (Hood, 1991; Ferlie et al., 1996). The significance of the study lies in addressing the growing complexity of social service delivery and the need for increased managerial autonomy and accountability in public organizations (Bryson et al., 2017; Hartley, 2021). The research tests four hypotheses (H1-H4) derived from the literature on managerial management and public sector reforms (Hood, Dixon, 2015; Berman, 2025). By integrating theoretical assumptions with empirical evidence, the study contributes to the understanding of the transformation of managerial roles in contemporary welfare systems.

2. Litearture review

The term ‘managerial management’ was coined as a result of *NPM* reforms. The slogan of D. Osborne and T. Gaebler: ‘let managers rule and authorities steer, not row’ (Osborne, Gaebler 1994, p. 34) is the best definition of the concept of ‘managerial management’. In the initial phase of the development of the *NPM* concept, managers were invited to ‘steer’. They were offered a choice of tools to achieve their goals in the most effective way for recipients as customers, rather than citizens, as was previously the case (Hood, Dixon, 2015). ‘Managerial management’ became an instrument of the *NPM* concept, which defines managerial roles and leadership standards, the development of public services, and how they are implemented in public management (Cook, 1998; Entwistle, 2021; Hartley, 2025). ‘Managerial management’ is primarily the replacement of the bureaucratic model of administration with a ‘culture of results’ (Maqdliyan, Setiavan, 2023). This means that managers have greater authority in choosing the tools for performing the tasks within their areas of responsibility (Berman, 2025). This element is referred to as flexibility in management, including freedom to choose a management style (Gruening, 2001). As part of the reforms carried out under the *NPM* concept, the terms of employment contracts with top-level managers were shortened. In return, high, individually negotiated bonuses were offered and the best managers were offered lucrative contracts (Dan et al., 2024). ‘Managerial management’ focuses on the goals set by the *NPM* concept in the context of the ability to formulate tasks and enforce them. Managers should therefore be able to outline a vision for the development of the organization and indicate methods for its implementation (Apaza, 2025). Among personality traits, charisma ranks first. ‘Managerial management’ is strongly associated with decentralization of management, in which tasks and responsibility for their implementation are transferred to lower levels of the organization (Van Dooren et al., 2015).

The main idea behind ‘managerial management’ is the ability to clearly formulate goals and tasks and achieve them. It gives people in managerial positions much greater authority in choosing how to carry out tasks that fall within their areas of responsibility (Zelek, 2023). It involves forming a new perspective on the role of organizational leaders and the qualities they should possess (Guy, 2025). Managers are expected to be able to outline a vision for the organization's development and identify ways to achieve it (Bartram, Casimir, 2007). At the same time, leaders are required to find the right ways to convince employees of the need for change (Cannaerts, 2025).

H. Mintzberg's concept provides an analytical framework for interpreting the role of a manager. Mintzberg points out that management consists of ten interrelated roles: interpersonal, informational, and decision-making, and not just the performance of classic management functions (Mintzberg, 1973). Under the new approach to public management, there is a clear shift in emphasis in the structure of these roles, particularly toward decision-making roles, which results from the emphasis on efficiency, results orientation, and managerial autonomy (Hood, 1991). At the same time, the specific nature of the public sector reinforces interpersonal and informational roles, especially the role of liaison, associated with operating in a complex environment of stakeholders and political pressure (Pollitt, Bouckaert, 2011). As a result, public managers, including welfare managers, perform the roles described by Mintzberg in a hybrid manner, combining ‘managerial management’ with the requirements of public and legal accountability (Zelek et al., 2025a).

A public organization manager is a person responsible for the implementation of a plan, program or the delivery of a product or service, directly and indirectly responsible to a public organization (Bovaird, Loeffler, 2024). In the decision-making process, this is a person who should have a significant level of autonomy in the disposal of the organization's financial resources and human capital (Barlow et al., 1996; Kożuch, 2004). This definition of the term ‘manager’ should facilitate the classification of public institution management personnel (Depre et al., 1996).

The task of managers in public organizations is to manage organizations providing public services effectively and economically, i.e., efficiently, in response to customer needs (Kożuch, 2004). In the public sector, managers are leaders whose primary responsibility is to manage organizations that provide high-quality public services, respond to new challenges in the environment, and keep pace with technological changes (Juknevičienė et al., 2025). Managers solve problems of non-compliance with political rationality criteria, taking into account economic rationality applied in a market economy (Kożuch, Sienkiewicz-Małyjurek, 2014). Public sector managers should not be restricted in their ability to be entrepreneurial and manage results. In practice, however, they encounter difficulties and are responsible for results that they cannot manage due to their excessive dependence on the authorities (Baryson et al., 2014). They should meet the following criteria (Kożuch, 2003): (1) responsibility for the implementation of a program or the delivery of a product or service; (2) evaluation of their work

on the basis of achieved results, according to clearly defined criteria and management objectives; (3) appointment to positions (positions in the organization) on the basis of an employment contract; (4) direct and indirect accountability to the public institution; (5) a significant level of autonomy in the decision-making process; (6) freedom in the use of financial and human resources; (7) achieving goals and results through human resources. The most important criterion for fulfilling the assumptions of the *NPM* concept in relation to 'managerial management' is giving managers freedom in performing their functions in exchange for imposing greater responsibility on them before citizens (Gregory, 2000; Naschold, Otter, 1996).

The emergence of the public manager function has brought with it a number of organizational problems. One of the barriers to the effective performance of managerial functions in the public sector is the direct measurement of the effects of their work (Stroińska, Tyszkiewicz, 2018). As M. Zawicki notes, local government often exhibits patterns that are contrary to 'managerial management'. These include (Zawicki, 2011): (1) focus on current issues; (2) giving managers detailed instructions; (3) lack of or low consistency in accounting for results; (4) a tendency to interfere in the performance of tasks assigned to managers; (5) the need to be well informed; (6) creating conditions for subordinates to consult on even trivial problems related to the performance of their tasks.

As L. Barendsen and H. Gardner note, social welfare managers should focus on solving social problems by following the example of mechanisms operating in the private sector and distinguish themselves through 'business acumen' (Barendsen, Gardner, 2004). They are visionaries, leaders, business leaders who act as educators and mentors, passing on practical skills and social values to their employees (Pache, Chowdhury, 2012). The roles of leaders and mentors are particularly important from the point of view of social welfare, whose mission is to improve the situation of people in need (Dacin et al., 2011).

Managers of social welfare organizations should have extensive knowledge of formal and legal issues (knowledge of laws, regulations, administrative decisions), but also mental resilience in the face of emerging problems (Zelek, 2025a).

When analyzing the roles of social welfare managers, attention should also be paid to senior managers in local government in Poland, a role performed by: commune heads, mayors, city presidents, elected in direct elections under *the Act of June 20, 2002, on the direct election of commune heads, mayors, and city presidents* (Journal of Laws of 2002, No. 113, item 984). Due to the electoral system, the act gives them a strong social mandate, strengthening their leadership (Journal of Laws of 2002, No. 113, item 984). When examining 'managerial management' one should also bear in mind the tasks of county administrators resulting from: (1) *the Act of March 8, 1990, on municipal self-government* (Journal of Laws of 1990, No. 16, item 95); (2) the Act of June 5, 1998, *on county self-government* (Journal of Laws 1998, No. 91, item 578). These legal acts grant very broad powers in managing subordinate staff within offices to commune heads, mayors, city presidents, and county administrators. However,

they have less influence on the management of subordinate organizations, including social welfare organizations at the local government level, that is, social welfare centers (OPS) and county family welfare centers (PCPR) (Zelek, 2024a). These managers are responsible to the executive bodies of local government (Zelek, 2024b).

As O.E. Hughes points out: ‘administration means following instructions, while management means achieving results’ (Hughes, 1994). It should be emphasized that management functions in social welfare should be performed by managers who, through their commitment to performing their tasks, are guided by a mission to help people in difficult life situations (Zelek, 2025b).

Based on a review of the literature, the following research hypotheses were adopted:

H1: Managers are dependent on their superiors in decision making.

This hypothesis reflects the persistent tension identified in the literature between formal managerial responsibility and limited decision-making autonomy in public sector organizations.

H2: The directions of the OPS and PCPR activities are consulted with managers.

This assumption relates to participatory governance and co-creation concepts, which emphasize the inclusion of managers in strategic decision-making processes.

H3: The charisma of the candidates is taken into account when selecting them for managerial positions.

This hypothesis refers to the growing importance of soft leadership competencies, such as charisma, in modern public management paradigms.

H4: Managers are employed on the basis of employment contracts, not management contracts.

This assumption highlights the institutional rigidity of employment forms in the public sector, which may limit the implementation of flexible, performance-oriented management models.

Despite the extensive body of literature on New Public Management and managerial roles, there is a limited number of empirical studies examining how these concepts are operationalized in social welfare organizations at the local government level. In particular, there is a research gap concerning the actual scope of managerial autonomy, decision-making power, and role configuration in hybrid governance systems combining administrative control with managerial principles. This study addresses this gap by providing large-scale empirical evidence from Polish social welfare institutions.

3. Methods

The main objective of the study was to diagnose 'managerial management' in local government social welfare organizations in Poland, that is, social welfare centers at the commune level (OPS) and district family welfare centers at the district level (PCPR). The diagnosis covered managers and employees of organizations at the lowest administrative level (Journal of Laws, 2004, No. 64, item 593). The study used the *Participatory Action Research (PAR)* method (Chevalier, Buckles, 2019), which offers broad possibilities for solving organizational problems (Eden, Huxham, 1996). The *PAR* method uses scientific achievements in solving practical social problems, with the broad participation of people affected by the problem (Cornish et al., 2023). The basic assumption of the research process based on the *PAR* method was scientific consulting, also known as research strategy or action research (Heron, 1996). The participants in the study became its full subjects (Brydon-Miller et al., 2020). The subjects were co-participants in the research process in all areas of research (Karlsen, 1991).

In the first phase of the study, a set of constructs (areas within aggregates) was defined, specifying their theoretical and empirical meaning. Each construct was formed using a combination of latent observable variables, that is, formative indicators (Diamantopoulos and Winklhofer, 2001). Next, a scaling procedure was selected and the decision made to use the Likert scale. This scale is characterized by high reliability coefficients and high correlation of results (Likert et al., 1993). On the basis of observable variables and sets of questions, an initial version of the research tool was created. Using electronic communication tools, a network of experimenting organizations was created and they were then invited to co-create the research tool. Due to the fact that the entire country was being studied, in accordance with the assumptions of the *PAR* method, in the first phase of creating the research tool, the OPS were divided according to the different specificities of their areas of operation according to the administrative division of the country. For each observable variable (construct) of 'managerial management' sets of eight statements were created, allowing study participants to evaluate this construct. The next step was to hide the observable variables and change the order of the questions/statements (S) in order to increase the reliability of the study by avoiding suggesting answers to the respondents. After collecting and considering comments, together with the experts involved, the management and employees of OPS and PCPR, the final version of the research tool was developed, which took the form of an electronic survey form called *OPS-OpenIndex* and *PCPR-Index,* posted on the server https://www.google.pl/. Management and employees received a link to the survey and were asked to complete it. Within 10 working days, a total of 1,959 questionnaires from OPS and 242 from PCPR.

Table 1.
A summary of the collected statistical data

	OPS	PCPR
Questionnaires sent	2573	328
Completed questionnaires	1959	242
% of fully completed questionnaires	76.1	75.7

Source: own study.

4. Results

The selection of variables and constructs used in the study was based on a synthesis of the literature and grounded in the theoretical assumptions of the New Public Management concept, particularly in relation to managerial autonomy, performance orientation, and accountability mechanisms (Hood, 1991; Lynn, 1998). The purpose of the study within the construct was to determine whether OPS and PCPR managers have clearly defined objectives, to what extent managers are dependent on their superiors in their decision making, and whether the directions of action are consulted with the management. Additionally, an attempt was made to determine the objectivity of the recruitment process and whether characteristics such as charisma are taken into account. Managerial turnover, the form of employment of managers and the extent to which political factors influence their employment were also examined. The position of managers was also asked whether its own vision and directions for the development of the organization. The construct measuring 'managerial management' in OPS and PCPR consisted of eight statements:

15. The tasks in the organization are carried out according to clearly defined goals.
45. The organization systematically monitors the effectiveness of my actions.
25. I have the opportunity to decide how to perform tasks.
68. I have a wide range of decision-making powers in the organization.
13. I have influence on setting the vision for the organization's development.
37. My immediate supervisor commands respect and is an authority figure for me.
51. There are frequent changes in management positions in the organization.
39. Managers are employed on the basis of employment contracts.

The data collected was exported to *MS Excel* and then subjected to statistical analysis in *Statistica 13*. The following statistical tools were used:

- *Cronbach's α* coefficient to assess reliability.
- *Cramér's V* coefficient to examine the relationship between qualitative variables.
- *Kendall's tau* coefficient to assess the correlation between respondents' answers to statements.

- A test probability value (p) of less than 0.05 provided grounds for rejecting the null hypothesis. The strength of the relationship was then examined using the *Cramer V* coefficient. The latter takes values from 0 to 1 from a two-tailed interval. The higher its value, the stronger the relationship between the variables. The construct 'managerial management' is reliable, as confirmed by *Cronbach's alpha* coefficient of 0.79.

OPS results

The distribution of the responses of the OPS respondents is presented in Table 2 and graphically in Figure 1.

Table 2.
Responses of OPS respondents within the 'managerial management' (in %, N = 1959)

Specification	S. 15	S. 45	S. 25	S. 68	S. 13	S. 37	S. 51	S. 39
Strongly disagree	3.06	7.91	6.43	18.43	16.95	14.45	5.92	0.61
I rather disagree	9.04	14.34	21.54	18.58	25.06	21.90	11.84	1.38
No opinion	12.00	15.88	14.29	20.01	23.18	29.35	5.41	3.52
I somewhat agree	51.51	40.28	46.45	28.94	26.95	20.98	49.67	39.87
Strongly agree	24.40	21.59	11.28	14.04	7.86	13.32	27.16	54.62

Source: own study based on research results.

A summary analysis of the survey results showed that 51.51% of the respondents moderately agreed with Statement 15, indicating that tasks in the organization are carried out according to clearly defined objectives. Significantly less agreement was observed on whether the organization systematically monitors the effectiveness of the respondent's activities (statement 45), which was moderately confirmed by 40.28% of respondents. Respondents expressed opinions that confirm that they have the opportunity to decide on the method of task implementation (statement 25). This relationship was moderately confirmed by 46.45% of the surveyed group, but the opposite relationship was expressed by 21.54% of the respondents. It is debatable whether the respondents have a wide range of decision-making power in the organization (statement 68). The answers to this statement varied, with 28.94% of the respondents agreeing to a moderate extent and 18.58% disagreeing. The aggregated results of the survey did not clearly indicate whether employees have an influence in setting the vision for the organization's development (statement 13). This was moderately confirmed by 26.95% of the group and moderately denied by 25.06% of the respondents. Respondents expressed mixed opinions about their immediate superiors, and 29.35% of them not specifying whether their superiors command respect and authority (statement 37). Similar results were obtained for contradictory responses.

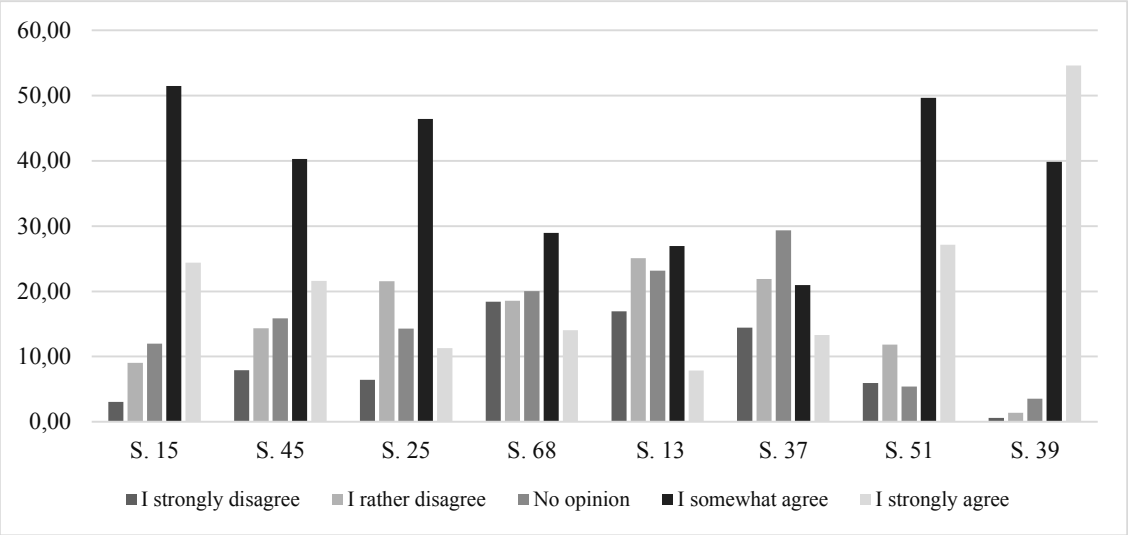

Figure 1. Responses of OPS respondents within the 'managerial management' construct (in %, N = 1959).

Source: own study based on research results.

49.67% of the respondents expressed moderate agreement that there are frequent changes in managerial positions in the organization (statement 51), which was strongly confirmed by 27.16%. There was complete agreement on Statement 39, with 94.49% of respondents moderately and strongly confirming that managers are employed on the basis of employment contracts.

The construct contained 8 statements, hence the range of possible results was between 8 and 40. The descriptive statistics obtained for OPS are presented in Table 3.

Table 3.
Descriptive statistics for the 'managerial management' construct in the OPS sample

N valid	Mean aytm.	Median	Minimum	Maximum	Range	Standard deviation
1959	27.82	28.00	8.00	40.00	32.00	5.73

Source: own study based on research results.

The minimum and maximum responses coincided with the boundaries of the construct. The mean and median were similar, at 27.82 and 28.0, respectively. The standard deviation was 5.73. A moderately strong, positive and statistically significant correlation was found between responses to statements 13 and 25. *Kendall's tau* coefficient was 0.44, and (p) was below 0.05. This means that respondents who claimed to have an influence on setting the organization's development vision generally expressed the opinion that they had the opportunity to decide on the choice of how to perform their tasks. A moderately strong, positive, and statistically significant correlation was also found, with p below 0.05 and tau equal to 0.4, between statements 15 and 51. People who believed that tasks were performed in the organization according to clearly defined goals expressed the opinion that there were frequent changes in management positions in the organization. The relationship between statements 68 and 13 was positive, moderately strong (*tau* coefficient = 0.4) and statistically significant ($p < 0.05$).

Respondents who believed that they had a wide range of decision-making power in the organization felt that they had an influence on setting the vision for the organization's development.

The summary results of the study indicate that 50.0% of respondents over 26 and 20.0% aged up to 25 years of age agreed with Statement 15 (tasks in the organization are carried out according to clearly defined goals). The relationship is statistically significant ($p = 0.00$) and weak (*Cramer's V* = 0.07). The relationship between the length of service and their answers was statistically insignificant. As for the fact that the organization systematically monitors the effectiveness of my activities (statement 45), 50.0% of respondents with up to 2 years of service and 33.0% with the longest length of service agreed to a moderate extent. The relationship is statistically significant ($p = 0.03$) and weak (*Cramér's V* = 0.06). The relationship between the age of the respondents and their responses was statistically insignificant.

PCPR results

The distribution of the responses from the PCPR respondents is presented in Table 4 and Figure 2. The construct is reliable, as confirmed by *Cronbach's alpha* coefficient of 0.76.

Table 4.
Responses of PCPR respondents within the 'managerial management' construct (in %, N = 242)

Specification	S. 15	S. 45	S. 25	S. 68	S. 13	S. 37	S. 51	S. 39
Strongly disagree	0.83	3.72	4.55	11.98	9.92	13.22	2.07	1.24
I rather disagree	9.09	14.05	15.29	17.36	21.07	24.38	12.40	2.89
No opinion	5.79	15.29	15.29	25.62	21.07	27.27	2.89	2.07
I somewhat agree	51.24	43.39	47.93	30.17	33.47	18.60	46.69	34.30
Strongly agree	33.06	23.55	16.94	14.88	14.46	16.53	35.95	59.50

Source: own study based on research results.

A summary analysis of the results of the PCPR survey shows that 51.24% of respondents expressed moderate agreement that tasks in the organization are carried out according to clearly defined objectives (statement 15), which was strongly confirmed by 33.06% of the respondents. The aggregated responses show that the organization systematically monitors the effectiveness of respondents' activities (statement 45). 43.39% of the group agreed with this statement to a moderate extent and 23.55% of respondents agreed strongly.

The aggregate assessment of statement 25 indicates that 47.93% of the respondents moderately agreed that they have the opportunity to decide how to perform their tasks. Only 4.55% of them strongly disagreed with this statement. PCPR respondents did not express clear opinions on whether they have a wide range of decision-making power in the organization (statement 68). Although 30.17% moderately confirmed this, 25.62% were unable to determine it and another 17.36% disagreed.

33.47% of the respondents moderately confirmed that they have an influence on setting the vision for the organization's development (statement 13), while 21.07% were unable to determine this and moderately disagreed with it. In this case, the respondents expressed their ambivalent attitude towards their immediate superiors (statement 37). The respondents did not express clear opinions on whether their superiors inspire respect and are an authority; 27.27% confirmed this relationship.

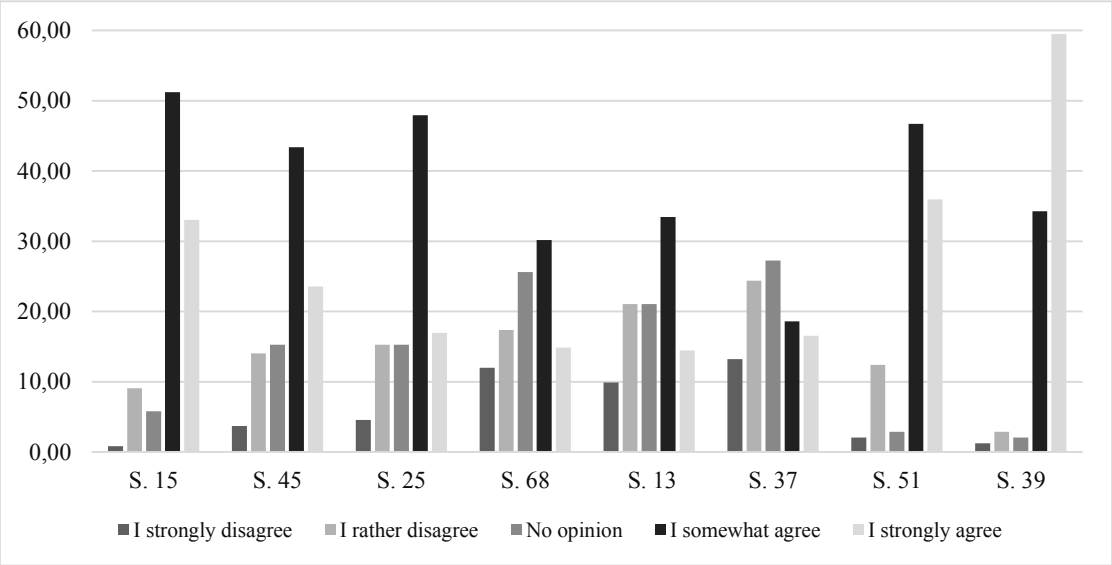

Figure 2. Responses of PCPR respondents within the 'managerial management' construct (in %, N = 242)**.**

Source: own study based on research results.

46.69% of the respondents moderately agreed with the statement (51) that there are frequent changes in managerial positions in their organization, and more than 35.95% of the respondents strongly agreed with this statement. The employment of managers on the basis of employment contracts (statement 39) was confirmed by 93.8% of respondents. The descriptive statistics obtained for PCPR are presented in Table 5.

Table 5.

Descriptive statistics for the construct 'managerial management' in the PCPR sample

N valid	Arithmetic mean	Median	Minimum	Maximum	Range	Standard deviation
242	29.24	29.00	14.00	40.00	26.00	5.35

Source: own study based on research results.

The minimum response within the PCPR construct was 6 points higher than its lower limit. The mean and median were 29.0, and the standard deviation was 5.35. A moderately strong, positive (*Kendall's tau* coefficient = 0.41) and statistically significant ($p < 0.05$) correlation was found between statements 13 and 45, which means that people who believed that they had influence on setting the vision for the development expressed the opinion that the organization systematically monitored the effectiveness of their activities. The relationship between

statements 15 and 45 was moderately strong, positive (Kendall *tau* coefficient = 0.45) and statistically significant ($p < 0.05$). Those who maintained that tasks in the organization are carried out according to clearly defined goals generally agreed that the organization systematically monitors the effectiveness of their activities. A not very strong, positive (*tau* coefficient = 0.38) and statistically significant correlation ($p < 0.05$) was also found between statements 25 and 15. This shows that respondents who believed that tasks in the organization were carried out according to clearly defined objectives often expressed the opinion that they had the opportunity to decide how to carry out their tasks.

5. Discussion

The findings of this study should be interpreted in the context of existing research on public management and managerial roles. Previous studies have emphasized the importance of managerial autonomy and performance orientation; however, they often rely on theoretical models or limited empirical evidence (Pollitt, Bouckaert, 2011; Entwistle, 2021). One of the key limitations of earlier research is the insufficient consideration of institutional constraints and political dependencies that affect managerial behavior in practice. The present study contributes new empirical insights by demonstrating that, despite the formal adoption of New Public Management principles, significant deficits remain in terms of decision-making autonomy and strategic influence of managers in social welfare organizations. These findings extend existing knowledge by highlighting the discrepancy between normative models of management and their practical implementation. The results have important implications for the broader field of public management, suggesting the need to redesign governance frameworks to better balance control and autonomy. The knowledge generated by this study can be used to inform policy reforms, improve managerial training programs, and support the development of more effective and responsive social welfare systems.

The study within the ‘managerial management’ was intended to determine whether OPS and PCPR managers are capable of clearly formulating goals and tasks and enforcing their achievement. An attempt was made to determine whether managers have the authority to choose how tasks are performed. The results of the study within the construct of ‘managerial management’ in OPS and PCPR were to assess: (1) the transparency of defined objectives; (2) the degree of decision-making autonomy; (3) the degree of dependence on superiors; (4) influence on the vision of the organization's development; (5) the charisma of managers; (6) the frequency of changes in managerial positions; (7) forms of employment of managers. Table 6 presents the verification of the hypotheses and the suggestions for improvements in specific areas.

Table 6.
Identified problems and proposed solutions within the organizational systems of OPS and PCPR – verification of the adopted hypotheses

Hypothesis	Verification	Solution
H1: Managers are dependent on their superiors in decision making.	Confirmed	Strengthening of managers' autonomy, manifested in the absence of the need to consult decisions with local authorities in exchange for submitting periodic reports on activities carried out.
H2: Organization's courses of action are consulted with managers.	Rejected	Consultation of social problem-solving strategies with social welfare managers.
H3: Charisma is taken into account when selecting candidates for managerial positions.	Rejected	Selection of managers who, in addition to their qualifications, have an impeccable reputation in the local community, are highly qualified, and have good personal skills.
H4: Managers are employed on the basis of employment contracts, not management contracts.	Confirmed	Increased awareness among local authorities of the legitimacy of using flexible forms of employment for social welfare managers (employment in individually negotiated management contracts).

Source: own study based on research results.

Deficits in 'managerial management' at OPS were identified, namely: (1) lack of broad decision-making powers in the organization, approximately 18.5% moderately and strongly agreed with this conclusion, taking into account the size of the research group and the fact that not only managers participated in the study, the sum of the responses should be classified as a negative phenomenon; (2) lack of influence on setting the vision for the organization's development, moderately confirmed by 25% of respondents; (3) managers are not authority figures for employees, 29.35% of respondents were unable to clearly define this, which allows for a negative conclusion to be drawn; (4) managers are employed on the basis of employment contracts, with almost 95% of respondents confirming this relationship. The dysfunctions identified within the construct of 'managerial management' for PCPR include: (1) lack of broad decision-making power in organizations, which was moderately confirmed by 30.2% of respondents, while 1/4 were unable to determine this; (2) lack of influence on setting the vision for the organization's development, which was confirmed by over 40% of respondents; (3) supervisors do not command respect and are not an authority for 27.3% of respondents; (4) the employment of managers on the basis of employment contracts was confirmed by almost 95% of respondents.

The results of this study are consistent with prior research indicating that the implementation of New Public Management principles often remains incomplete and constrained by institutional and political factors (Hood, 1991; Pollitt, Bouckaert, 2011). In particular, the identified limitations in managerial autonomy and decision-making power confirm earlier observations that public sector managers operate within hybrid governance structures, combining elements of managerialism with administrative control (Hood, Dixon, 2015; Bovaird, Loeffler, 2024). At the same time, the findings extend the literature by providing empirical evidence that the shift toward results-oriented management, emphasized in previous studies (Lynn, 1998; Berman, 2025), is not fully supported by corresponding changes in

organizational practices. The study also highlights the discrepancy between the theoretical assumptions of 'managerial management' and their practical implementation in social welfare organizations, which has been previously suggested but insufficiently empirically verified (Entwistle, 2021; Hartley, 2025). This confirms that, despite reforms, public managers continue to face structural constraints that limit their ability to perform strategic and leadership roles effectively. However, the study has several limitations that should be acknowledged. First, the research is limited to the Polish context, which may reduce the generalizability of the findings to other institutional settings. Second, the use of self-reported survey data may introduce response bias and affect the objectivity of the results. Third, although the PAR approach enhances practical relevance, it may also limit the level of standardization and comparability typical of purely quantitative studies.

6. Summary

Social welfare managers should use models taken from business: plan, introduce innovations and new solutions, and be creative in carrying out tasks. Based on a review of the literature and analysis of the research results, it can be concluded that the effectiveness of social welfare systems is not possible without a transformation of the roles of social welfare managers in response to the dynamic environment that determines social problems. Managers should present their vision through a broad view of social problems, anticipate, and build visions for the practical application of scientific achievements, as well as enter new areas of interpersonal relations by undertaking new ventures and contributing to the building of trust, which is an important element of social capital. In the classic model, the manager performs all of Mintzberg's roles in a relatively balanced manner, with interpersonal and informational roles supporting decision-making roles. On the contrary, in the modern approach to public service management, the manager becomes primarily a results manager, which strengthens the decision-making roles. Social welfare managers should be given greater operational autonomy, but at the same time be subject to greater accountability for achieving measurable results.

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THE ROLE OF DIGITAL TECHNOLOGY IN IMPROVING QUALITY OF EDUCATION

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Purpose: The paper examines the role and importance of digital technologies in ensuring the quality of education in Polish higher education institutions. It aims to identify best practices recognized by the Polish Accreditation Committee through Certificates of Excellence and to determine how the use of information technologies contributes to maintaining and improving educational standards.
Design/methodology/approach: The study is based on an original database of indicators derived from the Polish Accreditation Committee's reports assessing study programs at Polish universities, including the justifications for awarding Certificates of Excellence. Seven stimulant indicators were analyzed: the share of practical and laboratory classes, cooperation with the socio-economic environment, student participation in projects and problem-solving activities, use of innovative IT tools, blended learning and e-learning, use of remote learning platforms, and employment of specialized programs (e.g. Microsoft Teams, Blackboard).
To evaluate and rank the performance of academic fields, the study applies the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method—one of the multivariate statistical techniques within the MADM (Multiple-Attribute Decision-Making) framework.
Findings: The results indicate that the use of digital technologies is a major determinant of educational quality in Polish universities. The top-ranked group includes three programs in the discipline of exact and natural sciences and one program each in engineering and technical sciences, agricultural sciences, and social sciences. These programs are distinguished by extensive use of innovative IT tools and a high share of practical (laboratory) classes. Conversely, the lowest-ranked courses do not employ innovative IT tools, blended learning, or specialized platforms such as Microsoft Teams or Blackboard. The findings confirm that field-specific characteristics, rather than disciplinary classification, significantly influence the effectiveness of digitalization in improving educational quality.
Practical implications: The results provide practical guidance for higher education institutions and policymakers, emphasizing the need for strategic investment in digital infrastructure and technology-enhanced teaching as key drivers of quality and accreditation success.
Originality/value: This paper offers a novel, data-driven perspective on the relationship between digital technologies and educational quality from the accreditation viewpoint. By applying the TOPSIS method, it provides new empirical insights into how technological innovation supports excellence in higher education.

Keywords: quality assurance, teaching, software, education, higher education.
Category of the paper: Research paper.

1. Introduction

The European Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) define the quality of education. It is understood as "primarily a result of the interaction between teachers, students, and the institutional learning environment". Whereas ensuring the quality of education "focuses on “all activities within the continuous improvement cycle of higher education institutions” (Ubachs, Henderikx, 2022). One of the elements that is being paid attention to and has become increasingly important when assessing higher education quality is digital technologies (Van Pham, 2019). It particularly applies to education platforms, distance learning programs, and specialist software used during classes. Possession and use of specialist software during classes is one of the assessment criteria issued by institutions accrediting study programs and universities (Antony, Arumugham, 2004). The article aimed to analyse certificates of excellence issued by the Polish Accreditation Agency till 2022 to demonstrate best practices used at universities in using digital technologies and the impact of these technologies on quality assurance. In particular, the relationship between the discipline and field of study and the use of specialist software during classes and the implementation of IT solutions was sought. As a result, four typological groups were obtained, where the first, best group included fields such as biomedical engineering, food technology and human nutrition, or mathematics, and the weakest group included finance, investment and accounting, artistic education in the field of musical arts. The article consists of five parts: the first section is the introduction, the second contains a literature review, the third presents the methodology, the fourth is a discussion, and the fifth is the conclusion.

2. Literature review

Digital transformation has not only transformed society and the economy, but above all set a new direction for the future of education. It is increasingly affecting everyday life, revealing the urgent need to develop digital competences in education and training systems and institutions that need to keep up with dynamic technological changes. Computers and computer software used for training in manufacturing (computer-aided design, prototyping, and manufacturing) is becoming increasingly popular in educational institutions (Soomro et al., 2021).

The COVID-19 pandemic has become a catalyst for the transition to online and hybrid learning. The experience gained during this time has shown that the future of education lies in flexible, innovative forms of teaching that enable more personalised and engaging interaction between teacher and student in a digital environment. Florjančič and Wiechetek (2022) compared two platforms used in education, Moodle and Teams, based on the experience of two universities from Polish and Slovenia. The comparison showed that Moodle is a great, but complicated platform, while MS Teams is more modern and relatively simple tool that enables real-time communication and integration with Office 365. MS Teams works well in various types of communication (lectures, video conferencing, chat) and is more useful in general content creation, while the Moodle platform performs better in traditional learning tasks (assessments, peer-to-peer assessment, quizzes, categorization) (Krašna, Pesek, 2020). The Moodle platform also works well for the implementation of Team-Based Learning (TBL), as demonstrated in the Proctor and Hayslett (2024) study conducted in two groups of pharmacy students. Florjančič and Wiechetek (2022) noted that in the education process, Moodle and MS Teams platforms can be integrated to obtain a structured and administered course (Moodle) with the possibility of collaboration and communication (MS Teams). A comparison of the usability of the Moodle and Teams platforms among accounting students at the University of Gdańsk was conducted by Kujawski and Szadziewska (2024). Respondents indicated MS Teams as a more useful tool for university-level education.

The usability of the Moodle and Teams platforms was also studied in the context of education in individual scientific fields. Astafieva et al. (2023) investigated and confirmed the possibility of using the Moodle platform to implement an inquiry-based learning in mathematics (IBLM) approach to teaching mathematics based on student questions and active engagement. Anđelković et al. (2024) diagnosed the Moodle and MS Teams platforms in the context of English for Special Purposes (ESP) teaching at the University of Belgrade. Research shows that both platforms have similar functionalities in terms of delivering and managing educational content. For testing and evaluating and analysing students' learning progress and improving the learning process, Moodle has proven to be more useful.

The development of information technology has allowed the introduction of blended learning and e-learning. Kumar et al. (2021) and Müller and Mildenberger (2021) have shown in independent research that modern teaching methods are not more artificial than traditional ones, and Kirillova et al. (2019) have proven on the basis of their research that blended learning using project-based learning (PBL) is more effective compared to other teaching models for foreign language-based communication problems in learning. It allows students to engage in those activities that are more interesting to them and thus individualize their learning and career path. In addition, Schefer-Wenzl et. al. (2019) proved that blended learning can be integrated into mobile platforms for engineering and medical disciplines.

A relatively new direction of scientific research, but dynamically developing, is the use of AI in education. Based on previous studies, it has been shown that AI plays a key role in motivating students (Lin et al., 2021; Xia et al., 2022) and increasing the level of their engagement in learning (Huang et al., 2023a; Nazari et al., 2021). Adiguzel et al. (2023) presented the benefits of using AI not only for students but also for teachers.

Research conducted by Owan et al. (2023) focused on the role of teachers in the AI-based education system and showed that the use of AI will not replace the teacher in the role of a person adjusting the assessment to the individual abilities and capabilities of the student, interpreting the results of his or her work and individualizing the path of development and acquiring skills, providing and giving context to the information and content provided, and supporting critical thinking. The cited studies are in part a response to the concerns of teachers about whether the development of AI will reduce the demand for their work, especially in the context of learning foreign languages (Tseng, Warschauer, 2023).

Artificial intelligence-based tools are certainly useful in the process of acquiring knowledge, but they must be used wisely and not as a substitute for conventional approaches to learning (Genelza, 2024).

To the best of the authors' knowledge, there are no studies that are devoted to the use of IT techniques in relation to individual fields of study, and our study fills this gap.

3. Methodology

The basis for the empirical research, the results of which are presented in this paper, is a database of indicators created on the basis of reports of the Polish Accreditation Committee containing an assessment of study programs implemented at Polish universities, including justification for granting certificates in the field of ensuring the quality of education.

The following indicators were used in the study:

1) large/increasing share of practical classes (laboratory, laboratory),
2) cooperation with the socio-economic environment,
3) student participation in projects/focus on creative problem solving,
4) use of innovative IT tools that support the process,
5) blended learning/e-learning,
6) use of remote learning platforms,
7) using specialized programs (e.g. Microsoft Teams, Remote Education Platform, Blackboard platform).

The indicators presented above are stimulant, which means that with the increase in the value of this indicator, an improvement in the situation in the analysed area is observed.

In the paper, one of the methods of multivariate statistical analysis – the TOPSIS method (Technique for Order of Preference by Similarity to Ideal Solution) – was used for linear ordering of fields of study at Polish universities. This method has been developed as a tool to support the decision-making process in complex situations where many different criteria need to be taken into account. Therefore, it is included in the group of multi-criteria decision-making methods, referred to in the literature as MADM (multiple-attribute decision making) (Ghose, 2021; Parida, Sahoo, 2013; Proctor, Hayslett, 2024; Ghose, 2021; Roszkowska, 2019; Yoon, Kim, 2017; Zulqarnain et al., 2020). The TOPSIS procedure used for the linear ordering of multidimensional objects takes place in eight steps.

Step 1. The starting point is to define the matrix:

$$X = [x_{ij}] \tag{1}$$

where:

i – object number (i = 1, 2, ..., n),

j – diagnostic feature number (j = 1, 2, ..., m),

x_{ij} – the value of *j*-th feature for *i*-th object.

Step 2. In order to ensure the comparability of variables, the initial values of diagnostic features are normalized based on the formula:

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{2}$$

where: z_{ij} – the value of *j*-th standardized diagnostic feature for the *i*-th object.

Step 3. Values of normalized diagnostic features are weighted, which results in the matrix:

$$V = [v_{ij}] = [w_j z_{ij}] \tag{3}$$

for:

$$\sum_{j=1}^{m} w_j = 1 \tag{4}$$

where: w_j – weight of *j*-th diagnostic feature.

Step 4. For each normalized weighted diagnostic feature from the matrix (3), two reference points are determined, which are determined by the Positive Ideal Solution and Negative Ideal Solution coordinates, respectively:

$$v_j^+ = \begin{cases} \max\limits_i v_{ij} & \text{for stimulant} \\ \min\limits_i v_{ij} & \text{for destimulant} \end{cases} \tag{5}$$

$$v_j^- = \begin{cases} \min\limits_i v_{ij} & \text{for stimulant} \\ \max\limits_i v_{ij} & \text{for destimulant} \end{cases} \tag{6}$$

where:
v_j^+ – j-th coordinate of Positive Ideal Solution,
v_j^- – j-th coordinate of Negative Ideal Solution.

Step 5. For all objects, their Euclidean distances from the positive and negative ideal value are calculated, respectively:

$$d_i^+ = \sqrt{\sum_{j=1}^{m}\left(v_{ij} - v_j^+\right)^2} \tag{7}$$

$$d_i^- = \sqrt{\sum_{j=1}^{m}\left(v_{ij} - v_j^-\right)^2} \tag{8}$$

where:
d_i^+ – Euclidean distance of the i-th object from Positive Ideal Solution,
d_i^- – Euclidean distance of the i-th object from Negative Ideal Solution.

Step 6. The value of the aggregate variable denoting the relative proximity of the i-th object to the Positive Ideal Solution is determined as the quotient:

$$R_i = \frac{d_i^-}{d_i^- + d_i^+} \tag{9}$$

where: $0 \leq R_i \leq 1$.

The preferred object has the shortest distance from the positive ideal value and, at the same time, the most significant distance from the negative ideal value, i.e., it has the highest value of the coefficient R_i.

Step 7. Linear ordering of objects is performed due to the aggregate variable's non-increasing value (9).

Step 8. Using the three-median method to divide objects into typological groups with a similar level of the studied phenomenon according to formulas (Młodak, 2006):

Group I: $\mu_i > \text{med}_1(\boldsymbol{\mu})$ – very low risk of occurrence.

Group II: $\text{med}(\boldsymbol{\mu}) < \mu_i \leq \text{med}_1(\boldsymbol{\mu})$ – average threat of occurrence.

Group III: $\text{med}_2(\boldsymbol{\mu}) < \mu_i \leq \text{med}(\boldsymbol{\mu})$ – high risk of occurrence.

Group IV: $\mu_i \leq \text{med}_2(\boldsymbol{\mu})$ – very high risk of occurrence.

To summarize, the adopted methodological approach is based on a structured set of seven stimulant indicators reflecting key dimensions of educational quality related to the use of digital technologies. The application of the TOPSIS method enabled the transformation of multidimensional data into a synthetic measure, allowing for the linear ordering of the analyzed objects. The procedure ensures comparability of variables through normalization and incorporates equal weighting of criteria, thereby avoiding preferential bias in the evaluation process. As a result, the proposed approach provides a consistent and transparent framework for assessing and comparing the relative position of the examined objects within the analyzed dataset.

4. Results

The values of the seven indicators defined in the methodology were used in the TOPSIS method (i = 1, 2, …, 28; j = 1, 2, …, 7). According to the procedure of this method, they were normalized in the first step. The same weights were used in the weighting for all normalized values, which amounted to $w_j = \frac{1}{7}$, which results from the equal treatment of all characteristics.

Table 1.
Values of the aggregate variable, ranks, and typological groups of specialization

Discipline	Specialization	Measure	Group
Engineering and technical sciences	Biomedical Engineering	1.0000	I
Agricultural Sciences	Food Technology and Human Nutrition	1.0000	
Exact and natural sciences	mathematics	1.0000	
Social sciences	spatial management	0.7101	
Exact and natural sciences	chemistry	0.7101	
Exact and natural sciences	**computer science**	**0.7101**	
Engineering and technical sciences	Chemical and Process Engineering	0.6126	II
Social sciences	Internal security	0.6126	
Social sciences	Sociology	0.6126	
Engineering and technical sciences	Architecture	0.5359	
Social sciences	International Economic Relations	0.5359	
Social sciences	Law	0.5359	
Exact and natural sciences	Quantitative methods in economics and information systems	0.5359	
Arts Sciences	Organization of film and television production	0.5359	
Humanities	Ethnology	0.4641	III
Social sciences	Management and command	0.4641	
Exact and natural sciences	Hippology and horsemanship	0.4641	
Exact and natural sciences	cryptology and cybersecurity	0.4641	
Veterinary Sciences	veterinary medicine	0.4641	
Arts Sciences	composition and music theory	0.4641	
Arts Sciences	Direction	0.4641	
Engineering and technical sciences	Construction	0.3874	IV
Exact and natural sciences	Astronomy	0.3874	
Exact and natural sciences	Physics	0.3874	
Exact and natural sciences	Geography	0.3874	
Arts Sciences	Design	0.3874	
Social sciences	Finance, investment and accounting	0.2899	
Arts Sciences	Artistic education in the field of musical arts	0.2899	

Source: own elaboration.

The analysis of the information in Table 1 shows that the best first group includes three courses belonging to the discipline of exact and natural sciences and one course each from the disciplines of engineering and technical sciences, agricultural sciences and social sciences. These courses are characterized primarily by the use of innovative IT tools that support the teaching process. In addition, they have a large/increasing share of practical classes (laboratory). Courses belonging to group IV do not use innovative IT tools that support the teaching process, do not use blended learning/e-learning and do not use specialized programs (e.g. Microsoft Teams, Remote Education Platform, Blackboard platform.

5. Discussion

According to the current state of knowledge of the authors, there have been no similar studies in the literature, the results of which could serve as a direct point of reference for comparing the obtained results. However, there are scientific studies devoted to the analysis of the quality of education at the academic level, in which, like in this study, the TOPSIS method was used. The choice of this method results from its ability to simultaneously take into account many different evaluation criteria and, if necessary, assign them appropriate weights, which allows for a comprehensive analysis of the effects resulting from their cooperation. An additional advantage of the TOPSIS method is the elimination of the subjectivity of input data, the lack of the need to define the objective function and the lack of the requirement to meet restrictive test assumptions, which makes it a research tool with a high degree of universality and flexibility.

Wang et al. (2022b) conducted an analysis of the efficiency of higher education in the private university sector in Vietnam. The study took into account the following criteria: the number of students, the number of curricula, the number of lecturers, the quality of teaching infrastructure, the size of the budget and the employment rates of graduates. The highest rated universities were characterized by high efficiency in terms of employing graduates and significant investments in the development of educational infrastructure. The analysis revealed significant disparities between universities in terms of the efficiency and quality of educational services provided.

Wang et al. (2022a) evaluated the higher education systems in China, the US, and Germany. The study used a combination of the AHP (criteria hierarchy) and TOPSIS methods. This approach allowed for the creation of university rankings and the assessment of their performance. The results of the study indicated that universities with strong connections with industry and high levels of innovation performed better in the rankings.

A comparative assessment of the higher education systems in the United States, China, Japan, and Vietnam was conducted by Zhang (2021). The analysis took into account the following criteria: the number of institutions and students, the student-teacher ratio, the number of academic teachers, the employment rate of graduates, and the share of government spending on education in total public spending. The results of the study showed that the United States took the highest position in the ranking, followed by China, Japan, and Vietnam.

Cai et al. (2022), using the improved entropy-weighted TOPSIS method, assessed the level of entrepreneurship education at the higher education level based on 35 indicators grouped into five areas: curriculum systems, teaching staff development, organizational leadership, teaching process management, and institutional mechanisms. The study results suggest that Chinese universities should strengthen the practical component of education, and the teaching process should combine specialization with innovation. It also emphasized the need for continuous

development of academic staff competences and intensification of research activities, especially interdisciplinary and international ones.

Ersoy (2021) assessed the effectiveness of distance education in 56 public universities in Turkey. He used data envelopment analysis (DEA) and the TOPSIS method in his study. The results obtained varied depending on the method used: according to the DEA analysis, Anadolu University was the best in distance learning, while according to the TOPSIS method, Sakarya University was the best.

Kang (2025) assessed the degree of integration of education with industry at applied undergraduate universities using an advanced version of the TOPSIS method. The assessment of the quality of cooperation between universities and the industry sector was considered an important indicator of the effectiveness in terms of talent development, technological innovation and research cooperation. The study results can serve as a basis for formulating recommendations aimed at improving the quality of education and increasing the employment rate of graduates.

6. Summary

The article analyses the importance and role of digital technologies in ensuring quality in higher education institutions. In particular, best practices that contributed to this quality were identified, such as an increased share of laboratory classes in study programs, remote learning platforms, and specialist software. As a result, it was shown that universities educating in biomedical engineering, food technology and human nutrition, mathematics, spatial management, chemistry, and computer science mainly build their advantage in ensuring quality through digital technologies. The weakest in this respect are the fields of finance, investment, and accounting, as well as artistic education in musical arts. The specificity of the field has a significant impact on this. Still, the scientific discipline to which the field is assigned is unimportant because, for example, there were fields of study rated the best and the worst in the discipline of engineering and technical sciences. The study has its limitations. First, the analysis is based on a dataset restricted to accredited study programs evaluated by the Polish Accreditation Committee, which may limit the generalizability of the findings. Second, the temporal scope is constrained to certificates awarded in recent years, due to data availability. In addition to these data-related limitations, certain methodological assumptions inherent in the TOPSIS approach should be acknowledged. In particular, the method assumes the independence of evaluation criteria and may be sensitive to the choice of normalization procedure and weighting scheme. Although equal weights were adopted to ensure neutrality in the assessment, alternative specifications could lead to variations in the resulting rankings. Therefore, the findings should be interpreted with due consideration of these assumptions,

which are characteristic of multi-criteria decision-making methods. Future work plans an in-depth analysis in terms of taking into account the international perspective and comparing best practices assessments expressed by certificates in Poland and other European countries. It is also planned to expand the time perspective of the study.

The obtained results may serve as a useful source of information for higher education institutions as well as policymakers responsible for shaping educational policy. At the same time, they point to the need for a more structured and strategic approach to the integration of digital technologies in the educational process. In particular, universities may consider implementing targeted initiatives aimed at developing the digital competences of academic staff, including both systematic training and continuous professional development in the use of tools supporting the teaching process. Furthermore, it appears justified to develop and institutionalize standards for blended and online learning that address both pedagogical and technological aspects, which may contribute to enhancing the consistency and effectiveness of the educational process. Finally, a stronger focus on the integration of specialized software and digital platforms within curricula, tailored to the specific characteristics of individual fields of study, may support improvements in educational quality and better alignment with accreditation criteria.

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