POLITECHNIKA ŚLĄSKA **ZESZYTY NAUKOWE**

SILESIAN UNIVERSITY OF TECHNOLOGY SCIENTIFIC PAPERS

ORGANIZACJA I ZARZĄDZANIE
Zeszyt Naukowy nr 253

ORGANIZATION AND MANAGEMENT
Scientific Paper no. 253

Nowoczesność przemysłu i usług

Modernity of industry and Services

Pod redakcją
Bożeny SKOTNICKIEJ-ZASADZIEŃ
Radosława WOLNIAKA

Edited by
Bożena SKOTNICKA-ZASADZIEŃ
Radosław WOLNIAK

GLIWICE 2026

Kolegium redakcyjne

REDAKTOR NACZELNY – Dr hab. inż. Małgorzata KRÓL, prof. PŚ
REDAKTOR DZIAŁU – Prof. dr hab. inż. Radosław WOLNIAK

Wydano za zgodą
Rektora Politechniki Śląskiej

ISSN 1641-3466
ISSN 2720-751X

© Copyright by
Wydawnictwo Politechniki Śląskiej
Gliwice 2026

WYDAWNICTWO POLITECHNIKI ŚLĄSKIEJ
ul. Akademicka 5, 44-100 Gliwice
tel. (32) 237-13-81, faks (32) 237-15-02
www.wydawnictwopolitechniki.pl

Sprzedaż i Marketing
tel. (32) 237-18-48
wydawnictwo_mark@polsl.pl

Nakł. 30 Ark. wyd. 51,5 Ark. druk. 48,375 Papier offset 70x100, 80 g
Zam. 83/26

CONTENTS

Foreword 5

1. **Mohannad ALJAWARNEH, Beata MRUGALSKA** – From baseline to progress: tracking sustainable last-mile delivery at Inpost Poland 7
2. **Agnieszka BUKOWSKA-PIESTRZYŃSKA, Urszula MOTOWIDLAK** – Automation in creating supply chain ambidexterity 29
3. **Elwira DUŚ-PRIETO, Blanka WALAWSKA** – The role of embodiment, presence, and interactivity in shaping consumer experience in virtual spaces and digital services 47
4. **Joanna Alicja DYCZKOWSKA** – Uncertainty in IT systems for managing logistics processes at logistics centers 69
5. **Małgorzata GAJOWIAK** – Intergenerational cooperation under demographic changes – an empirical analysis of SMEs in the Poznań County 89
6. **Konrad GŁĘBOCKI** – European, state, local levels and strategies of Polish regions 107
7. **Adrian GRACA, Liliana HAWRYSZ** – Digital maturity as determinant of organizational agility in the Industry 4.0 context 119
8. **Magdalena HOFMAN-KOHLMEYER, Ewa CZYŻ-GWIAZDA, Katarzyna ŻAK, Katarzyna OLEJKO** – The presence of women on company board of directors – antecedents, benefits and future research 157
9. **Izabela JONEK-KOWALSKA, Tomasz L. NAWROCKI** – Resilience of international coal enterprises to economic crises from a financial perspective 189
10. **Edyta KARDAS, Zbigniew SKUZA** – The use of selected methods in the analysis of the efficiency of the machine and device – case study 225
11. **Marcin KOMAŃDA, Wiktor ZYGOSZ, Masoud HAJIZADE, Honorata KSIĄŻEK** – Customer-facing employees' knowledge use by supervisors in market-immature SMEs 239
12. **Anna KOROMBEL, Beata ZATWARNICKA-MADURA** – The role of communication in Enterprise Risk Management (ERM) – systematic literature review 253
13. **Jakub KOWALSKI, Grzegorz KRZOS** – Managing an EU-funded FMCG R&D project: Freshpot FEDS.01.02-IP.01-0111/24 case study 273
14. **Andrzej KOZINA** – The rules of concessions making in negotiations 289
15. **Ewelina KRZYŻOWSKA** – The relationship between the tendency to excessively use generative artificial intelligence and the degree of satisfaction of basic psychological needs 303
16. **Anna LIPKA** – The training market in the field of employee experience management in Poland and Germany 319
17. **Małgorzata ŁĘGOWIK-MAŁOLEPSZA** – The strategic dimension of ecomarketing and its consistency with the company's environmental policy 329

18. **Sylwia ŁĘGOWIK-ŚWIĄCIK, Daniel KIELAK** – Triangulation of AI models for anomaly detection in enterprise management processes 345
19. **Izabela MARZEC** – Managing an aging workforce: some evidence from Silesia 361
20. **Mateusz MAŚLANKA, Łukasz HADAŚ** – Business intelligence adoption in logistics: an empirical SWOT/TOWS-based strategic analysis 383
21. **Katarzyna MAZUR-WŁODARCZYK, Katarzyna ŁUKANISZYN-DOMASZEWSKA** – Hybrid aesthetics in contemporary crafts – cultural narrative in sustainable development 403
22. **Beata NOWOTARSKA-ROMANIAK, Sonia SZCZEPANIK** – Cross-subsidisation and perceived fairness among young drivers in Poland's motor insurance 417
23. **Marcin OLKIEWICZ** – Preferences of the younger generation in the sustainable development of last-mile logistics 447
24. **Marcin OPAS, Marcin WARDASZKO, Yulduz ALIMOVA** – Serious games for sustainable business transformation: evidence and practice gaps 465
25. **Jacek PASIECZNY** – Dysfunctions in organizational systems: compensatory mechanisms 525
26. **Kornelia PRZEDWORSKA** – Flexibility, learning, and business continuity as determinants of microenterprise resilience in Poland 549
27. **Szymon PRZYBOREK, Roman DOMAŃSKI** – Chatbot or human? Customer service preferences in the courier industry 565
28. **Jacek PUCHAŁA** – Essential functionalities of a decision support system for small farms: a qualitative approach 577
29. **Artur RADZIO, Eryk GŁODZIŃSKI, Anna Maria LIS** – Relationships in the innovation ecosystem: the perspective of VC funds 615
30. **Katarzyna RENIK, Łukasz BIELECKI** – Ethical standards and auditor-entrepreneur business relationships in a free-market context 641
31. **Jacek RYBICKI, Emilia DOBROWOLSKA** – Interconnections between strategy and strategic thinking – literature review 657
32. **Anna RYCHLIK, Roman DOMAŃSKI** – Crowdshipping in last-mile logistics: willingness to perform deliveries during daily trips 679
33. **Krzysztof SKOWRON** – Integrated management system and its relationship with the implementation of the medical facility strategy – conceptual model 695
34. **Zbigniew SKUZA, Marzena OGÓREK, Jacek OLCZAK** – Analysis of selected marketing elements in shaping a company's image 713
35. **Marcin STĘPIEŃ** – Asymmetry in the alignment of tax policy with corporate strategy in the light of empirical research 725
36. **Katarzyna SYTNIEWSKA** – Regulatory approaches in selected cosmetics markets in the context of institutional distance, institutional voids and compliance 743
37. **Karolina SZYMANIEC-MLICKA** – From reactive digitalisation to resident-centred services: municipal transformation in the context of ESG 757

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 37 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: sustainable development; supply chain management; services management; logistics; small and medium enterprises; Industry 4.0; economic; financial management; enterprise risk management; the impact of Artificial Intelligence on management; ecomarketing; human resource management; business continuity; innovation management; ethic in management and public management.

Bożena Skotnicka-Zasadzień
Radosław Wolniak

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

FROM BASELINE TO PROGRESS: TRACKING SUSTAINABLE LAST-MILE DELIVERY AT INPOST POLAND

Mohannad ALJAWARNEH[1*], Beata MRUGALSKA[2]

[1] Time Center Jordan; mohannadaljawarneh2@gmail.com, ORCID: 0009-0006-5127-9357
[2] Poznan University of Technology, Faculty of Engineering Management; beata.mrugalska@put.poznan.pl, ORCID: 0000-0001-9827-9449
*Correspondence author

Purpose: This paper presents a longitudinal sustainability analysis of InPost Poland, tracking key performance indicators (KPIs) across operational, financial, sustainability, and customer experience dimensions for 2021-2025. It evaluates the implementation status and measurable impact of five proposed sustainability solutions and identifies new challenges arising from the Corporate Sustainability Reporting Directive (CSRD).
Design/methodology/approach: A mixed-method longitudinal case study design is applied, using a four-dimensional KPI framework. Data are drawn from five InPost Group Integrated Annual Reports (2021–2025), supplemented by secondary academic literature on sustainable last-mile logistics.
Findings: InPost Poland's operational and financial KPIs grew consistently across the period. Scope 1 and 2 emissions declined by 56% against the validated Group baseline, decoupling from volume growth through rapid renewable energy adoption. Scope 3 emissions rose 70.8%, remaining tied to value-chain volume. Solar-powered and energy-efficient APMs and the Scope 3 Supplier Engagement Programme show active implementation. Electric cargo bikes are present but undisclosed quantitatively. Delivery drones and autonomous robots remain unconfirmed. The most significant new challenges are CSRD full implementation in 2024 and the international acquisitions of Menzies, Yodel, and Sending in 2024-2025.
Research limitations/implications: The study draws on a single company case using corporate self-reported data, which may reflect selective disclosure. Boundary changes from the Menzies and Yodel acquisitions limit direct comparability of Group-level Scope 3 figures across the full period. Future research should extend the framework to other European APM operators and use primary courier data.
Practical implications: The findings offer logistics operators, sustainability managers, and policymakers an empirically grounded benchmark for APM-based last-mile delivery performance under CSRD. The solution implementation matrix provides a replicable template for sustainability progress assessment in e-commerce logistics.
Originality/value: This is the first longitudinal, KPI-based sustainability progress assessment for InPost Poland covering 2021-2025. It contributes to the sparse empirical literature on company-level sustainability tracking in Central European e-commerce and introduces a four-dimensional analytical framework aligned with CSRD 2024 requirements.

Keywords: last-mile delivery, sustainable logistics, InPost, automated parcel machines, e-commerce sustainability.
Category of the paper: Research paper.

1. Introduction

In the last years a dramatic increase is noticeable in last-mile delivery transactions, which are the least efficient and most environmentally taxing part of the supply chain (Bartucz, Süle, 2024; Montuori et al., 2023; Yılmaz et al., 2023). This growth accelerated significantly during the COVID-19 pandemic (Silva et al., 2024). Online sales figures alone grew by nearly 300% between 2014 and 2019. Last-mile parcel demand is projected to grow by 78% by 2030, leading to an increase in delivery vehicles on the streets of the world's 100 largest cities by about 36% and urban freight-related congestion by 21% (World Economic Forum, 2020).

Last-mile delivery is already the most expensive and least efficient stage of the supply chain, absorbing between 13% and 75% of total fulfilment cost (Gevaers et al., 2009). As urban populations continue to concentrate, approximately 60% of the global population will live in cities by 2030, the environmental externalities of conventional van-based door-to-door delivery grow harder to ignore: noise, air pollution, road congestion, and greenhouse gas (GHG) emissions all worsen with each additional van in the network. For logistics operators in European e-commerce, this creates a structural problem: volume keeps growing, but the traditional delivery model produces costs and emissions that are increasingly unacceptable to regulators, investors, and customers alike (Boysen et al., 2020; Waqas et al., 2025).

The EU regulatory response has further sharpened that pressure considerably. The European Green Deal, adopted in 2019, set binding emissions reduction targets across the EU economy with the transport sector responsible for 25% of total global GHG emissions, of which 75% come from road transport (Dalewska, Mrugalska, 2024; Jaramillo et al., 2023). The Corporate Sustainability Reporting Directive (CSRD), which took effect in 2024, takes it even further: it legally obliges large companies to report not only their direct operational emissions (Scope 1 and 2) but also their full Scope 3 value chain emissions (European Commission, 2022). For last mile operators, Scope 3 is the hardest number to move. It includes emissions from third-party delivery partners, contracted couriers, and fuel suppliers' entities that a company can influence but not directly control. In a systematic review of sustainable supply chain management, Meixell and Luoma (2015) find that stakeholder pressure from governments, investors and customers tends to push firms through a sequence of sustainability awareness, then goal setting, and only eventually measurable practice change. Scope 3 reduction is the hardest final step because it requires sustained engagement across an extended external network.

However, despite this growing body of literature, longitudinal empirical studies following the sustainability performance of a single operator over multiple years, against a verified baseline, including an assessment of whether proposed solutions have actually been implemented are rare. Most published work is either cross-sectional or model based. The gap is particularly visible in the context of Poland and Central Europe at scale. Aljawarneh (2024) developed a comprehensive four-dimensional KPI baseline for InPost Poland for 2021-2023 and proposed five specific sustainability solutions: solar-powered APMs, electric cargo bikes, delivery drones, autonomous delivery robots, and a Scope 3 supplier engagement program. This paper extends that analysis across 2021-2025 using the same KPI framework, assesses whether the five solutions have been implemented and discusses what new challenges – particularly CSRD 2024.

The aim of this paper is to extend that longitudinal analysis to the period 2021-2025, evaluate the evolution of InPost Poland's sustainability KPIs against the established baseline, assess the implementation status and measurable impact of the five proposed solutions, and identify new sustainability challenges and strategic opportunities that have emerged in the intervening period, particularly following the full implementation of CSRD in 2024.

The paper is structured around three research questions:

RQ1. How have InPost Poland's operational, financial, sustainability, and customer experience KPIs evolved between 2021 and 2025?

RQ2. To what extent have the five proposed sustainable solutions been implemented, and what measurable impact have they produced?

RQ3. What new challenges and strategic opportunities have emerged in 2024-2025 that affect the sustainability of last-mile delivery in European e-commerce?

The paper is organized as follows. Section 2 presents the research methodology, including the mixed-method design, data sources, and the four-dimensional KPI framework. Section 3 reports the results across all KPI dimensions and the solution implementation assessment. Section 4 discusses the findings in relation to the three research questions. Section 5 summarizes the conclusions, theoretical and practical contributions, and directions for future research.

2. Sustainable Last-Mile Delivery: Literature Review

2.1. Sustainable last mile systems and APMs

Automated parcel machines (APMs) have been a response to the environmentally inefficient home delivery and have received sustained attention. In a study of the InPost APM network in Poland, Iwan, Kijewska and Lemke (2016) found that one courier delivering to

parcel lockers can deliver 600 parcels per day over 70 km, whereas in the traditional delivery model, 60 parcels are delivered over 150 km. This difference results in a reduction of annual CO_2 emissions from 32,500 tons to 1516 tons for the same volume of service. InPost's logistics model, which relies on a network of parcel lockers, produced up to 75% lower emissions per parcel than DHL's conventional door-to-door deliveries, reinforcing the ecological benefits of consolidated, network-oriented delivery methods. The scale of the company proved less critical than how well digitalization, automation, and ESG management were integrated (Masłowski et al., 2025). Due to this fact, APMs and collection points are among the most studied operational solutions. However, there is no single last-mile approach that is universally optimal and that a combination of solutions is necessary to meet the triple bottom line of sustainability (Wahab et al., 2022; Werner et al., 2024). Both economic and environmental performance are now treated as complementary rather than competing objectives in the literature, a shift with direct implications for how operators like InPost report their results.

2.2. Electric vehicles and other delivery methods

When evaluating vehicle alternatives for urban last-mile distribution, findings show that 64% of reviewed studies advocate transitioning to electric vehicles. Additionally, 47% of the research supports utilizing bicycles and tricycles, especially within densely populated urban environments (Oliveira et al., 2017). Electric Vehicles (EVs), including light electric freight vehicles (LEFVs), electric tricycles, and electric light-duty vehicles (LDVs), are widely recognized as sustainable transport alternatives. They reduce greenhouse gas (GHG) emissions and operational costs compared to conventional fuel-powered vehicles (Díaz-Ramírez et al., 2023; Giordano, Christidis, 2025). For example, replacing diesel vehicles with electric tricycles in Rio de Janeiro reduced emissions and costs while maintaining service levels (de Mello Bandeira et al., 2019). Electric cargo bikes, tricycles, and scooters are increasingly favored for urban deliveries due to their smaller size, lower energy consumption, and ability to navigate congested areas (Díaz-Ramírez et al., 2023; Oliveira et al., 2017). These vehicles are particularly effective for small-scale deliveries, such as food logistics, and can reduce GHG emissions by over 50% (Bányai et al., 2025). On the other hand, autonomous delivery robots and drones are emerging as innovative solutions, especially when combined with traditional vehicles in hybrid systems. These approaches can reduce costs and emissions while addressing traffic congestion challenges (Lubis, Lestari, 2025). Combining trucks, public transportation (e.g. metro), and micromobility vehicles offers a promising approach. For instance, using metro networks to distribute parcels to micro-hubs, followed by micromobility for final delivery, has shown significant reductions in pollution and operational costs (Stokkink, Geroliminis, 2025).

2.3. Consumer preferences for sustainable delivery

Parcel lockers have emerged as a promising solution, offering consolidated delivery points that reduce failed deliveries, lower emissions, and provide flexible access for consumers. However, the success of parcel lockers hinges not only on their operational efficiency but also on consumer acceptance, which is increasingly shaped by perceptions of environmental, social, and economic sustainability (Rose et al., 2025a; Wahab et al., 2025). Caspersen and Navrud (2021) use discrete choice modelling to show that among Norwegian consumers, people are willing to accept longer delivery times if this reduces GHG emissions, and that convenience-first delivery models may not be the only viable approach. According to Rose et al. (Rose et al., 2025) the urban consumers are more influenced by social norms, rural consumers by facilitating conditions and price value. Osakwe et al. (2022) find that the strongest predictors of willingness to use drone delivery are outcome expectancy and lifestyle compatibility and that delivery risk moderates the relationship between attitude and actual intention for European millennial consumers.

2.4. Scope 3 emissions and engagement with supply chain stakeholders

Meixell and Luoma (2015) identify that different stakeholder types - regulators, investors, customers and employees - exert unequal influence over different dimensions of supply chain sustainability. Customer pressure tends to be more influential on decisions regarding social sustainability, while government and regulatory pressure tend to be the most consistent driver for adoption of environmental sustainability. Mismar, Shamayleh and Qazi (2022), applying Bayesian Belief Network analysis to last-mile delivery risks, find that beyond the operational risks of IT failure and privacy breaches, regulatory non-compliance is an emerging exposure - one that CSRD 2024 (European Commission, 2022) has made concrete for any large logistics operator reporting in the EU. Boysen, Fedtke and Schwerdfeger (2021) observe, from an operational research perspective, that increasingly stringent governmental legislation now enforces courier services to intensify sustainability efforts, particularly around fleet electrification and alternative delivery modes.

3. Methods

3.1. Research Design

This paper adopts a mixed-method longitudinal case study design. The rationale for this choice follows directly from the nature of the three research questions. RQ1 asks how quantitative KPIs have evolved over time, which calls for a systematic numerical comparison across multiple years. RQ2 asks whether specific solutions have been implemented and what

impact they have produced, which requires documentary analysis and qualitative interpretation of corporate disclosures alongside the quantitative evidence. RQ3 asks what new challenges have emerged, which is inherently interpretive. As Jonker and Pennink, (2009) note, a mixed-method approach is particularly well suited when a researcher intends to verify results using multiple methods and data sources, because combining quantitative and qualitative data allows statistical trends to be read alongside contextual depths that numbers alone cannot provide.

The longitudinal dimension is equally deliberate. Rather than offering a cross-sectional snapshot of InPost's sustainability performance at a single point in time, this study follows the same set of indicators across five consecutive reporting years (2021, 2022, 2023, 2024, and 2025) against a baseline established for the period 2021-2023 (Aljawarneh, 2024). This approach makes the direction and magnitude of change observable in a way that a single-year study cannot. The case study boundary is InPost Poland, which is the company's original and largest operating segment, and for which consistent Poland-specific data is available throughout the entire observation period.

3.2. Data Sources

This paper draws mainly on five InPost Group Integrated Annual Reports covering the financial years that ended on 31 December 2021, 2022, 2023, 2024, and 2025. The reports are publicly available and were prepared under the Global Reporting Initiative (GRI) framework. Starting in 2024, they were also produced in line with the Corporate Sustainability Reporting Directive (CSRD), which brought in a requirement for limited third-party assurance of sustainability data.

The data collection process focused on data reported separately for Poland. It was important because InPost changed quite a bit during the studied period. Its international operations grew rapidly, and the company made a series of acquisitions that expanded the business footprint beyond what had existed in previous years; Menzies Distribution was acquired in the United Kingdom during the fourth quarter of 2024, Yodel followed in the second quarter of 2025, and Sending was added in Spain later the same year. As those businesses became part of the group, the reporting boundary behind the sustainability disclosures shifted as well. Group-level Scope 3 emissions reported for 2024 and 2025 cannot be compared directly with the equivalent figures from 2022 and 2023 because they cover a different organizational scope. Because of this, Poland-specific KPIs serve as the main time-series dataset throughout the analysis. Group-level figures are used next to that for context, and any reporting boundary change is pointed out where it affects the interpretation.

3.3. KPI Framework

The analytical framework applied in this paper is a four-dimensional KPI structure first developed in (Aljawarneh, 2024). It organizes InPost Poland's performance into four measurement dimensions: operational, financial, sustainability, and customer experience.

These four dimensions were selected on the basis that they capture the distinct but interrelated aspects of sustainability performance in a large-scale logistics operator - the volume and network growth that drives environmental load, the financial results that determine investment capacity, the direct and indirect emissions that determine environmental impact, and the customer-side demand signals that shape delivery model choice. The framework is reproduced here without modification to preserve comparability across the full observation period from 2021 to 2025 and is presented in Table 1.

Table 1.
Four-Dimensional KPI Framework

Dimension	KPI Indicator	Unit
Operational	Parcel volume — Poland	Million parcels
	APM network size — Poland	Number of machines
Financial	Revenue — Poland segment	PLN million
	Adjusted EBITDA — Poland segment	PLN million
Sustainability	Scope 1,2 GHG emissions	tCO_2e
	Scope 3 GHG emissions	tCO_2e
	Parcels delivered using electric vehicles	Million parcels
Customer Experience	Net Promoter Score — APM sending/collecting	Score
	Mobile app users	Million users
	Customer preference for APMs	%

Source: Aljawarneh, 2024.

3.4. Solution Assessment Criteria

The five sustainability solutions proposed in Aljawarneh (2024) are assessed against evidence found in the five annual reports. The assessment uses a four-level classification scale: *Fully implemented*, where the annual report confirms commercial deployment at scale with quantitative performance data; *Partially implemented*, where deployment is confirmed but remains limited in scope, in geographic coverage, or in measurable impact; *Unconfirmed*, where the annual report neither confirms nor explicitly excludes deployment; and *Not implemented*, where the annual report explicitly states that the solution has not been adopted or where no trace of it can be found across any of the five reports reviewed. This classification is based on disclosed information. Where a company has not reported on a particular solution, this is treated as an absence of confirmable evidence rather than definitive proof of non-implementation. This constraint that the analysis is bound by what companies choose to disclose is acknowledged as a limitation of the documentary method and is addressed further in Section 5.

4. Results

4.1. Operational and Financial KPI Evolution

To provide a comprehensive overview of the company, the details of InPost Poland's operational and financial KPIs from 2021 through 2025 are shown in Table 2.

Table 2.
Operational and Financial KPI Evolution - InPost Poland, 2021-2025

KPI	2021	2022	2023	2024	2025
Parcel volume (million)	424.0	508.0	589.5	709.2	763.1
APM network — Poland (machines)	16,445	19,306	21,969	25,269	28,261
Revenue — Poland segment (PLN m)	3,453.4	4,168.5	5,334.5	6,473.7	7,177.2
Adjusted EBITDA — Poland segment (PLN m)	1,626.4	1,819.3	2,474.7	2,993.6	3,515.3

Source: InPost Group Annual Reports (2021; 2022; 2023; 2024; 2025).

In the analyzed period InPost Poland's operational performance shows its sustained scale. Parcel volume increases every year without exception, from 424 million in 2021 to 508 million in 2022, then 589.5 million in 2023, 709.2 million in 2024, and 763.1 million in 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025). That is a cumulative rise of about 80% across the five years. The APM network grew right alongside it, expanding from 16,445 machines in 2021 to 28,165 by 2025 (InPost Group, 2021, 2025) roughly 12,000 machines added in four years. Volume growth in the later years drew on the maturing Polish e-commerce market and InPost's deepening density within it (InPost Group, 2024, 2025).

The financial dimension show that Poland-segment revenue rose from PLN 3,453.4 million in 2021 to PLN 4,168.0 million in 2022, PLN 5,334.5 million in 2023, PLN 6,473.7 million in 2024, and PLN 7,177.2 million in 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025) whereas revenue was more than doubled over the period, a rise of 108%. Adjusted EBITDA for the Poland segment followed, increased from PLN 1,626.4 million in 2021 to PLN 3,515.3 million in 2025 (InPost Group, 2021, 2025). Profitability did not just keep pace with the network build-out; it strengthened. By 2025 the Poland Adjusted EBITDA margin had reached 49%, up 200 basis points year on year (InPost Group, 2025), which indicates that the expansion was funded from an increasingly efficient core rather than at its expense.

4.2. Sustainability KPI Evolution

To illustrate the company's commitment to sustainable development, Table 3 details the trajectory of InPost Poland's sustainability metrics over the 2021-2025 period.

Table 3.
Sustainability KPI Evolution, InPost Poland, 2021-2025

KPI Indicator	2021	2022	2023	2024	2025
Scope 1 and 2 emissions, market-based (tCO_2e)	27,364	33,286	23,402	24,973	12,964
Scope 3 emissions (tCO_2e)	283,774	295,588	248,475	572,893	715,656

Source: InPost Group Annual Reports (2021; 2022; 2023; 2024; 2025).

Table 3 sets out the emissions story, and the two scopes pull in opposite directions. Scope 1 and 2 went up first, from 27,364 tCO_2e in 2021 to 33,286 in 2022, before dropping back to 23,402 in 2023 (Aljawarneh, 2024). The Group figures carry that downward move further: 24,973 tCO_2e in 2024 and just 12,964 in 2025 (InPost Group, 2024, 2025). That last number is a 56% cut against the validated 2021 base. Renewable electricity did heavy lifting, jumping from 45% of Group consumption in 2024 to 91% a year later (InPost Group, 2024, 2025).

In a case of Scope 3 the data show that it fell from 283,774 tCO_2e in 2021 to 248,475 in 2023 (Aljawarneh, 2024). Then the reported numbers climb steeply, reaching 572,893 tCO_2e in 2024 and 715,656 in 2025 (InPost Group, 2024, 2025). Some of the jump across 2023 and 2024 is the switch from Poland-only to Group-wide reporting rather than a real surge, so the break in the series should be read with that in mind. The trajectory is still clear enough. Measured against the validated 2021 Group base of 418,986 tCO_2e, the 2025 result sits 70.8% higher (InPost Group, 2025), which lines up with what Meixell and Luoma (2015) describe, where the emissions a company can lean on suppliers about but never directly switch off are the ones that refuse to come down. InPost says as much itself, expecting Scope 3 to keep rising until somewhere between 2027 and 2030 before it bends (InPost Group 2024, 2025). Volume and value-chain emissions are, for now, tied together.

4.3. Customer Experience KPI Evolution

Customer experience is the fourth dimension of the KPI framework, and it functions differently from the other three. Where volume, emissions, and revenue measure what the company produces, customer experience measures whether demand continues to support the APM model over conventional home delivery — which is the foundation of InPost's sustainability case. If customers shift away from lockers, the environmental argument weakens regardless of operational efficiency. Three indicators capture this: mobile app users as a proxy for platform engagement, Net Promoter Score for APM satisfaction, and customer preference for APMs as a delivery channel. Table 4 presents the evolution of these indicators for InPost Poland over the 2021-2025 period.

Table 4.
Customer Experience KPI Evolution - InPost Poland, 2021-2025

KPI	2021	2022	2023	2024	2025
Mobile App Users (million)	8.0	10.0	11.6	14.0	16.0
Net Promoter Score (NPS)	75	75	80	77	77
Customer preference for APMs / lockers (%)	91	59	93	93	87

Source: InPost Group Annual Reports (2021; 2022; 2023; 2024; 2025).

Customer indicators confirm that the operational scale rests on durable demand, and the demand was already strong at the start of the period. The Net Promoter Score for APM delivery in Poland sat at 75 in 2021 and again in 2022, rose to 80 in 2023, and settled at 77 across 2024 and 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025). The movement is marginal against a consistently high base, and InPost continued to report it as industry-leading in every market.

Adoption deepened on every other measure. Registered users of the Polish mobile app grew from roughly 8 million in 2021 - about 40% of the country's online shoppers at the time - to 10 million in 2022, 11.6 million in 2023, 14 million in 2024, and 16 million in 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025). Demand for the locker channel itself stayed dominant throughout: 91% of Polish online shoppers already chose InPost APMs as their delivery method in 2021, and the share naming APMs or lockers their preferred or most frequent channel held at 93% in 2023 and 2024 before reaching 87% in 2025 (InPost Group, 2021, 2023, 2024, 2025). Customer preference, not just operator efficiency, is what makes the model work. This aligns with Klein and Popp (2022), who find lockers score strongly on perceived environmental sustainability, and with Caspersen and Navrud (2021) on the loyalty of out-of-home models.

4.4. Solution Implementation Assessment

The second research question determines whether the five solutions proposed by Aljawarneh (2024) were effectively implemented and whether they produced quantifiable results. Each intervention is assessed against the five reports applying the four-level scale from Section 2.4, and the final evaluations are consolidated in Table 5.

Table 5.
Implementation Assessment of the Five Proposed Sustainability Solutions

Proposed Solution *(Aljawarneh, 2024)*	**Status in Annual Reports 2024-2025**	**Evidence in Annual Reports 2024-2025**
Solar-powered / energy-efficient APMs	Partially implemented	Screenless 2.0 "battery-ready" APMs introduced in Poland, 1,977 units installed, consuming 40% less energy than the previous generation (InPost Group, 2024); off-grid readiness via the Bloq.it stake (EUR 11.0m), ~2,000 infrastructure-free machines deployed in 2025, ~20,000 planned over five years (InPost Group, 2025)
Electric cargo bikes	Partially implemented	Cargo bikes and e-cargo bikes used for the micro-hub final leg; no volume, fleet, or emissions figure disclosed (InPost Group, 2025)
Scope 3 supplier engagement program	Partially implemented	Formal phased program; suppliers with science-based targets rose from 0% (2021) to 7.2% (2024) and 8.9% (2025), against a 15% target (InPost, 2024; InPost, 2025)

Cont. table 5.

Delivery drones	Unconfirmed	No deployment or pilot reported in any of the four reports
Autonomous delivery robots	Unconfirmed	No deployment or pilot reported in any of the four reports

Source: InPost Group Annual Reports (2024; 2025); (Aljawarneh, 2024).

The supplier engagement program has gone furthest. InPost folded it into its formal ESG strategy as a phased Supplier Engagement Program tied to the science-based-targets commitment for 2027, and there is a real number behind it: the share of suppliers, weighted by emissions, holding Science Based Targets in Scope 1 and 2 climbed from nothing in 2021 to 7.2% in 2024 and 8.9% in 2025 (InPost Group, 2024, 2025). That still falls short of the 15% the company set for 2025. So, the work is happening and being measured, just not yet at the level it aimed for, which is why it lands as partially implemented.

Energy-efficient APMs sit in much the same place, though the route InPost took is more interesting than the original proposal imagined. Rather than bolt solar panels onto lockers, the company went after the machines' own power draw. In 2024 it rolled out Screenless 2.0, a "battery-ready" generation that swaps the old display for a small OLED unit and pulls 40% less energy than the previous model, with 1977 units already installed in Poland (InPost Group, 2024). The screen was where a lot of the consumption sat, so dropping it does double duty: lower power, plus the freed-up space fits two extra A-size lockers per machine. On top of that came the off-grid push, backed by a EUR 11.0 million minority stake in Bloq.it for battery-powered units that need no fixed infrastructure at all, roughly 2000 of them in the ground by the end of 2025 and around 20,000 planned over five years (InPost Group, 2025). Confirmed at scale, then, even if the solar-panel version of the idea never quite materialized in the form first suggested.

In the subsequent years under review, cargo bicycles began to be deployed; however, overall uptake remained limited. They first appear in the 2025 report within the context of a micro-hub logistics model, in which larger vehicles deliver consignments to a hub and lighter transport modes undertake the final delivery segment (InPost Group, 2025). Notably, the reports do not associate cargo bicycles with any quantitative indicators: there are no data on parcel volumes handled, fleet size, or emissions reductions achieved. Their presence is thus documented only qualitatively and without indication of scale, a condition that appears to contribute to their continued status as a partially implemented solution.

The last two never appear. Delivery drones and autonomous robots show up nowhere across the five reports, neither as live operations nor as pilots. Following the documentary rule set in Section 2.4, that silence is logged as unconfirmed rather than read as outright rejection. It also tracks with Mohammad et al. (2023), who found that regulatory and infrastructure hurdles keep both technologies parked well short of commercial deployment.

5. Discussion

5.1. Evolution of the KPIs

This study set out to track InPost Poland's sustainability performance across 2021-2025 against an established baseline, assess whether five proposed solutions had been implemented, and identify new challenges that emerged over the period. The first research question asked how InPost Poland's operational, financial, sustainability, and customer-experience KPIs evolved across 2021-2025, and the answer is that they did not move as one. Operational scale, financial robustness, and customer demand all exhibited growth over the observation period. In contrast, the sustainability dimension bifurcated into two distinct trajectories, and this divergence constitutes the most analytically salient outcome in the entire dataset. Parcel volumes increased by approximately 50%, the network expanded to more than 28,000 machines, revenues grew by 72%, and the operating margin in Poland reached 49% by 2025. The expansion was therefore self-financing. The density logic that Iwan, Kijewska and Lemke (2016) measured for the early InPost network - a single courier serving hundreds of parcels from one locker bank rather than chasing addresses across a city - is exactly what shows up here as widening margins rather than thinning ones, since each new machine deepens an already efficient route structure instead of stretching it.

The emissions profile then begins to diverge across scopes. Scope 1 and 2 emissions declined by 56% relative to the validated baseline despite concurrent growth in parcel volume, indicating that InPost effectively decoupled its operational emissions from its throughput. The principal driver of this decoupling was a rapid transition in the Group's electricity mix, with the share of renewable electricity increasing from less than half of total consumption to nearly 100% within a single year (InPost Group, 2024, 2025). This outcome exemplifies the complementary relationship, in which emissions reduction and business expansion cease to be mutually exclusive, and it is consistent with Boysen, Fedtke, and Schwerdfeger's (2021) analysis of regulatory pressure steering logistics operators toward lower-emission fleets and infrastructure.

Scope 3 emissions, however, did not follow this trajectory. This is the most unexpected finding of the study. Value-chain emissions increased by 70.8% and remained closely correlated with volume, and the underlying determinant appears to be asset ownership. Emissions from assets and activities under InPost's direct control - such as its automated parcel machines and electricity procurement - were decarbonized rapidly, whereas emissions embedded in an externally managed network of couriers, suppliers, and upstream goods were not. This pattern reflects precisely the asymmetry identified by Meixell and Luoma (2015) as the structural barrier that many firms encounter once the most straightforward internal abatement measures have been exhausted.

The customer dimension, in turn, helps to discount demand-side reluctance as a limiting factor. The number of active application users increased to 16 million, the parcel locker channel maintained its dominant position in customer preference, and the Net Promoter Score exhibited minimal variation over the period. These indicators suggest that demand for the more sustainable delivery model is not currently the binding constraint (Caspersen, Navrud, 2021). RQ1 is therefore confirmed: the KPIs evolved significantly across the period, but not uniformly — operational and financial growth was consistent, Scope 1 and 2 emissions decoupled from volume, while Scope 3 rose in an unexpected direction, reflecting a structural challenge that internal decarbonization efforts alone cannot resolve.

5.2. Implementation of the Proposed Solutions

The second research question addressed the extent to which the five solutions proposed in Aljawarneh (2024) had been implemented in practice. In this regard, there is a clear misalignment between the original proposals and the realised outcomes—a discrepancy that constitutes an empirical finding in its own right. The pattern of implementation closely followed loci of organisational control: InPost acted rapidly on the measure that could be executed entirely within its own operational boundaries and proceeded more slowly on those requiring prior action by external actors.

Energy-efficient automated parcel machines (APMs) provide the most salient example. Instead of installing solar panels on parcel lockers, as recommended in the thesis, the company focused on reducing the intrinsic energy consumption of the machines themselves through the development of the Screenless 2.0 generation and through investment in off-grid units, thereby achieving the same overarching objective of reduced energy use via an alternative pathway that it could design, implement, and fully control (InPost Group, 2024, 2025). The initial proposal thus functioned as a hypothesis regarding the means of achieving a sustainability goal; InPost subsequently identified and adopted a more effective or more feasible means.

The supplier engagement program constitutes the primary intervention explicitly targeting the Scope 3 emissions challenge identified in the preceding section, and its rate of progress reflects this complexity. The proportion of suppliers covered by science-based targets increased from zero to 8.9%, which represents substantive advancement but remains below the 15% benchmark. This shortfall is largely attributable to the program’s reliance on the independent actions of numerous external firms, each of which must establish and achieve its own emissions-reduction objectives (InPost Group, 2024, 2025). This dynamic aligns with the final, and typically slowest, phase of the progression described by Meixell and Luoma (2015), which occurs only after organizational awareness and goal-setting mechanisms have been established.

Cargo bicycles, by contrast, occupy an intermediate position between demonstrated technical potential and empirically documented organizational impact. However, the academic literature provides evidence of their effectiveness. For example, Schünemann et al. (2022) report substantial reductions in greenhouse gas emissions emphasizing the role of such parameters as the use of renewable energies for the charging of the batteries, the utilization of the payload capacity and the production of the battery. They demonstrate that life cycle GHG emissions are substantially reduced when the batteries are charged using solar energy. Integrating solar-powered e-cargo bikes into the freight transport modal split in the accra region would lead to greenhouse gas emission reductions of approximately 4-8%. Moreover, Shramenko et al. (2025) underline also such benefits as strengthening corporate image and compliance with regulatory standards in some cities. They demonstrate the operational feasibility and reducing costs of cargo‑bike‑based routing under European conditions. However, InPost does not disclose quantitative indicators - such as processed shipment volume, fleet size, or emissions reductions - attributable specifically to cargo‑bike operations. Consequently, cargo bicycles are integrated into the logistics system but remain effectively invisible within the reported performance metrics.

Unmanned aerial vehicles (drones) and delivery robots do not appear in the disclosed data at all. This absence is consistent with broader sectoral developments. Mohammad et al. (2023) identify regulatory and infrastructure barriers that continue to impede large‑scale deployment. However, Sillero Illanes et al. (2025) show that, although these technologies may outperform conventional vans in simulation or pilot studies, they still remain a potential solution in Poland. Osakwe et al. (2022) further introduce a demand‑side qualification for drones, indicating that users' willingness to adopt drone delivery depends on determinants that are not fully controllable by the operator. Accordingly, the lack of confirmed impact at InPost should be interpreted less as a deficiency of corporate ambition and more as a reflection of the current state of development across the entire sector.

RQ2 is partially confirmed: three of the five solutions show evidence of active implementation, but none reached full deployment. The pattern follows organizational control boundaries rather than ambition levels, a finding that aligns with but also extends the stakeholder-influence sequence described by Meixell and Luoma (2015).

5.3. Emerging Challenges and Opportunities

The third research question turned to the new challenges and strategic opportunities that emerged over the period, and two shifts in particular reshaped the terrain after the baseline thesis was written. The first is CSRD. Before the directive took effect in 2024, a company's value-chain emissions could stay largely in the dark; afterwards they had to be reported and independently assured (European Commission, 2022). Part of the steep Scope 3 rise in Section 4.1 is therefore an accounting effect — better counting, not only more emitting —

which cuts both ways for InPost. The assurance requirement lifts the credibility of the later figures, an asset for a company whose sustainability claims now carry regulatory weight. At the same time, it converts disclosure into exposure, making regulatory non-compliance the kind of live operational risk that Mismar, Shamayleh and Qazi (2022) identify as new material for any large EU logistics operator.

The second shift is structural growth. The acquisitions of Menzies, Yodel, and Sending pushed the Group well beyond its Polish locker core and broke the clean Poland time series in the process, which is why the 2025 Group figures are reported on a pre-acquisition basis at all. Here the tension is sharp. Bringing conventional courier and distribution networks into a group whose entire sustainability narrative rests on out-of-home density imports exactly the van-based, third-party emissions profile that the APM model was built to avoid, and it does so into the Scope 3 line that is already the hardest to bend. The opportunity hides inside the same move. If the density logic that drove Poland's results can be carried into the United Kingdom and Spain, the acquisitions become a testbed rather than a drag.

One trend ties the two shifts together. Domestic volume growth cooled from above 20% to 7.6%, a sign the Polish market is maturing, which means the next chapter of both expansion and emissions will be written abroad (InPost Group, 2025). The sustainability question moves with the company. Whether the model travels are now the thing worth watching.

RQ3 is confirmed: two significant challenges emerged in 2024-2025 that were not anticipated in the baseline thesis — the full binding effect of CSRD and the structural disruption caused by the acquisitions of Menzies, Yodel, and Sending. Both reshape the sustainability trajectory in ways that the original KPI framework will need to track going forward.

6. Conclusions

This paper set out to follow InPost Poland from a baseline into the years that came after, tracking how its sustainability performance moved rather than how it was projected to. Three questions framed the work, and the answers, taken together, sketch a company doing well on most fronts and stuck on the one that matters most for last-mile delivery.

On the first question, the KPIs grew in nearly every direction. Volume climbed by around the half, the network passed 28,000 machines, revenue rose 72%, and the Poland margin reached 49%, all while operational emissions fell 56% against the validated base. Growth and clean operations stopped fighting each other. The exception was Scope 3, which rose 70.8% and stayed tied to volume, marking the clear boundary of what InPost has managed to control so far. The second question turned the five proposed solutions into a pattern worth naming: implementation tracked ownership. Energy-efficient APMs, the solution sitting entirely inside InPost's own walls, advanced fastest and by a smarter route than the thesis imagined, swapping

solar panels for screenless, low-draw, off-grid machines. The supplier engagement programme made real but partial headway because it depends on outside firms' acting. Cargo bikes are present without numbers, and drones and robots never appear at all. The third question pointed at two shifts that arrived after the thesis: CSRD, which made value-chain emissions both more visible and more legally binding, and the wave of foreign acquisitions, which broke the clean Polish series and imported exactly the kind of conventional, third-party delivery the locker model was built to avoid.

The theoretical contribution is straightforward. This is a longitudinal, company-level test of whether proposed sustainability solutions get built, against a verified prior baseline. The control-based reading of implementation, where a firm moves fast on what it owns and slows on what it must persuade others to do, gives a simple lens for reading any operator's sustainability progress, and it puts empirical weight behind the stakeholder-influence sequence that Meixell and Luoma (2015) describe. On the practical side, the solution implementation matrix offers logistics operators, sustainability managers, and policymakers a plain template for separating what has been deployed from what has merely been announced, which matters more now that CSRD has made the difference legally consequential.

The limitations are real and worth stating plainly. This is a single case, and it leans on corporate self-reported data, which can be selectively disclosed; the unconfirmed verdicts reflect the silence of the reports, not proven absence. The acquisitions of Menzies, Yodel, and Sending shifted the organizational boundary partway through, so Group-level Scope 3 cannot be compared cleanly across the full period, and the switch from Poland-specific to Group figures sits right at the point where the emissions data tells its most dramatic story. These are constraints of the documentary method, not gaps that careful framing can erase.

Future work follows from each of those limits. The four-dimensional framework could be carried to other European APM operators, turning a single case into a comparison that would show whether the patterns found here travel. Primary data from contracted couriers would open up the supplier engagement program from the inside, getting past what the annual reports choose to reveal. And the most pressing thread is the one Section 4 left hanging: whether the density logic that drove Poland's results can survive the move into the United Kingdom and Spain, where the acquired networks look nothing like a wall of lockers. That is the question the next baseline will have to answer.

References

1. Aljawarneh, M. (2024). *Analysis and Evaluation of Sustainable Solutions in E-commerce-based Last Mile Delivery Systems in InPost Company*. Poznan University of Technology, Faculty of Engineering Management, Master's Diploma Thesis.
2. Bányai, Á., Kaczmar, I., Bányai, T. (2025). Green Micromobility-Based Last-Mile Logistics from Small-Scale Urban Food Producers. *Systems*, *13*(9). https://doi.org/10.3390/systems13090785
3. Bartucz, C., Süle, E. (2024). Sustainable Cities by Collaborative Last Mile Parcel Delivery - Live Example Insight. *Springer Proceedings in Earth and Environmental Sciences: Part F2516* (pp. 457-468). https://doi.org/10.1007/978-3-031-48532-9_42
4. Boysen, N., Fedtke, S., Schwerdfeger, S. (2021). Last-mile delivery concepts: A survey from an operational research perspective. *Or Spectrum*, *43*(1), 1-58.
5. Caspersen, E., Navrud, S. (2021). The sharing economy and consumer preferences for environmentally sustainable last mile deliveries. *Transportation Research Part D: Transport and Environment*, *95*. https://doi.org/10.1016/j.trd.2021.102863
6. Dalewska, M., Mrugalska, B. (2024). Innovative Transport: Environmental, Social, and Economic Aspects. *Human Perspectives of Industry 4.0 Organizations* (pp. 224-235). CRC Press.
7. de Mello Bandeira, R.A., Goes, G.V., Schmitz Gonçalves, D.N., D'Agosto, M.D.A., Oliveira, C.M.D. (2019). Electric vehicles in the last mile of urban freight transportation: A sustainability assessment of postal deliveries in Rio de Janeiro-Brazil. *Transportation Research Part D: Transport and Environment*, *67*, 491-502. https://doi.org/10.1016/j.trd.2018.12.017
8. Díaz-Ramírez, J., Zazueta-Nassif, S., Galarza-Tamez, R., Prato-Sánchez, D., Huertas, J.I. (2023). Characterization of urban distribution networks with light electric freight vehicles. *Transportation Research Part D: Transport and Environment*, *119*. https://doi.org/10.1016/j.trd.2023.103719
9. European Commission (2022). Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting. *Official Journal of the European Union, L 322*, pp. 15-80. https://eur-lex.europa.eu/eli/dir/2022/2464/oj
10. Gevaers, R., Van de Voorde, E., Vanelslander, T. (2009). Characteristics of innovations in last-mile logistics-using best practices, case studies and making the link with green and sustainable logistics. *Association for European Transport and Contributors*, *1*, 21.

11. Giordano, A., Christidis, P. (2025). Green Last-Mile Delivery: Adapting Beverage Distribution to Low Emission Urban Areas. *Future Transportation*, *5*(2). https://doi.org/10.3390/futuretransp5020065
12. InPost Group (2021). *Integrated Annual Report 2021*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2022-04/InPost%20Annual%20Report%202021.pdf, May 11, 2026
13. InPost Group (2022). *Integrated Annual Report 2022*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2023-04/InPost%20Annual%20Report%202022.pdf, May 11, 2026
14. InPost Group (2023). *Integrated Annual Report 2023*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2024-04/IAR%20InPost%202023.pdf, May 11, 2026
15. InPost Group (2024). *Integrated Annual Report 2024*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2025-04/InPost%20Raport%202024.pdf, May 11, 2026
16. InPost Group (2025). *Integrated Annual Report 2025*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2026-04/InPost%20Group%20IAR%202025.pdf, May 11, 2026
17. Iwan, S., Kijewska, K., Lemke, J. (2016). *Analysis of Parcel Lockers' Efficiency as the Last Mile Delivery Solution - The Results of the Research in Poland*. Transportation Research Procedia. Elsevier B.V., pp. 644-655. https://doi.org/10.1016/j.trpro.2016.02.018
18. Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuodeke, O.E., Kajino, T., Lee, D.S., Nugroho, S.B., Ou, X., Hammer Strømman, A. (2023). *Transport (chapter 10). IPCC 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,* 1049-1160.
19. Jonker, J., Pennink, B.W. (2009) *The essence of research methodology: A concise guide for master and PhD students in management science, The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science*. Berlin/Heidelberg: Springer. https://doi.org/10.1007/978-3-540-71659-4
20. Lubis, R.A.S., Lestari, Y.D. (2025). Green vehicles adoption for last-mile delivery: A systematic literature review and current trend. *International Journal of Logistics Systems and Management, 51(2),* 211-229. https://doi.org/10.1504/IJLSM.2025.146707
21. Masłowski, D., Giera, J., Kubinka, B., Śliwińska, A. (2025). Zielona transformacja logistyki dzięki innowacjom technologicznym ograniczającym emisję CO2 w firmach kurierskich – case study. *Ekonomika i Organizacja Logistyki, 10(2),* 59-76. https://doi.org/10.22630/EIOL.2025.10.2.12

22. Meixell, M.J., Luoma, P. (2015). Stakeholder pressure in sustainable supply chain management: A systematic review. *International Journal of Physical Distribution and Logistics Management, 45*, pp. 69-89. https://doi.org/10.1108/IJPDLM-05-2013-0155
23. Mismar, H., Shamayleh, A., Qazi, A. (2022). Prioritizing Risks in Last Mile Delivery: A Bayesian Belief Network Approach. *IEEE Access, 10,* pp. 118551-118562. https://doi.org/10.1109/ACCESS.2022.3220626
24. Mohammad, W.A.M. et al. (2023). *Innovative solutions in last mile delivery: concepts, practices, challenges, and future directions.* Supply Chain Forum. Taylor and Francis Ltd., pp. 151-169. https://doi.org/10.1080/16258312.2023.2173488
25. Iwan, S., Kijewska, K., Lemke, J. (2016). *Analysis of Parcel Lockers' Efficiency as the Last Mile Delivery Solution - The Results of the Research in Poland*. Transportation Research Procedia. Elsevier B.V., pp. 644–655. https://doi.org/10.1016/j.trpro.2016.02.018
26. Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuodeke, O.E., Kajino, T., Lee, D.S., Nugroho, S.B., Ou, X., Hammer Strømman, A. (2023). Transport (chapter 10). *IPCC 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, 1049-1160.
27. Jonker, J., Pennink, B.W. (2009). *The essence of research methodology: A concise guide for master and PhD students in management science*, *The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science*. Berlin/Heidelberg: Springer. https://doi.org/10.1007/978-3-540-71659-4
28. Lubis, R.A.S., Lestari, Y.D. (2025). Green vehicles adoption for last-mile delivery: A systematic literature review and current trend. *International Journal of Logistics Systems and Management*, *51*(2), 211-229. https://doi.org/10.1504/IJLSM.2025.146707
29. Masłowski, D., Giera, J., Kubinka, B., Śliwińska, A. (2025). Zielona transformacja logistyki dzięki innowacjom technologicznym ograniczającym emisję CO2 w firmach kurierskich – case study. *Ekonomika i Organizacja Logistyki*, *10*(2), 59-76. https://doi.org/10.22630/EIOL.2025.10.2.12
30. Meixell, M.J., Luoma, P. (2015). Stakeholder pressure in sustainable supply chain management: A systematic review. *International Journal of Physical Distribution and Logistics Management*, *45*, pp. 69-89. https://doi.org/10.1108/IJPDLM-05-2013-0155
31. Mismar, H., Shamayleh, A., Qazi, A. (2022). Prioritizing Risks in Last Mile Delivery: A Bayesian Belief Network Approach. *IEEE Access*, *10*, pp. 118551-118562. https://doi.org/10.1109/ACCESS.2022.3220626
32. Mohammad, W.A.M. et al. (2023). *Innovative solutions in last mile delivery: concepts, practices, challenges, and future directions.* Supply Chain Forum. Taylor and Francis Ltd., pp. 151-169. https://doi.org/10.1080/16258312.2023.2173488
33. Montuori, G., Tumino, A., Seghezzi, A. (2023). *Logistics challenges of e-grocery last-mile delivery: A literature review*. Proceedings of the Summer School Francesco Turco.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85193712657&partnerID=40&md5=11e0bcb63ddd2846b08ee065fdc81a7f

34. Oliveira, C.M. de, Albergaria De Mello Bandeira, R., Vasconcelos Goes, G., Schmitz Gonçalves, D.N., D'Agosto, M.D.A. (2017b). Sustainable vehicles-based alternatives in last mile distribution of urban freight transport: A systematic literature review. *Sustainability*, *9*(8), 1324.
35. Osakwe, C.N. et al. (2022). Critical factors characterizing consumers' intentions to use drones for last-mile delivery: Does delivery risk matter? *Journal of Retailing and Consumer Services*, *65*. https://doi.org/10.1016/j.jretconser.2021.102865.
36. Rose, W.J., Confente, I., Peinkofer, S.T., Russo, I. (2025). Activating the Consumer: Toward More Sustainable Last-Mile Delivery. *Journal of Business Logistics*, *46*(4). https://doi.org/10.1111/jbl.70041
37. Schünemann, J., Finke, S., Severengiz, S., Schelte, N., Gandhi, S. (2022). Life Cycle Assessment on Electric Cargo Bikes for the Use-Case of Urban Freight Transportation in Ghana. *The 29th CIRP Conference on Life Cycle Engineering, April 4-6, 2022, Leuven, Belgium.*, *105*, 721-726. https://doi.org/10.1016/j.procir.2022.02.120
38. Sillero Illanes, C., Rogalski, T., De Cubber, G., Kowalik, M. (2025). *Case Study of the Drone Ecosystem of Podkarpackie (Poland) - Insights from the Exploratory Research Activity Regions Dual Use Open Strategic Autonomy Exploratory (REGDUALOSA)*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/2679576, JRC143402.
39. Silva, K.O.A.N., Lima, R.S., Alves, R. (2024). The Impacts of the Pandemic on Urban Freight Deliveries: A Case Study in a Brazilian Carrier. *International Journal of Simulation Modelling*, *23*(1), 65-76. https://doi.org/10.2507/IJSIMM23-1-672
40. Stokkink, P., Geroliminis, N. (2025). On the optimal micro-hub locations in a multi-modal last-mile delivery system. *Transportation Research Part E: Logistics and Transportation Review*, *203*. https://doi.org/10.1016/j.tre.2025.104344
41. Shramenko, N., Hupfer, C., Shramenko, V., Trojanowski, P. (2025). Electric Cargo Bikes in Urban Logistics: Scenarios and Their Contribution to Sustainable Mobility. *9th EAI International Conference on Management of Manufacturing Systems: MMS 2024*, 1.
42. World Economic Forum (2020).*Urban Deliveries Expected to Add 11 Minutes to Daily Commute and Increase Carbon Emissions by 30% until 2030 without Effective Intervention*. Retrieved from: https://www.weforum.org/press/2020/01/urban-deliveries-expected-to-add-11-minutes-to-daily-commute-and-increase-carbon-emissions-by-30-until-2030-without-effective-intervention-e3141b32fa/, June 1, 2026.
43. Wahab, S.N., Ahmed, N., Samsuddin, S.F. (2025). Parcel Locker as a Solution for Sustainable Operations and a Contactless Self-Service Solution for Last-Mile Delivery. *Operations and Supply Chain Management*, *18*(1), 79-88. https://doi.org/10.31387/oscm0600456

44. Wahab, S.N., Hye, M.N., Ramakrishna, Y. (2022). Impact of Automated Parcel Stations on E-Commerce's Last-Mile Delivery. *Environment-Behaviour Proceedings Journal*, *7*(21), 49-55.
45. Waqas, U., Umair, S., Mrugalska, B., Ali Sulaiman, M.A.B. (2025). Twin transformation: The role of digitalization with artificial intelligence, big data and circular supply chain in circular economy performance for sustainability. Equilibrium. *Quarterly Journal of Economics and Economic Policy, 20(2),* 613-645. https://doi.org/10.24136/eq.3350
46. Werner, P.A., Porczek, M., Kaleyeva, V., Brauntsch, P. (2024). Automated Parcel Machines Innovation: The Case Study of InPost in the EU and in Poland. *International Conference on Computational Science and Its Applications*, 312-323.
47. Yılmaz, İ., Özceylan, E., Mrugalska, B. (2023). A framework for evaluating electrical vehicle charging station location decisions in a spherical fuzzy environment: a case of shopping malls. *Annals of Operations Research*, 1-25. https://doi.org/10.1007/s10479-023-05772-x

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

AUTOMATION IN CREATING SUPPLY CHAIN AMBIDEXTERITY

Agnieszka BUKOWSKA-PIESTRZYŃSKA[1*], Urszula MOTOWIDLAK[2]

[1] Institute of Logistics and Informatics, Faculty of Economics and Sociology, University of Lodz;
agnieszka.bukowska@uni.lodz.pl, ORCID: 0000-0002-0088-2352
[2] Institute of Logistics and Informatics, Faculty of Economics and Sociology, University of Lodz;
urszula.motowidlak@uni.lodz.pl, ORCID: 0000-0002-2777-9451
* Correspondence author

Purpose: The aim of the article is to show how automation affects the ambidexterity of the supply chain and the problem on which the study was focused comes down to answering the question: What market-oriented changes have occurred in the logistics center as a result of process automation? The hypothesis was verified: The automation of logistics processes has a positive impact on supply chain ambidexterity (by simultaneously enhancing resilience and agility).
Design/methodology/approach: The research methods and techniques used included, among others: content analysis, non-standardized interview, selected methods of qualitative analysis, case study.
Findings: The article reviews selected definitions of resilience, agile and ambidexterity supply chain. Automation creates the ability of the supply chain to withstand unexpected disruptions in the short term, as well as the ability to adapt to change and growth in the long term. Based on a literature review, the A–R/A–A (Automation–Resilience/Agile–Ambidexterity) model is proposed, identifying the mechanisms through which automation enhances both resilience and agility, creating a synergy effect that leads to SC-Ambidexterity. Theoretical considerations are supplemented with a case study - that demonstrates the benefits of automation, including operational, cost and organizational aspects.
Research limitations/implications: The empirical part of the study has limitations because a single observation does not allow for broad conclusions and generalization of results. Further research projects in this area should include a larger research group.
Practical implications: The presented benefits of implementing automation in a logistics center may serve as a point of reference for other entities.
Social implications: Automation increases the demand for digital competences, which implies the need for employee training (e.g. in the use of robots and AI systems).
Originality/value: This work demonstrates the importance of automation for synergizing supply chain resilience and agility. The presented case study serves as an example of good practices in logistics center automation to achieve supply chain ambidexterity.
Keywords: ambidexterity supply chain, resilience supply chain, agile supply chain, automation, Industry 4.0.
Category of the paper: research paper.

1. Introduction

Operating in a VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) environment requires a redefinition of the approach to supply chain design (Bukowska-Piestrzyńska et al., 2022). High volatility and uncertainty in the environment—exacerbated by the COVID-19 pandemic and geopolitical conflicts—have rendered traditional management models inadequate. Research indicates that companies operating in a turbulent environment must develop dynamic capabilities that enable them to quickly respond to changes and maintain operational continuity (Kołodziej et al., 2024). The literature highlights two complementary approaches: supply chain resilience (SC-Resilience) and agility (SC-Agile), as a response to contemporary challenges. Both are key elements in building competitive advantage, especially in conditions of unpredictable disruptions. Their synergy results in ambidexterity (SC), the ability of an organization to simultaneously achieve resilience and agility—the ability to balance two goals: leveraging existing capabilities (efficiency and cost reduction) and exploring new solutions. Research indicates that companies which can balance these areas achieve higher efficiency and better market results (Alsawalhah, 2025).

In the digital era, ambidexterity is particularly important – technologies such as AI, IoT, predictive analytics, and blockchain enable both risk monitoring and rapid response to changes (Berko, 2025). Automation and robotics increase flexibility, minimizing human error and adapting an entity's operations to changing demand. Thanks to these solutions, supply chains can better respond to the challenges of modern markets, achieving higher efficiency and customer satisfaction in global networks.

The aim of this article is to identify the essence and significance of ambidexterity – rooted in resilience and agility – o in modern supply chains, and to determine the impact of selected Industry 4.0 technologies on its development. The hypothesis will be verified: The automation of logistics processes has a positive impact on supply chain ambidexterity (by simultaneously enhancing resilience and agility). The proposed A-R/A-A (Automation–Resilience/Agile–Ambidexterity) model synthesizes insights from a comprehensive literature review and explains the mechanisms through which automation shapes organizational resilience and agility, ultimately strengthening their synergy in the pursuit of ambidexterity. Theoretical assumption are complemented by an empirical illustration based on the case of Arvato SCS Ltd., which supports the investigation of the research question: *What market-oriented changes have occurred in a logistics center as a result of process automation?* The analysis demonstrates that automation constitutes a critical driver of competitive advantage in turbulent environments. The article is theoretical and empirical in nature.

2. Literature review

2.1. Resilience and agility in developing Supply Chain Ambidexterity

Supply Chain Resilience – defined in the literature at the beginning of the century (Christopher, Peck, 2004) – is the ability of a system to prepare for disruptions, absorb their effects, and quickly return to a state of equilibrium or achieve a new, stable level of functioning. The literature emphasizes that resilience encompasses both structural elements (e.g., resource redundancy) and behavioral elements (e.g., an organizational culture that promotes flexibility) (Kołodziej et al., 2024). The main actions that increase supply chain resilience include: supplier diversification, information integration, employee competency development, and the implementation of digital technologies enabling real-time risk monitoring (Wang, 2023). From an analytical perspective, resilience is not a state but a continuous process, and in conditions of permanent volatility, it should include (Craighead et al., 2007; Sheffi, 2021):

- systematic identification of threats/disruptions,
- absorbing their effects and assessing the vulnerability of individual links,
- testing alternative operating scenarios and reconfiguring processes,
- implementing solutions that increase flexibility and shorten response time – returning to a stable operational level.

SC-Resilience – as complex adaptive systems – is capable of not only surviving periods of instability but also quickly rebuilding its operational potential and returning to market competition, often strengthened with new competencies and advantages. This means consciously and systematically strengthening mechanisms that enable business continuity and the capability to quickly responding to changes in the environment (Azevedo et al., 2013). In the context of competitiveness, resilience allows enterprises to limit losses resulting from disruptions, maintain supply continuity, and build a reputation as a reliable business partner. In summary, supply chain resilience is a decisive factor for long-term success – thanks to flexible, reliable and comprehensive logistics solutions supported by digital tools, real-time transparency and intelligent automation, entities can maintain/increase their competitive position in the market.

Supply Chain Agile is a concept that has become crucial in recent years of logistics, when pandemic-related disruptions in supply chains significantly impacted the functioning of enterprises. A responsive supply chain enables rapid response to market changes – it refers to the ability to quickly react to changes in demand, market conditions, and customer requirements (Christopher, 2000). That is particularly important in industries with high demand volatility and short product lifecycles, as it ensures rapid response to customer needs through flexible logistics processes (Gligor, Holcomb, 2013). Analyses confirm that agile supply chains achieve higher operational efficiency and better financial results thanks to their ability to quickly adapt to market changes (Alfalla-Luque et al., 2023). This includes, among other things, shortening lead

times, flexible production planning, rapid resource reconfiguration, and effective information management.

Contemporary definitions of agile logistics revolve around the following interpretations (Gligor, Holcomb, 2013):

- responsiveness – quick response to changes in demand,
- resource flexibility – the ability to reconfigure networks and processes,
- data visibility – the role of big data, IoT, and analytics,
- customer focus – logistics designed "backwards.

Assuming that agile logistics is the ability to quickly reconfigure a logistics network through the integration of physical and information infrastructure, automation solutions and Industry 4.0 technologies (e.g., the use of big data and analytics for rapid decision-making) are crucial for its implementation (Obora, 2020).

In today's economy, agility and resilience are intertwined – agility enables rapid response to change, while resilience allows for resilience to withstand disruptions. Together, they form the foundation of the so-called ambidextrous supply chain, meaning one capable of simultaneously exploring new opportunities and utilizing existing resources (Khan, 2024). Logistics ambidexterity can be thought of as the ability to quickly reconfigure flows and resources in response to disruptions and demand variability (Tushman, O'Reilly, 1996). Research also indicates that supply chain ambidexterity is a strong predictor of Supply Chain 4.0 maturity (Alamsjah, Yunus, 2022). The literature indicates that companies that combine resilience and agility achieve the greatest competitive advantage. Integrating these approaches allows for both minimizing risk and maximizing flexibility, which is crucial in conditions of uncertainty (Khan, 2024; Kołodziej et al., 2024).

2.2. Automation in the Catalog of Industry 4.0 Solutions

The economy is witnessing a rapid acceleration in the automation of logistics centers (investments in mobile robots, autonomous systems, digital twins, and advanced data analytics). Logistics is becoming an area of intense digitization, and logistics centers are transitioning from a manual work model to one based on data and automation. Based on research by Boustan et al. (2022), it can be concluded that automation:

- stabilizes processes,
- reduces dependence on human labor,
- increases precision and repeatability,
- enables scalability of operations.

And although it also carries risks: system failures, dependence on technology suppliers, and high investment costs, the benefits resulting from it cannot be overestimated. In practice, it encompasses not only the use of robots, stacker cranes, and conveyors (to maintain operational continuity without relying on personnel), but also enables:

- automatic inventory tracking and identification of goods in warehouses and the reduction of inventory errors (RFID systems),
- monitoring the location of vehicles and shipments, enabling route optimization and delay detection (GPS sensors),
- monitoring deviations and ensuring compliance with standards in cold chains, e.g., food and pharmaceuticals (temperature and humidity sensors),
- detecting damage during transport, supporting proactive logistics (shock and vibration sensors).

Industry 4.0 is contributing to the emergence of new solutions supporting the functioning of modern supply chains, including by increasing process transparency, reducing human error, shortening response times, and enabling data-driven decision-making. The most popular solutions in the area of Industry 4.0 information technology include: the Internet of Things (IoT), the Internet of Services (IoS), the Internet of Things (IIoT), big data and data analytics (BD/BDA), cloud computing (CC), Blockchain technology (BC), additive manufacturing with 3D printing (AM/3D-P), augmented and virtual reality (AR/VR), and artificial intelligence (AI) with its supporting algorithms, machine learning (ML) and deep learning (DL) (Nascimento et al., 2019). These can be used in logistics to create ambidextrous supply chains: capable of real-time adaptation, intelligence, and self-organizing. Example applications include:

- real-time monitoring of material flows (thanks to IoT), which supports the pull system,
- supporting optimization of schedules and transport routes, automated decision-making, and waste detection in processes (using AI),
- supporting the identification of waste sources, optimization of transport routes, demand prediction, and lead time reduction (thanks to BDA),
- supporting standardization and error elimination (thanks to mobile robots (AMRs), autonomous vehicle guidance (AGVs), and automated warehouse systems (AS/RS),
- increasing supply chain transparency, reducing documentation errors, and strengthening the "right first time" principle (thanks to BC capabilities). - centralization of data from WMS/ERP to forecast disruptions (BD/BDA),
- simulation training and rapid location of goods in crisis (VR/AR).

Literature points to implementation barriers such as high investment costs, lack of employee digital competencies, resistance to change (Piercy & Rich, 2009), lack of a coherent process improvement strategy, and difficulties in integrating IT systems. Despite this, investments in automation and digitization generate ROI by reducing costs and increasing flexibility and are a step towards ensuring sustainable ambidexterity of supply chains.

2.3. Automation and Ambidexterity

Assuming that automation directly impacts both the resilience and agility of the supply chain, a model of this relationship can be presented – see the figure. The authors attempted to present a model combining three key elements:

- automation (understood as the implementation of technologies and systems that increase the efficiency and standardization of logistics processes),
- resilience (understood as the system's ability to maintain operational continuity and quickly respond to disruptions),
- agility (referring to the flexibility and speed of adaptation to changing market conditions) of the supply chain.

The result of an integrated approach to supply chain security is ambidexterity. It is determined primarily by the quality of system integration, employee competencies, and the level of process standardization, closely related to the level of automation in the logistics center.

The figure 1 shows examples of the impact of automation on supply chain resilience and agility. Automation solutions and the application of Industry 4.0 technologies enable:

- absorption of disruptions, ensuring stability and business continuity, increasing supply chain resilience,
- easier reconfiguration and scalability of resources, and increased response speed, thus improving supply chain agility.

This results in the creation of an ambidexterity supply chain, which can be described as:

- data is a key element, and its proper use (e.g., predictive analytics supporting decisions) enhances the synergy of combining resilience and agility,
- optimal supply chain resilience and agility is achieved through a hybrid approach, combining automation with flexibility and human competencies. Therefore, a balance between these elements is necessary – related to investments in technology, employee development, and contingency planning,
- automation is a tool supporting resilience and agility, but it does not completely replace the role of humans in the supply chain.

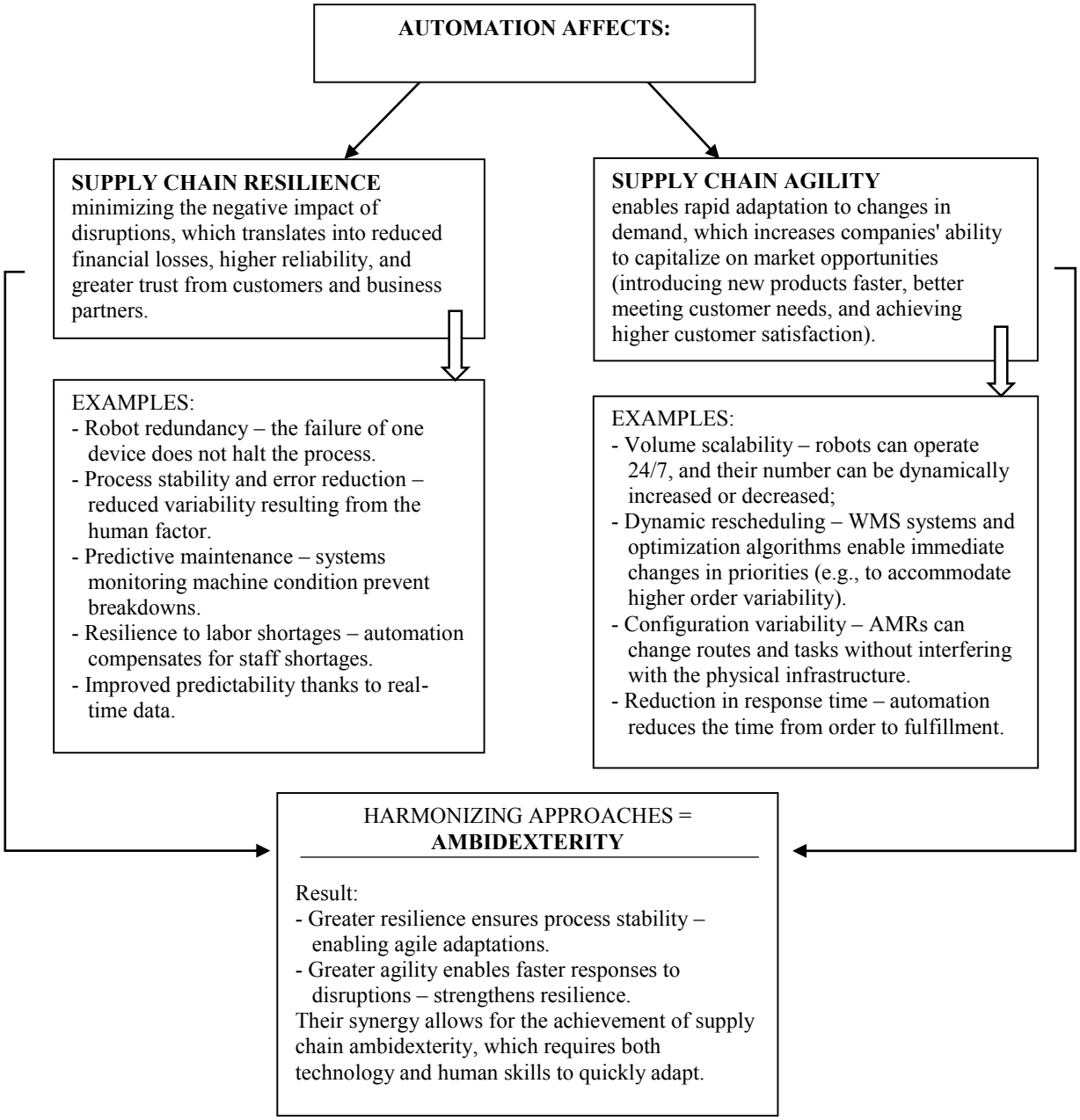


Figure 1. Model A – R/A – A (Automation – Resilience/Agile – Ambidexterity).

Source: own elaboration.

In summary, data plays a key role as an element integrating both dimensions: agility and resilience – thus creating a new approach to supply chains: ambiexterity. Automation should be designed modularly and scalably to simultaneously increase resilience without hindering agility. Therefore, it is crucial to:

- invest in employee digital skills,
- consistently and continuously develop monitoring and cybersecurity systems,
- use digital twins to test disruption scenarios.

3. Methods

Selected research methods and techniques were applied to achieve the study's objective. Descriptive analysis was used to characterize the research subject. The method of literature analysis and criticism proved useful for systematizing current scientific findings and the state of knowledge regarding the specific nature of contemporary supply chains and the role of automation in their functioning. The literature review followed the classical methodological approach.

The empirical part of the study employed qualitative research methods, specifically a case study (based on a study visit conducted on 26-28 March 2026) and an unstructured interview**.** The interview involved the warehouse operations manager and a WMS specialist. They were asked among other things:

- how automation had influenced supply chain resilience and agility,
- what changes had occurred in the flow and duration of logistics processes,
- how the implementations had affected the center's ability to handle disruptions,
- what changes had taken place regarding staffing and the scope of employee responsibilities.

The primary data source consisted of direct observations of warehouse processes**,** including picking, packaging, returns handling, internal transport, and human–robot interactions. Additional insights were obtained from an unstructured interview with the operations manager of the logistics center. It should be emphasized that a single observation limits the scope of inference and does not allow for broad generalization of the results to other entities; however, it provides a valuable reference point for further research.

The analyzed entity was Arvato SCS Ltd., located in Stryków-Pieńki near Łódź, one of the key logistics centers serving the global H&M network in Central and Eastern Europe. The facility functions as a regional distribution hub integrating warehousing, picking, automation, and omnichannel order-fulfillment processes. In recent years, the company has implemented extensive modernization initiatives, including the automation of warehouse operations and the deployment of the Shuttle system[1] (supplied by KNAPP).

[1] The system occupies 10,000 m², has a capacity of 270,000 cartons, and employs 144 trolleys (moving at speeds of up to 70 km/h along 15 aisles on 16 storage levels). The total operational area is 98,000 m² (including mezzanine space) thanks to a high-bay warehouse facility using reach trucks to service 8.7-meter-high racks.

4. Results

Arvato SCS Ltd., as a logistics operator serving a global fashion brand, operates under conditions of high demand volatility, seasonality, and time pressure. Therefore, market conditions require the resilience and agility of the supply chain to be maintained. Ambidexterity is particularly important for Arvato, as it handles both its business partner's stores (B2B) and e-commerce customers (B2C). In the fashion industry, logistics is a key factor in building a competitive advantage, so the operator responsible for it must operate in a way that not only meets sales targets but also responds quickly to short-term trends (which, especially under the influence of social media, can change overnight).

Before making the investment, a diagnosis of the main operational risks was conducted at Arvato SCS Ltd. to identify areas requiring special attention. Among other things, the following were identified[2]:

- demand disruptions – sudden changes in H&M's order volumes, especially during sales and marketing campaigns,
- operational risks – infrastructure failures, overloaded manual processes,
- HR risks – seasonal employee shortages.

These identified risks became the basis for implementing automation as a tool to increase supply chain ambidexterity. The drive to quickly respond to changes (bypassing them or shortening the time from occurrence to repair/elimination) and, on the other hand, strengthen the ability to survive disruptions (through reactive response and recovery) was intended to help achieve higher functionality and better meet customer needs (both in B2B and B2C). The main expected effects of automation at Arvato SCS Ltd. include[3]:

- an increase in picking efficiency by 30-40%,
- a 25% reduction in operational errors,
- a 15-20% reduction in order fulfillment times and the achievement of an "order today – receive tomorrow" delivery model.

To achieve these goals, the company implemented solutions including[4]:

- the Shuttle automated storage system, which provides high storage capacity and utilizes an extensive fleet of forklifts operating across multiple rack levels. This solution significantly increases operational flexibility; the system can dynamically adapt to changing order volumes.

[2] Based on internal company documents *Risk & Continuity Assessment 2023*.
[3] Internal document *Operational Excellence Report 2023*.
[4] Internal *Automation Roadmap 2022-2025.*

- advanced logistics automation – designed to improve process stability and reliability. Full automation of the goods receipt process[5] (from the loading dock to product placement in the Shuttle[6]) eliminates downtime, reduces errors, and accelerates product flow. The proprietary "Leleka" robotic system is responsible for retrieving fashion items from bulk packaging and precisely placing them in the pocket sorting system. Thanks to a vision system (based on AI), it determines the optimal arrangement of goods (even irregularly shaped ones) in the container, checks barcode readability, and ensures correct product orientation. An extensive internal transport system, based on conveyor belts[7], integrates various warehouse zones. The use of AGVs traveling in loops over 4 km long, automated picking systems (AS/RS), high-performance sorting systems, automated packaging lines, and multi-level mezzanines increases the independence of processes from random factors. Automation ensures repeatability and high efficiency, eliminating the risk of human error and bottlenecks in the picking process. This allows for maintaining a high level of customer service under increased load. Additionally, dynamic replenishment algorithms are used to control the flow of goods between the high-bay and picking areas, minimizing the risk of bottlenecks that could disrupt operational continuity.
- Digitalization and predictive analytics (Big Data) – process visibility is the foundation of ASC, and operations management is supported by the SAP system, which allows for real-time monitoring of flows. Thanks to Big Data analytics, Arvato is able to forecast resource requirements (people and equipment), preventing infrastructure overload during peak sales periods. Advanced WMS systems with predictive modules support real-time decision-making and dynamic location management[8], significantly increasing chain ambidexterity (e.g., rapid response to potential disruptions – such as manufacturer delivery delays or courier transport problems).

[5] As goods are unloaded from a delivery truck, conveyor belts extend to support the unloading process. They adjust to the vehicle's depth, streamlining the unloading process and reducing the workload for employees. The goods are then transported to their designated location via conveyor belts. They are automatically scanned during the movement, allowing for smooth and rapid product movement.

[6] The Shuttle High-Bay System streamlines warehouse space management and accelerates order picking by automatically delivering goods to operators. This reduces the need for employees to move around the warehouse, reducing errors, increasing operational efficiency, and improving work ergonomics.

[7] Telescoping Conveyor Belts enable rapid loading and unloading of goods (directly into trailers and containers). Their flexible design significantly shortens the time of reloading operations while reducing physical exertion on workers, improving ergonomics and occupational safety.

[8] In the event of a sudden increase in demand for a given group of goods/the appearance of a new collection, the system automatically allocates it the places closest to the packing zone to shorten the time (which guarantees quick adaptation to the change).

- Regularly conducting resilience tests, which include[9]: volume stress tests (simulations of surges in orders), automated system failure tests, IT continuity tests, and scenario analyses of transport disruptions. Test results form the basis for further process improvements (in line with the Kaizen philosophy).
- Improving employee competencies[10] – employee training is conducted in the use of automated systems and the development of the analytical potential of operational teams, which facilitates the creation of interdisciplinary teams (combining IT, operations, and planning). Cross-skilling is crucial for operational employees – employees are trained to handle various operations (multiskilling) to increase operational flexibility and accelerate process execution. A culture of continuous improvement is promoted.

Al-Banana et al. (2023) point to the growing convergence of research on resilience, investment in digital technologies, and the Industry 4.0 transformation. The authors found that organizations increasingly view digital investments as a strategic tool for building resilience and agility.

Industry 4.0 technologies significantly enhance supply chain ambidexterity by increasing flow visibility, enabling faster detection of and response to disruptions, and streamlining decision-making processes (including real-time decision-making) (Totorella et al., 2022).

5. Discussion

Creating the foundation for such advanced infrastructure would not have been possible without the full commitment of employees from both Arvato SCS Ltd. and its partner, H&M. The three-year expansion of the center now allows the logistics service provider to fully utilize SC-Ambidexterity in practice and reap the benefits of the implemented solutions – implementing the "order today – receive tomorrow"[11] delivery model while maintaining scalability of operations (meaning significantly reduced order fulfillment times and the ability to process significantly higher order volumes during peak periods, such as Black Friday, without the need for a proportional increase in staffing). Examples of the specific benefits achieved through the three-year investment are presented in the table 1.

[9] In accordance with the procedures described in the Business Continuity Plan 2023.
[10] In accordance with the guidelines of the internal document People & Skills Development Report 2023.
[11] In the e-commerce industry, this is one of the most important competitive factors.

Table 1.
Benefits of the implemented automation changes at Arvato SCS Ltd.

Levels of effects of implementing automation and digitization at Arvato SCS Ltd.	Examples of benefits
Technological changes	- real-time system integration, leading to increased process efficiency, • increased use of operational data, • transition from reactive to predictive systems, - development of IoT infrastructure.
Operational changes	- Reduction in picking times, - Process stabilization – robots eliminate variability resulting from human labor, e.g., during peak periods, - Reduction in errors and complaints, - Increased throughput and process stability – standardization and automatic alerts allow for shorter response times to disruptions, - Greater scalability of operations during periods of increased demand, without the need to increase staffing levels or reorganize the warehouse, - Better inventory control, - Automation of internal transport,
Cost changes	- reduction of labor costs, - optimization of space costs,
Organizational changes	- reducing the need for heavy physical labor, - new job positions, e.g., robotics technicians, or increasing the number of data analyst and system operator positions, - flattening the management structure and changing the role of managers – from operational supervision to data management, - increasing the role of interdisciplinary teams,
Competency changes	- increased demand for digital skills, - training in the use of robots and AI systems, - shifting the nature of work from manual to supervisory.
Competitiveness of a company	- increased flexibility and responsiveness to market changes, - faster order fulfillment and greater product availability with fewer order errors improves the quality of customer service (in both B2B and B2C), - increased technological advantage. - potential for scalability and further automation, - shortened order fulfillment times, - reduced operating costs.

Source: own elaboration.

The operations of the Arvato logistics center in Sosnowiec-Pieńki for H&M demonstrate that implementing the SC-Ambidexterity concept is not only possible, but also necessary in modern logistics to build long-term cooperation with a business partner.

Further actions that could impact the SC-Ambidexterity of the analyzed company could include:

- introducing smart glasses/wristbands/watches for employees, which would inform them in real time about changes in priorities and notify them of errors[12]. This would enable seamless human resources management,

[12] In the event of a bottleneck (e.g. a failure), an IT employee could easily and quickly delegate one of the warehouse employees who is closest/has the appropriate competences to deal with the problem (e.g. repair the fault).

- predictive analysis using AI could go beyond standard planning (assessing traffic situations) and, for example, introduce algorithms that can predict sudden demand for specific clothing models based on weather or social media trends,
- introducing a full Digital Twin – moving from simple process visibility to hyper-predictability – a virtual copy of the warehouse would enable testing of crisis scenarios (e.g., simulating crises – a failure of the main sorter or border closures – without interrupting operations). This would allow for optimizing flows and identifying bottlenecks before they actually occur, and developing ready-made response procedures.

The results obtained from the case study confirm that automation should not be viewed solely as a cost-reduction tool, but rather as a strategic instrument for building resilience, agility, and long-term competitive advantage. While the analysis of changes within a single entity limits the generalizability of the findings to other logistics centers, it can serve as a benchmark for comparative analysis. The obtained results can be linked to the findings of Belhadi et al. (2021), who indicate that Industry 4.0 technologies alone do not ensure improved supply chain performance. A key role is played by digital transformation supported by organizational ambidexterity, which enables the simultaneous improvement of existing processes and the creation of new operating models. Thus, ambidexterity acts as a mediator between Industry 4.0 capabilities and operational outcomes.

The conclusions indicate that successfully fostering ambidexterity requires not only technological investments but also data integration, process standardization, and the development of employees' digital competencies—a challenge for both the workforce and the organization. Ultimately, the greatest value is generated by hybrid operational models that combine automation capabilities with human potential, enabling organizations to respond effectively to disruptions, capitalize on emerging market opportunities, and maintain high competitiveness in a turbulent environment.

Research by Ghobakloo et al. (2025) also indicates that Industry 4.0 technologies enhance the resilience and agility of supply chains.

In summary, Arvato SCS Ltd. in Stryków is an example of a modern, resilient, and agile logistics center, where process automation, customer collaboration, and employee competency development create a coherent system that increases stability and operational efficiency. The implemented solutions align with the concept of complex adaptive systems, enabling the company to function effectively in conditions of volatility and uncertainty typical of the fashion and TFL industries.

6. Conclusions

The increasing unpredictability of the external environment has become a defining characteristic of 21st-century economic reality, making enhanced adaptability and agility essential imperatives for strategic supply chain management**.**

Dynamic market fluctuations, rising customer expectations, and growing pressure to reduce order-fulfillment times have positioned logistics centers as a critical domain of digital transformation. Technologies such as automation, robotics, IoT, predictive analytics, and artificial intelligence are reshaping warehouse operations, enabling greater flexibility, resilience, and efficiency.

A comprehensive literature review indicates that SC-resilience and SC-agility constitute the foundation for achieving competitive advantage in today's turbulent business environment. Resilience allows organizations to withstand disruptions and maintain operational continuity, whereas agility enables rapid responses to market changes and the ability to seize emerging opportunities. However, the greatest competitive value arises from integrating both approaches – an orientation known as SC-ambidexterity. Firms that develop dynamic capabilities, invest in digital technologies, and cultivate an organizational culture that promotes flexibility and innovation achieve superior levels of resilience, agility, and overall market performance.

Automation is a significant factor in strengthening SC-ambiexterity. It creates the supply chain's ability to withstand unexpected disruptions in the short term, as well as the ability to adapt to change and thrive in the long term (Pettit et al., 2010). Its impact is visible primarily on three levels: operational (changing the way processes are performed), information (improving the quality and speed of data flow), and structural (changing the resource architecture). Properly designed automated systems increase companies' ability to respond to disruptions, maintain business continuity, and adapt to changing market conditions.

In logistics centers, Industry 4.0 tools and operational improvements significantly improve SC-Ambidexterity, enabling real-time monitoring, disruption prediction, and rapid adaptation. Digitalization leverages IoT for real-time monitoring, AI for disruption prediction, and big data for process optimization. Automation and robotics, such as autonomous unloading, increase flexibility, minimize human error, and adapt to fluctuating demand. Digitalization makes supply chains more resilient to crises, for example, through real-time forecasting and centralized inventory management. The results include shorter lead times, higher efficiency, and improved customer satisfaction across global networks. And predictive analysis enables agile behaviors that allow for organizational flexibility.

The logistics center operated by Arvato SCS Ltd. illustrates the practical implementation of the ambidextrous supply chain concept. The application of advanced IT systems for warehouse management enables real-time monitoring of material flows, inventory levels, and the coordination of order-picking and shipping activities. This capability supports the rapid

identification of operational irregularities and the timely introduction of corrective measures. Digitalization enhances overall process transparency, which is particularly critical in environments characterized by high product volumes and intensive warehouse traffic, such as the apparel sector.

Although the study examined a single logistics center—thereby limiting the generalizability of the findings—it nonetheless allows several broader observations:

- Resilience and agility do not stem from robotization alone but from the integration of data and the process standardization that automation necessitates.
- Automation should be viewed as an element of a broader SC-Ambidexterity strategy rather than solely as a tool for cost reduction.
- The development of hybrid human–robot work models is becoming increasingly important, and logistics centers should invest in strengthening employees' analytical and technical competencies.

Furthermore, the insights gained from this case study will enable the authors to develop a structured interview questionnaire that can be used in research at subsequent logistics centers.

Based on the relevant literature (Belhadi et al., 2021; Tortorell et al., 2022; Wang et al., 2023), the authors consider the research direction concerning the Supply Chain Ambidexterity model—supported by Industry 4.0 technologies—to remain within their scope of interest.

References

1. Alamsjah, F., Yunus, E.N. (2022), Achieving Supply Chain 4.0 and the Imortance of Agility, Ambidexterity, and Organizational Culture: A Case of Indonesia. *Journal of Open Innovation: Technology, Market, and Complexity, 8(2),* p. 83, http://doi.org?10.3390joitmc8020083
2. Al-Banna, A., Rana, Z.A., Yaqot, M., Menezes, B.C. (2023), Interconnectedness between Supply Chain Resilience, Industry 4.0, and Investment. *Logistics, 7(3),* p. 50, https://doi.org/10.3390/logistics7030050
3. Alfalla-Luque, R., Garcia, D.E.L., Marin-Garcia, J.A. (2023). Supply chain agility and performance: evidence from a meta-analysis. *International Journal of Operations & Production Management, 43(10),* pp. 1587-1633, http://doi.org/10.1108/IJOPM- 05-2022-0316
4. Alsawalhah, A. (2025). Exploring the Theoretical Framework and Core Dimensions of Organizational Ambidexterity. *Journal of Business and Administrative Studies, 2(2),* pp. 1-12.

5. Azevedo, S.G., Govindan, K., Carvalho, H., Cruz-Machado, V. (2013). Ecosilient Index to Asses the Greenness and Resilience of the Upstream Automotive Supply Chain. *Journal of Cleaner Production, vol. 56*, pp. 131-146, http://doi.org/10.1016/j.jclepro.2012.04011
6. Belhadi, A., Kamble, S.S., Gunasekaran, A., Mani, V., Benkhati, I., Toriki, F.E. (2021). Analyzing the mediating role of organizational ambidexterity and digital business transformation on Industry 4.0 capabilities and sustainable supply chain performance. *Supply Chain Management: An International Journal, 26(6),* pp. 696-711, https://doi.org/10.1108/SCM-04-2021-0152
7. Berko, L.O. (2025). Advanced supply chain analytics: Leveraging digital twins, IoT and blockchain for resilient, data-driven business operations. *World Journal of Advanced Research and Reviews, no. 2*, pp. 1777-1799, http://doi.org/h1030574/ wjarr.2025.25.2.0572
8. Boustan, L.P., Choi, J., Clingingsmith, D. (2022). Computerized Machine Tools and the Transformation of US Manufacturing. *NBER Working Paper No. 30400.* https://www.nber.org/papers/w30400
9. Bukowska-Piestrzyńska, A., Doński-Lesiuk, J., Karkowski, T.A., Motowidlak, U. (2022). *Adaptacyjność łańcuchów dostaw we współczesnej gospodarce. Studium na przykładzie produktów leczniczych i wyrobów medycznych.* Łódź: Wyd. UŁ.
10. Christopher, M. (2000). The Agile Supply Chain: Competing in Volatile Markets. *Industrial Marketing Management, 29(1)*, pp. 37-44. https://doi.org10.1016/S0019-8501(99)00110-8
11. Christopher, M., Peck, H. (2004). Building the Resilient Supply Chain. *The International Journal of Logistics Management, 15,* pp. 1-14. https://doi.org/10.1108/ 09574090410700275
12. Craighead, Ch.W., Blackhurst, J., Rungtusanatham, J.M., Handfield, R.B. (2007). The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities. *Decision Sciences, vol. 38, no. 1*, pp. 131-156, https://doi.org/10.1111/j.1540-5915.2007.00151.x
13. Ghobakhloo, M., Iranmanesh, M., Foroughi, B., Tseng, M.-L., Nikbin, D., Khanfar, A.A.A. (2025). Industry 4.0 digital transformation and opportunities for supply chain resilience: a comprehensive review and a strategic roadmap. *Production Planning & Control, 36(1),* pp. 61-91, https://doi.org/10.1080/09537287.2023.2252376
14. Gligor, D.M., Holcomb, M.C. (2013). Antecedents and consequences of supply chain agility: Establishing the link to firm performance. *Journal of Business Logistics, 33(4),* pp. 295-308, https://doi.org/10.1111/jbl.12003
15. Internal documents of Arvato SCS Ltd.

16. Khan, M.H. (2024). Enhancing supply chain resilience: The role of SC-ambidexterity and SC-agility. *Journal of Future Sustainability, no. 4,* pp. 189-214, https://doi.org/10.5267/j.jfs.2024.10.002
17. Kołodziej, D., Żak, K., Rydzewski, R., Zatoński, M. (2024). Organizational resilience and its contexts – a systematic review of the literature. *Scientific Papers of Silesian University of Technology. Organization and Management Series, no 207*, pp. 251-273, http://dx.doi.org/10.291191641-3466.2024.207.14
18. Nascimento, D., Alencastro, V., Quelhas, O., Caiado, R., Garza-Reyes, J., Lona, L., Tortorella, G. (2019). Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal. *Journal of Manufacturing Technology Management, 30(3),* pp. 607-627. https://doi.org/10.1108/JMTM-03-2018-0071
19. Obora, H. (2020). Integracja podejść lean i agile w zarządzaniu łańcuchem dostaw. In: Kołodziejczak, M., Bednarska-Wnuk, I., Świątek-Barylska I., *Metody i Techniki zarządzania. Inspiracje dla teorii i praktyki.* Łódź: Wydawnictwo Uniwersytetu Łódzkiego, pp. 71-87, https://doi.org/10.18778/8220-435-3.04
20. Pettit, T.J., Fiksel, J., Croxton, K.L. (2010). Ensuring Supply Chain Resilience: Development of a Conceptual Framework. *Journal of Business Logistics, vol. 31, no. 1*, pp. 1-21; http://doi.org/10.1002/j.2158-1592.2010.tb00125.x
21. Piercy, N., Rich, N. (2009). Lean transformation in the pure service environment: the case of the call service centre. *International Journal of Operations & Production Management, 29(1)*, pp. 54-76. https://doi.org/10.1108/01443570910925361
22. Sheffi, Y. (2021). *What everyone gets wrong about the never-ending CVID-19: A cause study of JD.com*. IEEE Transactions on Engineering, https://doi.org/10.1002/joom.1161
23. Tortorella, G., Fogliatto, F.S., Gao, S., Chan, T.-K. (2022). Contributions of Industry 4.0 to supply chain resilience. *International Journal of Logistics Management, 33(2),* pp. 547-566. https://doi.org/10.1108/IJLM-12-2020-0494
24. Tushman, M.L., O'Reilly, C.A. (1996). Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review, 38(4),* pp. 8-30.
25. Wang, Y. (2023). Digital Transformation and Resilience in Global Supply Chains: A Comprehensive Review and Future Directions in the Post-COVID-19 Era. *Advances in Economics Management and Political Sciences 51(1),* pp. 140-145, http:doi.org/10.54254/2754-1169/51/20230649
26. Wang, Y., Yan, F., Jia, F., Chen, L. (2023). Building supply chain resilience through ambidexterity: an information processing perspective. *International Journal of Logistics Research and Applications, 26(2),* pp. 172-189. https://doi.org/10.1080/13675567.2021.1944070

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE ROLE OF EMBODIMENT, PRESENCE, AND INTERACTIVITY IN SHAPING CONSUMER EXPERIENCE IN VIRTUAL SPACES AND DIGITAL SERVICES

Elwira DUŚ-PRIETO[1*], Blanka WALAWSKA[2]

[1] Akademia Leona Koźmińskiego, Warszawa; edus@kozminski.edu.pl, ORCID: 0000-0003-0996-6648
[2] Akademia Leona Koźmińskiego, Warszawa; 45679@kozminski.edu.pl, ORCID: 0009-0009-0022-4403
* Correspondence author

Purpose: The purpose of this paper is to examine the role of immersive technologies in shaping consumer experience in virtual spaces and to identify the significance of embodiment, presence, and interactivity for the development of modern digital services.
Design/methodology/approach: The study is based on a quantitative research approach conducted among users of immersive technologies. Data were collected through a structured questionnaire and analyzed using descriptive statistics, correlation analysis, and regression analysis. The theoretical framework is grounded in the EPI model (Embodiment, Presence, Interactivity) and contemporary consumer experience theory.
Findings: The results indicate that immersive technologies significantly contribute to the quality of consumer experience in virtual environments. Interactivity demonstrated the broadest associations with consumer experience components and appears to play an integrative role in shaping the overall experience. Presence was most strongly related to the emotional component and also showed substantial associations with sensory and cognitive experiences. Embodiment was primarily linked to emotional and cognitive aspects of consumer experience.
Research limitations/implications: Its main limitations relate to the size and structure of the research sample, as well as the focus on selected immersive technologies. Future research should involve larger and more diverse samples, compare different types of virtual environments to provide a more comprehensive understanding of immersive consumer experiences.
Practical implications: The findings provide valuable insights for companies developing digital services, e-commerce platforms, and virtual environments. Understanding the factors that shape consumer experience may support the design of more engaging, personalized, and effective digital interactions.
Social implications: The growing adoption of immersive technologies may transform the way consumers interact with digital services, culture, education, and entertainment. The study highlights the increasing importance of virtual environments in everyday consumer experiences and social interactions.
Originality/value: The paper contributes to the growing body of knowledge on consumer experience in virtual spaces by integrating the EPI model with the context of modern digital services. It provides empirical evidence on the role of immersive technologies and offers practical recommendations for organizations operating in the digital economy.

Keywords: immersive technologies, consumer experience, EPI model, interactivity, digital services.
Category of the paper: research paper**.**

1. Introduction

The digital transformation has significantly influenced the development of the e-commerce and innovative digital services sectors, reshaping the nature of consumer–brand interactions and creating new opportunities for customer engagement in virtual environments (Vargo et al., 2024; Soto Setzke et al., 2023; Mazurek, 2018). Contemporary e-commerce often relies on new technologies, transforming it from sales channels into digital ecosystems and are a central element of an organization's digital transformation strategy (Verhoef et al., 2021). As online retail environments become increasingly sophisticated, consumer expectations extend beyond functional aspects of the purchasing process and encompass factors such as convenience, personalization, and the quality of the overall shopping experience (Ambika et al., 2025). At the same time, the absence of direct physical interaction with products remains one of the fundamental limitations of online shopping (Rudzewicz, 2010; Bartczak, 2016).

In response to these challenges, companies offering digital services, especially those operating in the e-commerce sector, increasingly employ immersive technologies, including virtual fitting rooms, 3D product configurators, digital showrooms, and augmented reality applications ((Narojczyk, 2025; Çil et al., 2026). These solutions enable consumers to interact with products in more engaging ways and contribute to the creation of enhanced digital experiences. Previous studies have generally shown that immersive technologies positively affect consumer perceptions, engagement, satisfaction, and behavioral intentions in retail environments (Poushneh, Vasquez-Parraga, 2017; Hilken et al., 2017; Jin et al., 2021; Kim et al., 2023).

Recent research suggests that the effectiveness of immersive environments is strongly shaped by the degree to which they evoke a sense of presence, embodiment, and interactivity (Lin et al., 2025; Mansoor et al., 2024; Leveau, Camus, 2023; Orus et al., 2021; Flavian et al., 2019). These dimensions influence consumers' cognitive, emotional, and behavioral responses during digital interactions with products and brands (Di Dalmazi et al., 2024). Furthermore, immersive technologies contribute to enhancing customer experience by facilitating greater engagement, product understanding, and perceived value (Çil et al., 2026).

Despite the growing body of literature on immersive technologies and virtual shopping environments, relatively little attention has been devoted to examining how specific dimensions of immersive experiences influence individual components of consumer experience. Existing studies tend to focus on the technological aspects of immersive solutions or their impact on selected behavioral outcomes, while the relationships between embodiment, presence,

interactivity, and the cognitive, emotional, sensory, pragmatic, lifestyle, and relational dimensions of consumer experience components identified by Gentile et al. (2007), remain insufficiently explored. This research gap is particularly evident in the context of integrated models that explain how virtual environments shape consumer experiences and generate value for digital service providers. Consequently, understanding the characteristics of virtual environments that shape consumer experience has become an important area of research within the fields of digital marketing and consumer behavior.

Therefore, the aim of this paper is to examine the role of immersive technologies in shaping consumer experiences in virtual spaces with particular emphasis on the significance of embodiment, presence, and interactivity in the context of modern digital services. The study refers to the six consumer experience components identified by Gentile et al. (2007): sensory, emotional, cognitive, pragmatic, lifestyle, and relational experience. At the same time, the empirical analysis focuses on four components considered especially relevant to immersive online shopping - sensory, emotional, cognitive, and pragmatic experience - which are examined in relation to the dimensions of the EPI model using correlation and regression analysis. The findings are intended to contribute to a better understanding of how immersive technologies can support the design of innovative digital services and virtual shopping environments.

2. Literature review: The EPI Model as a Framework for Understanding Consumer Experience in Virtual Spaces

Consumer Experience (CX) is commonly defined as a consumer's internal and subjective response to any direct or indirect contact with a company (Meyer, Schwager, 2007). It has also been conceptualized as an interactive process of value co-creation, in which customers actively participate in shaping their own experiences (Gentile et al., 2007). According to Gentile et al. (2007), consumer experience is dynamic in nature, evolving over time as a result of the cumulative interactions between the customer and the brand.

Consumer experience is increasingly recognized as a central element of organizational strategy and, consequently, should be deliberately designed and managed (Zomerdijk, Voss, 2010). More recent conceptualizations describe CX as a complex and longitudinal process involving the subjective and context-dependent interpretation of interactions with stimuli provided by a company (Becker, Jaakkola, 2020). From this perspective, consumer experience develops over time through multiple interactions between customers and a company.

Among the various conceptualizations of consumer experience, the framework proposed by Gentile et al. (2007) is particularly relevant in the context of immersive technologies. By stimulating users' senses, emotions, cognition, and interactions, immersive digital

environments create multidimensional experiences that can be effectively analyzed through the sensory, emotional, cognitive, pragmatic, lifestyle, and relational components identified by the authors.

According to Gentile et al. (2007), a product or service may activate a single experience component or a configuration of multiple components, thereby generating experiences that create hedonic, functional, or symbolic value for consumers. The sensory component refers to experiences that stimulate the senses and enhance perceptual engagement (Gentile et al., 2007). In virtual environments, this component can be activated through visual and audiovisual stimuli, image realism, and the synchronization of sensory cues. These elements contribute to perceived attractiveness and a stronger sense of presence, thereby enhancing sensory engagement (Flavián et al., 2019; Hilken et al., 2017).

The emotional (affective) component encompasses feelings and emotions elicited through interactions with a product, service, or brand, ranging from short-term emotional reactions to more enduring affective attitudes (Gentile et al., 2007). Emotions have long been recognized as a central element of consumption experiences within the experiential view of consumption (Holbrook, Hirschman, 1982), challenging earlier perspectives that emphasized predominantly rational consumer behavior (Bagozzi, 1975; Kotler, 1972). In virtual environments, emotional experiences may be enhanced by the sense of presence, which increases the realism of the experience and intensifies affective responses (Steuer, 1992; Lombard, Ditton, 1997). Furthermore, interactivity and embodiment, through increased perceptions of control over both the environment and one's virtual representation, may foster stronger engagement, more intense experiences, and more positive emotional responses (Javornik, 2016; Flavián et al., 2019).

Another component identified by Gentile et al. (2007) is the cognitive component, which encompasses mental processes such as thinking, learning, analysis, creativity, and problem-solving. This component may be activated when an experience intellectually stimulates consumers or enables them to explore and evaluate available offerings. In virtual environments, perceived information diagnosticity, often facilitated by interactivity and presence (Grohmann et al., 2007; Hilken et al., 2017), can contribute to cognitive engagement. Interactivity, in particular, supports cognitive processing through three-dimensional visualizations, opportunities for product manipulation, and enhanced perceptions of control, all of which increase the depth of information processing (Javornik, 2016; Hilken et al., 2017).

Gentile et al. (2007) further extended earlier multidimensional conceptualizations of experience by introducing the pragmatic component, which refers to the practical aspects of experience, including usability, functionality, and ease of interaction with a product or service. These aspects correspond to the motivations traditionally emphasized in consumer behavior research (Bagozzi, 1975; Kotler, 1972). In the context of immersive technologies, this component may be stimulated through perceived information diagnosticity associated with interactivity and presence, as well as through perceived control facilitated by embodiment (Hilken et al., 2017). By reducing uncertainty and perceived risk, these factors may facilitate

purchase decision-making and positively influence purchase intentions (Huang, Liao, 2017; Hilken et al., 2017).

The lifestyle component reflects consumers' personal values, beliefs, and aspirations, which are often expressed through their behaviors and consumption choices (Gentile et al., 2007). Experiences may activate this component when a product or service serves as a means of expressing values associated with a particular brand or lifestyle to which consumers aspire. In digital environments, the lifestyle component may be expressed through virtual self-representation and personalization features that allow users to align their digital experiences with their values, preferences, and aspirations (Gentile et al., 2007; Flavián et al., 2019). Stronger identification with a virtual representation may also contribute to a greater sense of embodiment (Flavián et al., 2019).

Finally, the relational component concerns an individual's relationships with others and with the broader social environment (Gentile et al., 2007). This component may be activated by products and services that facilitate shared consumption experiences or reinforce a sense of belonging to a social group. Gentile et al. (2007) also highlight the close relationship between the lifestyle and relational components when consumption serves to affirm social identity. In digital environments, relational experiences may emerge through interactions with other users and shared virtual experiences. Virtual spaces that enable communication and collaboration can generate a sense of co-presence understood as the perception of being together with others in a shared environment, which may strengthen the relational component of consumer experience (Schroeder, 2008; Flavián et al., 2019).

The multidimensional nature of the consumer experience framework proposed by Gentile et al. (2007) makes it particularly relevant for the study of immersive technologies. Virtual environments may stimulate various dimensions of consumer experience, including sensory, emotional, cognitive, pragmatic, lifestyle, and relational responses, thereby generating complex experiences that extend beyond purely functional interactions. Consequently, the framework provides a focused basis for examining how the dimensions of the EPI model - embodiment, presence, and interactivity - contribute to the formation of consumer experience in virtual spaces.

According to the literature, a virtual space can be understood as a digitally generated environment that allows users to interact with both virtual objects and other participants within a simulated spatial structure (Schroeder, 2008). Examples of virtual spaces include virtual showrooms, virtual fitting rooms, augmented reality (AR) applications, virtual reality (VR) environments, product configurators, digital twins, and metaverse platforms. Such solutions provide interactive and often three-dimensional environments that facilitate product exploration, evaluation, and customization, thereby replicating the most relevant elements of the shopping experience traditionally associated with physical retail stores (Flavián et al., 2019).

In modern digital services and e-commerce, immersion and interactivity are considered key dimensions of virtual spaces that can be leveraged to shape and enhance consumer experience. Immersion, conceptualized as the objective degree to which a technology isolates users from the physical environment while providing naturalistic sensory input (Slater, 2009), and interactivity are factors influencing the perception and processing of stimuli in digital environments (Steuer, 1992). The literature differentiates between immersion as a property of technology and presence as a psychological state experienced by users within a digital space (Slater, 2009).

A comprehensive framework for understanding experiences in virtual environments is provided by the EPI (Embodiment, Presence, Interactivity) model developed by Flavián, Ibáñez-Sánchez, and Orús (2019). The model conceptualizes users' experiences with immersive technologies through three interrelated dimensions. Earlier studies primarily focused either on the perceptual and psychological aspects of presence (Steuer, 1992) or on the technological characteristics of immersion and interactivity (Mollen, Wilson, 2010). In contrast, the EPI model adopts a more comprehensive perspective, arguing that a truly immersive virtual experience depends on the simultaneous interaction of all three dimensions: presence as a perceptual - psychological state in which individuals perceive themselves as being situated within a mediated or virtual environment rather than in their immediate physical surroundings, embodiment as the sense of having a body and agency within a virtual environment, and interactivity as the behavioral capacity to influence and respond to the digital environment. According to the authors, only the combined effect of these dimensions can fully explain the quality and intensity of users' experiences in virtual spaces.

The authors argue that embodiment can enhance the immersive quality of XR experiences and stimulate users both sensorially and emotionally, thereby increasing their level of engagement (Flavián et al., 2019, 2020). As a result, embodiment may foster greater interest in brand-related content, encourage interaction with digital environments (Flavián et al., 2019), and contribute to higher levels of experience satisfaction (Flavián et al., 2019), which may subsequently translate into stronger purchase intentions (Flavián et al., 2016, 2019).

Presence has been associated with a higher quality of consumer experience by increasing user engagement, facilitating the mental simulation of product use, and enhancing visual appeal, all of which may positively influence purchase intentions (Orús et al., 2021). Previous studies have also shown that presence can increase technology acceptance (Huang, Liao, 2017) and improve consumers' confidence in decision-making processes (Hilken et al., 2017). Furthermore, presence may enhance the perceived diagnosticity of information, thereby facilitating more accurate evaluations of product value (Hilken et al., 2017).

According to Flavián et al. (2019), interactivity enhances user engagement and overall experience quality, indirectly fostering stronger purchase intentions. Furthermore, higher levels of interactivity are associated with greater perceived control, increased information

diagnosticity, and more positive product evaluations (Grohmann et al., 2007; Hilken et al., 2017).

The EPI model proposed by Flavián et al. (2019) conceptualizes immersive digital experiences as emerging from the interaction of three dimensions: embodiment, presence, and interactivity. As such, it provides a useful framework for examining modern digital services and e-commerce environments. By enhancing these dimensions, XR technologies can help overcome key limitations of online shopping, including the lack of physical product contact, limited interaction opportunities, and difficulties in imagining product use in real-life situations (Hilken et al., 2017).

3. Methods

The study adopts a quantitative research approach aimed at examining the relationships between the dimensions of the EPI model of virtual spaces - embodiment, presence, and interactivity - and the components of consumer experience proposed by Gentile et al. (2007). The conceptual framework assumes that immersive technologies influence consumer experience through mechanisms associated with the perception of one's virtual representation, the sense of being present in a virtual environment, and the level of interaction with digital content.

To systematically present the assumed relationships, a matrix was constructed illustrating the connections between the EPI dimensions and the consumer experience components (Table 1). This matrix served as the basis for the development of research questions, and the subsequent empirical analysis.

The primary objective of the study is to identify which dimensions of the EPI model are most strongly associated with individual components of consumer experience in e-commerce environments and digital services settings. To achieve the research objectives, the following research question was formulated:

RQ1: How are the dimensions of the EPI model (embodiment, presence, and interactivity) associated with the components of consumer experience in e-commerce and digital services settings?

This research question addresses the theoretical objective of the study by exploring the relationships between the characteristics of immersive technologies and the dimensions of consumer experience. At the same time, the analysis provides practical implications for digital commerce and virtual environment design by identifying which features of immersive technologies are most relevant for shaping positive consumer experiences.

Table 1.
Relationships between EPI Dimensions and Consumer Experience Components

EPI Model Dimensions	Findings form the Literature	Consumer Experience Components (potentially activated)
Embodiment	Integration of perception and movement enhances body ownership, sensory stimulation, and product engagement.	Sensory
Embodiment	Embodiment intensifies users' emotional involvement and experience intensity.	Emotional
Embodiment	Perceived control resulting from embodiment reduces uncertainty and purchase risk.	Pragmatic
Embodiment	Identification with a virtual representation may strengthen self-expression and identity construction.	Lifestyle
Presence	The feeling of "being there" increases realism, affective responses, and engagement.	Emotional
Presence	Presence facilitates mental simulation of product usage.	Cognitive
Presence	Realistic virtual environments enhance the perception of sensory stimuli.	Sensory
Presence	The perception of others' presence in virtual environments supports social experiences.	Relational
Interactivity	Product interaction increases information diagnosticity and depth of information processing	Cognitive
Interactivity	Perceived control and system responsiveness enhance usefulness and reduce purchase risk.	Pragmatic
Interactivity	Social and metaverse-based interactions facilitate relationship building among users.	Relational

Source: Flavián et al. (2016, 2019, 2020), Orús et al. (2021), Gentile et al. (2007), Steuer (1992), Lombard, Ditton (1997), Hilken et al. (2017), Javornik (2016).

Based on the literature review, a conceptual model was developed linking the three dimensions of the EPI model with consumer experience framework proposed by Gentile et al. (2007), which includes sensory, emotional, cognitive, pragmatic, lifestyle, and relational experience. The model assumes that embodiment, presence, and interactivity function as independent variables, while the consumer experience dimensions constitute dependent variables.

However, due to the exploratory and pilot character of the research, the in-depth statistical analysis focuses on four components considered most directly related to immersive online shopping: sensory, emotional, cognitive, and pragmatic experience. These dimensions were selected because immersive technologies primarily affect consumers through multisensory stimulation, emotional engagement, cognitive evaluation, and perceived usefulness in the shopping process. Lifestyle and relational experience, although important, are discussed at the conceptual level of the study and are not included in the in-depth statistical analysis at this stage, as they require broader contextual and longitudinal investigation.

Data were collected through an online survey questionnaire. The study employed non-probability purposive sampling with elements of snowball sampling. Respondents were expected to have experience with online shopping and potentially with immersive technologies, such as virtual reality (VR), augmented reality (AR), mixed reality (MR), or virtual shopping environments. The questionnaire consisted of measurement scales adapted from validated

instruments reported in previous studies. Responses were recorded using a 7-point Likert-type scale, ranging from 1 = strongly disagree to 7 = strongly agree. The variables were operationalized by calculating the mean values for individual scales corresponding to the dimensions of the EPI model - embodiment, presence, and interactivity - as well as to the components of consumer experience as conceptualized by Gentile et al. (2007). Prior to the empirical analysis, the reliability of the measurement scales was assessed. Internal consistency was evaluated using Cronbach's alpha (α), with values above 0.70 considered indicative of satisfactory reliability.

The collected data were analyzed using statistical methods appropriate to the exploratory character of the study and the structure of the variables. Descriptive statistics, including the mean, median, and standard deviation, were calculated to characterize the main measurement scales and respondents' evaluations of the analyzed constructs. In addition, cross-tabulation and percentage distribution analysis were applied to identify patterns between selected demographic variables, online shopping behavior, and the use of immersive technologies. To examine the relationships between the key research constructs, Pearson's correlation analysis and regression analysis were conducted. These methods were used to assess the strength, direction, and significance of the relationships between the EPI dimensions and consumer experience components. Statistical significance was assessed at the $p < 0.05$ level.

The adopted analytical approach enabled the identification of those features of immersive technologies that were most strongly associated with positive consumer experiences in virtual shopping environments. At the same time, considering the exploratory nature of the study and the limited sample size, the results of the regression analysis should be interpreted as preliminary and viewed within the context of these methodological constraints.

4. Results

The initial sample consisted of 100 respondents. Nevertheless, after applying the screening question, only participants who had prior experience with immersive tools in e-commerce were included in the final analysis. As a result, the analytical sample comprised 46 respondents. The relatively small analytical sample should be interpreted in the context of the exploratory and pilot character of the study. The research constitutes the first stage of a broader project on the role of immersive technologies in shaping consumer experience in virtual shopping environments. In this initial stage, the analysis was limited to respondents with actual prior experience using immersive e-commerce tools, which reduced the final sample size but increased the substantive relevance of the responses, as the analysis was based only on responses from users capable of evaluating embodiment, presence, and interactivity in virtual shopping environments.

Consequently, the results should be treated as preliminary and indicative rather than fully generalizable. They provide a foundation for subsequent stages of the research, which will include a larger sample and a broader assessment of the remaining dimensions of consumer experience. The distribution of respondents by age and online shopping frequency in relation to the use of immersive technologies is presented in Tables 2 and 3.

Table 2.
Respondents' Age Distribution by Use of Immersive Technologies

Age	I have not used immersive technologies such as AR/VR	I have used immersive technologies such as AR/VR
<18	25%	75%
18-24	49%	51%
25-30	53%	47%
31-40	57%	43%
41-50	59%	41%
51-60	62%	38%
>60	100%	0%

The analysis of the collected data indicates that the use of immersive technologies, particularly AR and VR, varies by age. The highest share of users was recorded among respondents aged under 18, with 75%, and 18-24, with 51% of this group declaring prior experience with such technologies. A decreasing trend was observed with age: in the 25-30, 31-40, 41-50, and 51-60 age groups, the corresponding shares were 47%, 43%, 41%, and 38%, respectively. Among respondents aged over 60, no participants reported having used immersive technologies, while shopping online. Respondents with prior experience using immersive technologies most frequently indicated AR-based product try-on tools (28%), virtual fitting rooms (18%), and 3D configurators (12%). The least frequently reported form of experience was contact with 3D showrooms (10%).

Table 3.
Respondents' Online Shopping Frequency by Use of Immersive Technologies

Online Shopping Frequency	I have not used immersive technologies such as AR/VR	I have used immersive technologies such as AR/VR
Several times a week or more often	21%	79%
Once a week	33%	67%
Several times a month	58%	42%
Once a month	86%	14%
Once every 2–3 months	75%	25%
Less often than once every 3 months	60%	40%

The table 3 presents the relationship between online shopping frequency and the use of immersive technologies, including AR/VR tools. The analysis of respondents' declared answers indicates that such tools are used more frequently by consumers who shop online several times a week or more often (78.57%) and by those who use e-commerce once a week (66.67%). As the frequency of online shopping decreases, the share of respondents using AR/VR

technologies also declines. Among respondents who shop online once a month, only 14% reported such experience. However, in the group of respondents who shop online less often than once every three months, 40% declared experience with this type of technology.

The statistical analysis began with an examination of the descriptive statistics for the research variables included in the EPI model and the consumer experience components (Tab. 4).

Table 4.
Descriptive Statistics of the Research Variables

Variable	Mean	Median	Standard Deviation
Embodiment	4.25	4.42	1.57
Presence	3.60	3.50	1.68
Interactivity	4.28	4.00	1.66
Sensory	3.87	3.67	1.83
Emotional	3.83	3.67	1.80
Cognitive	4.44	4.33	1.74
Pragmatic	4.77	4.83	1.70
Lifestyle	3.83	3.67	1.76
Relational	3.34	3.17	1.81

The analysis indicates a moderately varied level of evaluations of the EPI model dimensions and consumer experience components during the use of virtual spaces. Among the analyzed variables, the pragmatic component received the highest mean score (M = 4.77, Me = 4.83, SD = 1.70). A relatively high mean value was also recorded for the cognitive component (M = 4.44, Me = 4.33, SD = 1.74). Similar mean values were obtained for embodiment (M = 4.25, Me = 4.42, SD = 1.57) and interactivity (M = 4.28, Me = 4.00, SD = 1.66). The presence dimension was rated notably lower than the other elements of the EPI model (M = 3.60, Me = 3.50, SD = 1.68). Among all analyzed variables, the relational component received the lowest score (M = 3.34, Me = 3.17, SD = 1.81).

The analysis of standard deviations, ranging from 1.57 to 1.83, indicates a moderate variability of responses across all variables. The lowest standard deviation was observed for embodiment, which may suggest a relatively consistent perception of this aspect among respondents. Higher standard deviations for the sensory, emotional, and relational components suggest greater variability in respondents' evaluations, which may be related to the more subjective nature of these aspects of consumer experience.

The results may indicate that elements such as functionality, cognitive evaluation of information, active interaction, and a sense of control over the experience are rated more favorably by consumers in the context of digital environments. Respondents rated the presence dimension relatively lower, which may suggest that the analyzed tools do not generate a strong sense of immersion in the virtual environment. However, drawing stronger conclusions in this regard would require further in-depth analysis. The analyzed solutions may also be insufficient in evoking the relational component of consumer experience, which may result from the

specific nature of e-commerce, where the experience is often more individual than socially oriented.

Table 5.
Reliability of the Research Scales (Cronbach's Alpha)

Measured Construct	Number of items	*Cr*onbach's Alpha (α)
Embodiment	4	0.91
Presence	4	0.87
Interactivity	4	0.90
Sensory	3	0.92
Emotional	3	0.95
Cognitive	3	0.93
Pragmatic	3	0.88
Lifestyle	3	0.86
Relational	3	0.94

The reliability of the measurement scales was assessed using Cronbach's alpha coefficient. All scales achieved high reliability values ($\alpha > 0.85$), indicating very strong internal consistency of the measurement scales. The highest internal consistency was observed for the emotional component ($\alpha = 0.95$), while the lowest, although still very high, was recorded for the lifestyle component ($\alpha = 0.86$). Subsequently, Pearson's correlation analysis was conducted between the dimensions of the EPI model and the selected components of consumer experience. The results are presented in Table 6.

Table 6.
Correlations Between the EPI Model Dimensions and Consumer Experience Components (Pearson's r)

EPI model dimension	Sensory	Emotional	Cognitive	Pragmatic
Embodiment	r=0.69	r=0.79	r=0.75	r=0.62
Presence	r=0.78	r=0.84	r=0.71	r=0.59
Interactivity	r=0.80	r=0.79	r=0.80	r=0.76

Note. All correlations are statistically significant at $p < 0.001$. Values represent Pearson correlation coefficients.

The analysis indicates positive and statistically significant associations across all examined relationships. The results presented in the table show that the dimensions of the EPI model are strongly associated with the components of consumer experience. However, the strength of these relationships varies, suggesting that individual EPI dimensions are related to different aspects of consumer experience to varying degrees. The strongest correlations were observed for interactivity. Interactivity was strongly associated with the sensory component ($r = 0.80$), the cognitive component ($r = 0.80$), the emotional component ($r = 0.79$), and the pragmatic component ($r = 0.76$). The highest correlations with the sensory and cognitive components suggest that the possibility of actively interacting with the tool, controlling the view, exploring the product, or modifying its features may be related to stronger experiential responses associated with perception and information processing. The strong associations between interactivity and both the cognitive and emotional components may indicate that interactivity

is linked to the way consumers process and emotionally respond to stimuli in virtual shopping environments.

The strongest relationship among all analyzed correlations was observed between presence and the emotional component (r = 0.84). This result may indicate that the sense of being present in a virtual environment is strongly associated with the emotional perception of the experience. Presence was also highly correlated with the sensory component (r = 0.78) and the cognitive component (r = 0.71). This may suggest that a stronger sense of presence in a virtual space is related to a more intensive perception of stimuli and a more favorable cognitive evaluation of the experience.

For embodiment, the strongest correlation was observed with the emotional component (r = 0.79). A similar relationship was found between embodiment and the cognitive component (r = 0.75), while a slightly lower correlation was observed with the sensory component (r = 0.69). These results suggest that the sense of embodied control in a digital environment may be associated with a more engaging experience, particularly at the emotional and cognitive levels.

The lowest correlation values in the table concern the relationships between embodiment and the pragmatic component (r = 0.59), as well as between presence and the pragmatic component (r = 0.62). Both correlations are positive and statistically significant. These findings suggest that the pragmatic dimension of consumer experience is more strongly associated with interactivity, whereas embodiment and presence appear to be more closely related to the emotional component of consumer experience. To extend the interpretation of the strongest correlation results, simple linear regression analyses were also conducted.

Table 7.
Results of Simple Linear Regression Analysis

Independent Variable	Dependent Variable	β	R^2	Significance
Embodiment	Emotional Component	0.79	0.62	$p < 0.001$
Presence	Emotional Component	0.84	0.70	$p < 0.001$
Interactivity	Cognitive Component	0.80	0.64	$p < 0.001$

Note. β = standardized regression coefficient; SE = standard error of the standardized coefficient; R^2 = coefficient of determination. All models are statistically significant at $p < 0.001$

The results presented in Table 7 indicate that all analyzed regression models were statistically significant ($p < 0.001$). The values of the standardized beta coefficients and R^2 suggest strong positive predictive relationships between the selected EPI dimensions and the corresponding components of consumer experience. The highest explanatory power was observed for the model in which presence predicted the emotional component of consumer experience ($\beta = 0.84$, $R^2 = 0.70$), indicating that presence accounted for 70% of the variance in the emotional component. Interactivity explained 64% of the variance in the cognitive component, while embodiment explained 62% of the variance in the emotional component. These results suggest that individual dimensions of the EPI model may be associated with different aspects of consumer experience to varying degrees.

With regard to the emotional component of consumer experience, both embodiment ($\beta = 0.79$; $R^2 = 0.62$) and presence ($\beta = 0.84$; $R^2 = 0.70$) showed statistically significant predictive relationships. The results indicate that both dimensions explain a substantial proportion of the variance in users' emotional responses, although a stronger relationship was observed for presence. A statistically significant predictive relationship was also found between interactivity and the cognitive component of consumer experience ($\beta = 0.80$; $R^2 = 0.64$). This result suggests that interactivity is strongly associated with the aspect of user experience related to information processing, explaining 64% of its variance.

The figures below illustrate positive associations between the EPI model dimensions and the consumer experience components for which these dimensions obtained the highest correlation values. As the levels of embodiment, presence, and interactivity increase, higher evaluations of specific CX components can be observed. The distribution of points indicates a clear upward trend, although some variability in respondents' answers is also visible, suggesting that the relationships are not perfectly linear. The trend lines and the values of the coefficient of determination confirm statistically significant and relatively strong predictive relationships between the analyzed variables.

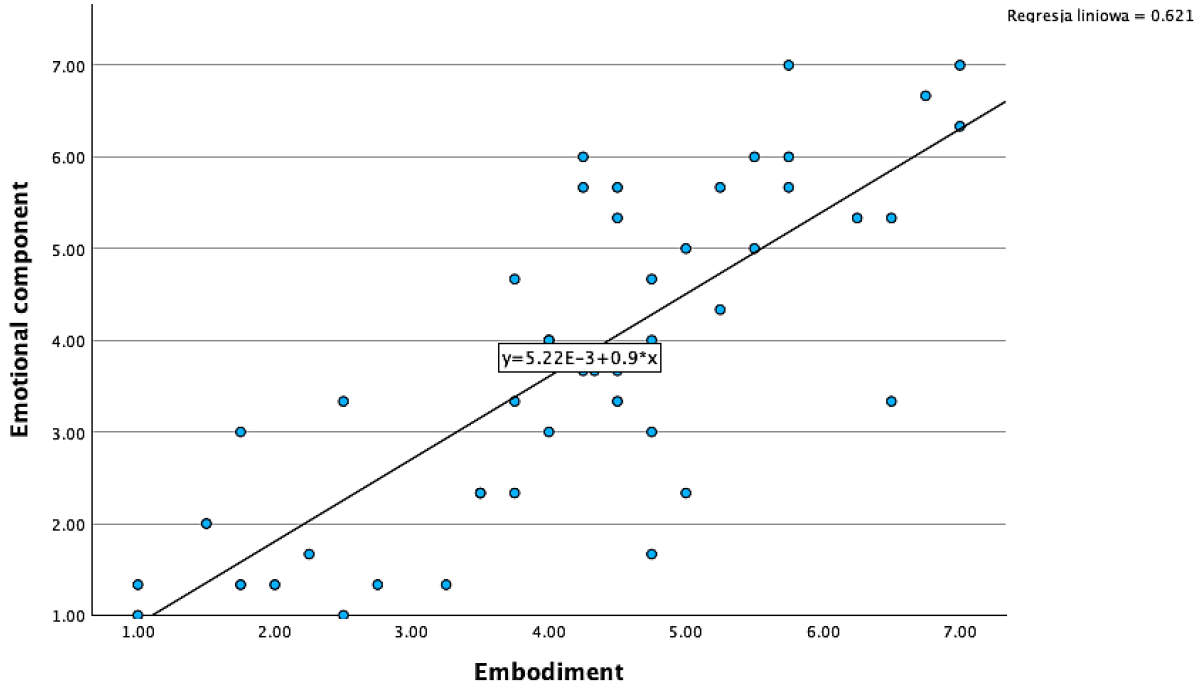


Figure 1. Relationship Between Embodiment and the Emotional Component.

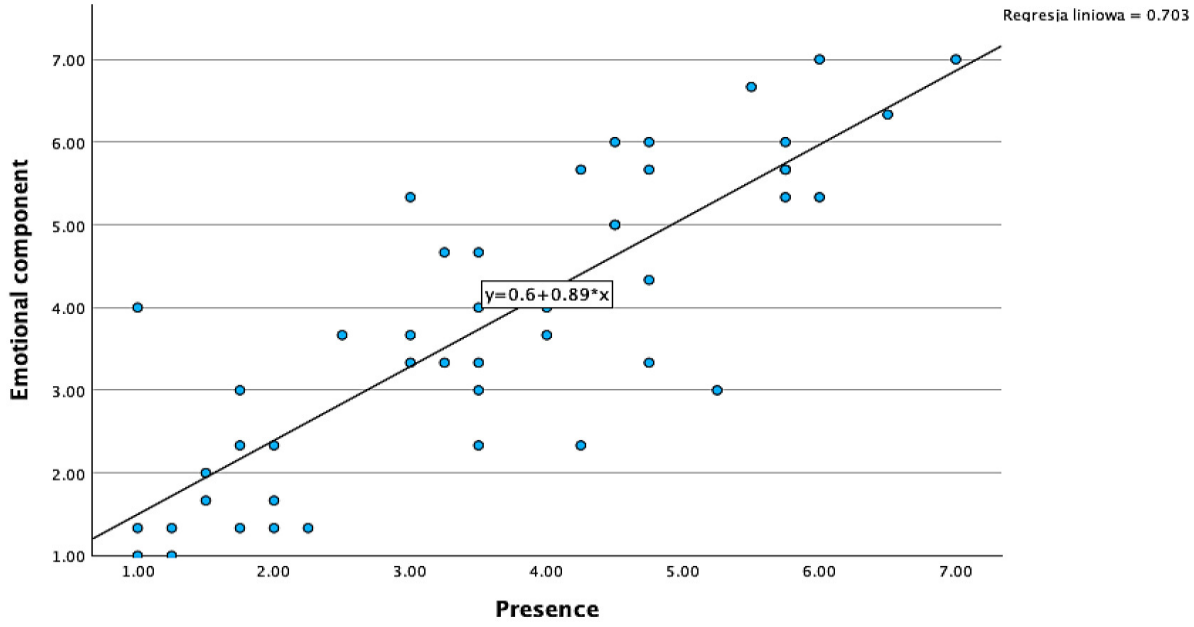


Figure 2. Relationship Between Presence and the Emotional Component.

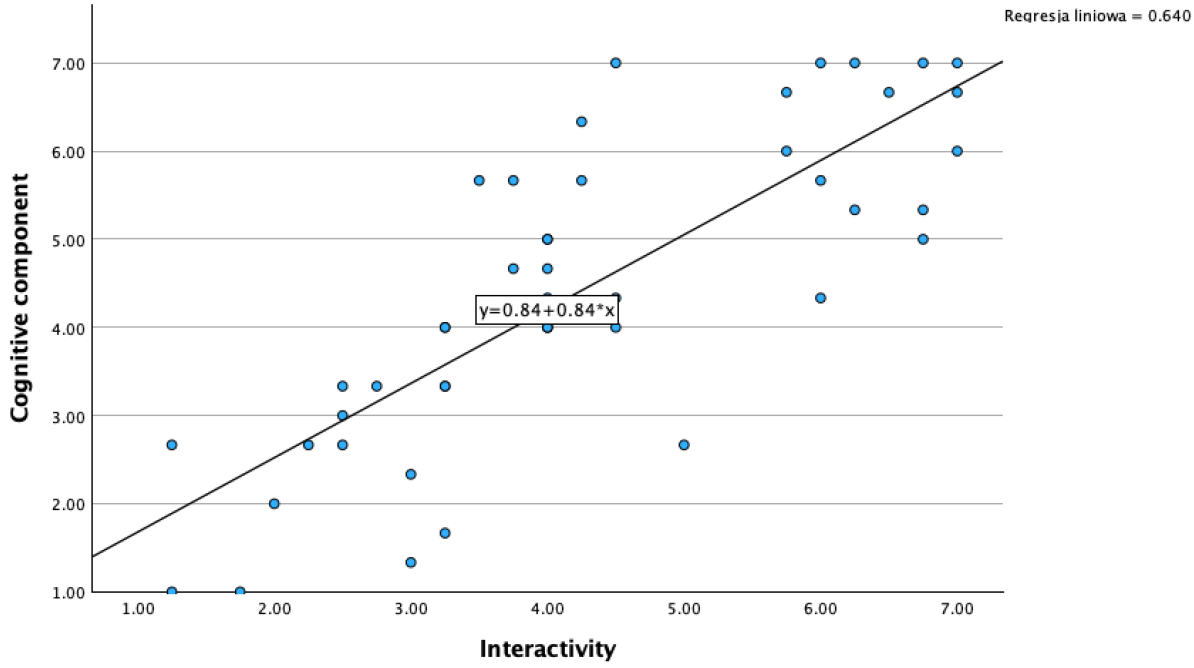


Figure 3. Relationship Between Interactivity and the Cognitive Component.

To provide a more comprehensive understanding of the mechanisms shaping consumer experience in virtual shopping environments, the relationships between the dimensions of the EPI model were also examined using Pearson's correlation analysis. This additional analysis made it possible to assess the extent to which embodiment, presence, and interactivity are interrelated and jointly contribute to the formation of immersive consumer experiences.

Table 8.
Correlations Between the EPI Model Dimensions (Pearson's r)

EPI model dimension	Embodiment	Presence	Interactivity
Embodiment	X	r=0.82	r=0.77
Presence	r=0.82	X	r=0.72
Interactivity	r=0.77	r=0.72	X

Note. All correlations are statistically significant at $p < 0.001$. Values represent Pearson correlation coefficients.

Table 8 presents the results of the correlation analysis between the dimensions of the EPI model. All correlations were positive, statistically significant, and strong. The highest correlation was observed between embodiment and presence ($r = 0.82$), while the lowest, although still strong, was found between presence and interactivity ($r = 0.72$). The results may indicate that all EPI dimensions are closely interrelated. These findings provide valuable insights for companies developing digital services, e-commerce platforms, and virtual environments. Understanding the factors that shape consumer experience may support the design of more engaging, personalized, and effective digital interactions.

5. Discussion

The analysis of the research results presented in this article allows for the verification of assumptions found in the literature regarding immersive technologies in e-commerce and contributes to the growing body of knowledge on consumer experience in virtual environments. Embodiment is understood as the integration of perception and movement, leading to a sense of body ownership and a more intense experience of digital stimuli. Previous studies suggest that AR-based product fitting can increase sensory stimulation and user engagement (Flavián et al., 2019b, 2020). Presence, in turn, refers to the subjective sensation of "being there" in a mediated environment and has been associated with consumers' ability to mentally simulate product use (Orús, Ibáñez-Sánchez, Flavián, 2021). Based on these findings, relationships were expected between embodiment and the sensory component of consumer experience, and between presence and the cognitive component.

However, the findings revealed a somewhat different pattern. Embodiment was more strongly associated with the cognitive component than with the sensory component, while presence showed a stronger relationship with the sensory component than with the cognitive component. One possible explanation is that the realism of the virtual environment, which is a key antecedent of presence (Flavián et al., 2019), may enhance the perception of sensory stimuli and their attractiveness, thereby strengthening the sensory dimension of the experience. At the same time, the immersive tools examined in this study, such as virtual fitting rooms, may have encouraged consumers to evaluate product fit, appearance, and functionality more carefully, thus supporting information processing and cognitive assessment. Similar

observations have been reported in studies indicating that AR-based product visualization facilitates product evaluation and decision-making processes (Hilken et al., 2017).

The literature also emphasizes the subjective nature of presence. Even technologically advanced solutions cannot fully guarantee a high level of presence because individual psychological predispositions influence how users experience virtual environments (Lombard, Ditton, 1997; Slater, 2009; Flavián et al., 2019). Moreover, technologies characterized by lower levels of immersion, such as smartphones or laptops, may be less effective in creating a strong illusion of being physically located in a virtual environment than fully immersive VR systems (Flavián et al., 2019). The findings are broadly consistent with this interpretation. Presence received the lowest mean score among the EPI dimensions (M = 3.60), which may be related to both the characteristics of the examined solutions and the devices used by respondents.

The study also demonstrated strong positive relationships among all three dimensions of the EPI model, supporting the conceptual assumptions proposed by Flavián et al. (2019). These authors argue that embodiment, presence, and interactivity coexist within immersive experiences and jointly contribute to users' perceptions of virtual environments. While the strongest relationship identified in the present study was between embodiment and presence, a high correlation was also observed between embodiment and interactivity. This finding suggests that, within the examined context, the dimensions may reinforce one another rather than operate independently.

According to the EPI framework, interactivity may strengthen users' sense of control and engagement, thereby supporting the experience of embodiment and presence (Flavián et al., 2019). The present findings revealed strong associations between interactivity and the remaining EPI dimensions. However, the results do not provide direct empirical evidence for the moderating role of interactivity proposed in the conceptual model, as such a mechanism would require a different analytical approach. Instead, the findings suggest that the three dimensions are closely interconnected and may contribute differently to specific aspects of consumer experience.

Interactivity demonstrated relatively strong associations with a broad range of consumer experience components, particularly the pragmatic component. Nevertheless, all relationships involving the pragmatic dimension were weaker than those observed for sensory, emotional, and cognitive experience. Similar observations have been reported in previous research on immersive consumer experiences, which suggests that higher levels of immersion do not necessarily translate into greater perceptions of functionality or usefulness.

6. Summary

The aim of this study was to examine the role of immersive technologies in shaping consumer experiences in virtual spaces and to identify the significance of embodiment, presence, and interactivity for the development of modern digital services. To achieve this objective, the study investigated the relationships between the dimensions of the EPI model of virtual spaces - embodiment, presence, and interactivity - and the components of consumer experience proposed by Gentile et al. (2007). The findings confirmed that all three EPI dimensions are significantly associated with consumer experience, although their roles differ. These results underscore the significance of embodiment, presence, and interactivity as important factors shaping consumer experiences in virtual environments and provide valuable insights for the design and development of innovative digital services.

Interactivity demonstrated the broadest associations with consumer experience components and appears to play an integrative role in shaping the overall experience. Presence was most strongly related to the emotional component and also showed substantial associations with sensory and cognitive experiences. Embodiment was primarily linked to emotional and cognitive aspects of consumer experience. These results indicate that immersive technologies influence consumer experience through multiple interconnected mechanisms, contributing to the creation of a comprehensive and multidimensional customer experience.

The study also provides practical implications for the design of immersive e-commerce environments and modern digital services. The findings emphasize the importance of interactivity as a key driver of consumer experience. Features enabling product exploration, manipulation, personalization, and active user participation should be prioritized, as they support consumer engagement, facilitate product evaluation, and strengthen the perceived value of digital interactions. At the same time, designers should focus on creating emotionally engaging experiences through realistic visualization, compelling digital environments, intuitive interfaces, and user-centered interaction design. These elements may increase the attractiveness of virtual environments and support the development of more effective, personalized, and competitive digital services.

Although the study offers valuable insights, its limitations should also be acknowledged. The main limitations are related to the size and structure of the research sample, the focus on selected immersive technologies, and the exploratory and pilot character of the research. Due to these methodological conditions, the in-depth statistical analysis focused only on four components of consumer experience considered most directly related to immersive online shopping: sensory, emotional, cognitive, and pragmatic experience. Lifestyle and relational experience, although important for a comprehensive understanding of consumer experience, were discussed at the conceptual level of the study and were not included in the in-depth statistical analysis at this stage. These dimensions require broader contextual and longitudinal

investigation, as they may develop over time and depend on wider social, cultural, and behavioral conditions. Therefore, the results may not fully reflect the diversity and complexity of consumer experiences across all types of virtual environments.

Future research should include larger and more diverse samples, compare different types of immersive technologies and virtual environments, and incorporate lifestyle and relational dimensions into more advanced statistical analyses. Such studies could provide a more comprehensive understanding of how embodiment, presence, and interactivity influence consumer perceptions, attitudes, behaviors, and long-term relationships with digital services.

Overall, the findings demonstrate that consumer experience in virtual environments is complex, multidimensional, and shaped by several interconnected mechanisms. The dimensions of the EPI model are closely associated with the structure of consumer experience and reinforce one another in shaping user perceptions. One of the key lessons learned from the study is that immersive technologies should not be considered only as technical tools, but also as experience-shaping environments that influence emotional, cognitive, sensory, and behavioral aspects of consumer interaction. Therefore, the design of immersive e-commerce solutions and digital services should adopt a holistic approach that simultaneously considers embodiment, presence, interactivity, and the interdependencies among consumer experience components.

The study contributes to the growing body of research on consumer experience in virtual spaces by integrating the EPI model with contemporary consumer experience theory and the context of modern digital services. The new knowledge provided by the study concerns the differentiated role of embodiment, presence, and interactivity in shaping specific components of consumer experience. In particular, the findings show that interactivity plays an integrative role in the overall experience, presence is especially important for emotional engagement, and embodiment is strongly connected with emotional and cognitive dimensions. This contributes to a better understanding of the mechanisms through which immersive technologies influence consumer perceptions and behaviors.

The importance of the research extends beyond the e-commerce context. As immersive technologies are increasingly used in digital commerce, education, culture, entertainment, tourism, and other service sectors, understanding how users experience virtual environments becomes essential for both researchers and practitioners. The findings may be further used in future studies on immersive consumer behavior, virtual service design, and digital transformation. They may also support organizations in developing more engaging, personalized, user-centered, and socially relevant digital solutions. In this way, the study highlights the broader significance of immersive technologies for the future development of digital services and consumer interactions in virtual spaces.

References

1. Ambika, A., Shin, H., Jain, V. (2025). Immersive technologies and consumer behavior: A systematic review of two decades of research. *Australian Journal of Management, 50*(1), 55-79.
2. Bagozzi, R.P. (1975). Marketing as exchange. *Journal of Marketing, 39(4),* 32-39. https://doi.org/10.1177/002224297503900407
3. Bartczak, K. (2016). *Bariery rozwojowe handlu elektronicznego*. Wrocław: Exante.
4. Becker, L., Jaakkola, E. (2020). Customer experience: Fundamental premises and implications for research. *Journal of the Academy of Marketing Science*, *48(4),* 630-648. https://doi.org/10.1007/s11747-019-00718-x
5. Çil, E., Erkan, I., Acikgoz, F. (2026). Understanding virtual customer experience: a systematic analysis of immersive technology applications. *Journal of Research in Interactive Marketing, Vol. 20, No. 5,* pp. 657-674.
6. Di Dalmazi, M., Mandolfo, M., Guixeres, J., Alcañiz Raya, M., Lamberti, L. (2024). How immersive technologies impact behavioral responses in destination marketing: the role of physiological arousal, presence, and age. *International Journal of Contemporary Hospitality Management*, *Vol. 36, No. 11,* pp. 3628-3650, doi: https://doi.org/10.1108/IJCHM-09-2023-1511
7. Flavián, C., Gurrea, R., Orús, C. (2016). Choice confidence in the webrooming purchase process: The impact of online positive reviews and the motivation to touch. *Journal of Consumer Behaviour*, *15(5),* 459-476.
8. Flavián, C., Ibáñez-Sánchez, S., Orús, C. (2019). The impact of virtual, augmented and mixed reality technologies on the customer experience. *Journal of Business Research*, *100*, 547-560.
9. Flavián, C., Ibáñez-Sánchez, S., Orús, C. (2020). Impacts of technological embodiment through virtual reality on potential guests' emotions and engagement. *Journal of Hospitality Marketing & Management*, *29(2),* 123-150.
10. Gentile, C., Spiller, N., Noci, G. (2007). How to sustain the customer experience: An overview of experience components that co-create value with the customer. *European Management Journal, 25*(5), 395-410. https://doi.org/10.1016/j.emj.2007.08.005
11. Grohmann, B., Spangenberg, E.R., Sprott, D.E. (2007). The influence of tactile input on the evaluation of retail product offerings. *Journal of Retailing, 83*(2), 237-245.
12. Hilken, T., de Ruyter, K., Chylinski, M., Mahr, D., Keeling, D.I. (2017). Augmenting the eye of the beholder: Exploring the strategic potential of augmented reality to enhance online service experiences. *Journal of the Academy of Marketing Science, 45*(6), 884-905. doi:10.1007/s11747-017-0541-x

13. Holbrook, M.B., Hirschman, E.C. (1982). The experiential aspects of consumption: Consumer Fantasies, Feelings, and Fun. *Journal of Consumer Research, 9(*2), 132-140.
14. Huang, T.-L., Liao, S. (2017). Creating e-shopping multisensory flow experience through augmented-reality interactive technology. *Internet Research, 27(2),* 449-475.
15. Javornik, A. (2016). Augmented reality: Research agenda for studying the impact of its media characteristics on consumer behaviour. *Journal of Retailing and Consumer Services, 30*, 252-261.
16. Jin, B., Youn, S., Cho, H. (2021). Consumer store experience through virtual reality: Its effect on emotional states and consumer outcomes. *Psychology & Marketing, 38(8),* 1250-1269.
17. Kim, J.H., Kim, M., Park, M., Yoo, J. (2023). Immersive interactive technologies and virtual shopping experiences: Differences in consumer perceptions between augmented reality (AR) and virtual reality (VR). *Telematics and Informatics, 77*, 101936.
18. Kotler, P. (1972). A generic concept of marketing. *Journal of Marketing, 36(2),* 46-54.
19. Leveau, P.-H., Camus, S. (2023) Embodiment, immersion, and enjoyment in virtual reality marketing experiences. *Psychology and Marketing*, *40(7),* pp. 1329-1343.
20. Lin, Y., Mustafa, H., Guo, Y. (2025). The role of embodiment and presence in metaverse's consumer purchase behaviour: A systematic literature review. *Jurnal Komunikasi: Malaysian Journal of Communication, 41*(2), 81-107. https://doi.org/10.17576/JKMJC-2025-4102-06
21. Lombard, M., Ditton, T. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication, 3*(2).
22. Mansoor, S., Rahman, S.M., Bowden, J.L.-H. (2024). Purchase spillovers from the metaverse to the real world: The roles of social presence, trialability, and customer experience. *Journal of Consumer Behaviour, 23*(5), 2501-2552.
23. Mazurek, G. (2018). *Transformacja cyfrowa - perspektywa marketingu*. Warszawa: PWN.
24. Meyer, C., Schwager, A. (2007). Understanding customer experience. *Harvard Business Review, 85*(2), 116-126.
25. Mollen, A., Wilson, H. (2010). Engagement, telepresence and interactivity in online consumer experience: Reconciling scholastic and managerial perspectives. *Journal of Business Research, Vol. 63*, *Iss. 9-10*, pp. 919-925, ISSN 0148-2963.
26. Narojczyk, S. (2025). Nowe trendy w rozwoju technologii. In: *Przedsiębiorstwa w erze globalnych kryzysów i przemian technologicznych: aspekty ekonomiczne, społeczne i prawne* (pp. 132-160). Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu.
27. Orús, C., Ibáñez-Sánchez, S., Flavián, C. (2021). Enhancing the customer experience with virtual and augmented reality. *International Journal of Hospitality Management, 98,* 103019.

28. Poushneh, A., Vasquez-Parraga, A.Z. (2017). Discernible impact of augmented reality on retail customer's experience, satisfaction and willingness to buy. *Journal of Retailing and Consumer Services, 34*, 229-234. doi:10.1016/j.jretconser.2016.10.005
29. Rudzewicz, A. (2010). Funkcjonowanie e-handlu w Polsce. *Ekonomiczne Problemy Usług, 55*, 551-56.
30. Schroeder, R. (2008). Defining Virtual Worlds and Virtual Environments. *Journal of Virtual Worlds Research, 1*(1).
31. Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviou in immersive virtual environments. *Philosophical Transactions B, 364(1535),* 3549-3557.
32. Soto Setzke, D., Riasanow, T., Böhm, M., Krcmar, H. (2023). Pathways to digital service innovation: The role of digital transformation strategies in established organizations. *Information Systems Frontiers, 25*, 1017-1037. https://doi.org/10.1007/s10796-021-10112-0
33. Steuer, J. (1992). Defining virtual reality: Dimensions Determining Telepresence. *Journal of Communication*, *42(4),* 73-93.
34. Vargo, S.L., Fehrer, J.A., Wieland, H., Nariswari, A. (2024). The nature and fundamental elements of digital service innovation. *Journal of Service Management*, *35(2),* 227-252. https://doi.org/10.1108/JOSM-02-2023-005
35. Verhoef, P.C., Broekhuizen, T.L., Yakov B., Bhattacharya, A., Dong Qi, J., Fabian, N.E., Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research, 122(4).*
36. Zomerdijk, L.G., Voss, C.A. (2010). Service design for experience-centric services. *Journal of Service Research, 13*(1), 67-82. https://doi.org/10.1177/1094670509351960

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

UNCERTAINTY IN IT SYSTEMS FOR MANAGING LOGISTICS PROCESSES AT LOGISTICS CENTERS

Joanna Alicja DYCZKOWSKA

Koszalin University of Technology; joanna.dyczkowska@tu.koszalin.pl, ORCID: 0000-0001-9866-3897

Purpose: The purpose of this article is to assess IT-related uncertainties in the management of logistics processes at logistics centers (LC). The research question is formulated as follows: To what extent does uncertainty affect the IT system used in the management of logistics processes at logistics centers?
Design/methodology/approach: This study employed a literature review, uncertainty analysis methodologies based on the use of an IT system registry, and mathematical methods. The analysis covered the IT system used in the logistics process by LC logistics operators.
Findings: The results of the calculations show that, of the five information events in the logistics processes of the analyzed CL, two are characterized by a moderate level of significance, two are highly significant, and one is critical. In this case, there are no insignificant events.
Research limitations/implications: The study focused exclusively on the IT system within the logistics process at LC. It is suggested that the method under consideration be refined by assessing the impact of logistics process uncertainty on various aspects and outcomes at LC. Future research should cover other areas such as collaboration with partners, deliveries to LC, and customer relations (CRM).
Practical implications: Uncertainty analysis of logistics systems can be used as an ongoing analysis of events throughout the supply chain, followed by a comparison of the results with management decisions.
Social implications: It is recommended that the method proposed in this paper be used to identify and mathematically assess the uncertainty of information systems in LC, in combination with other methods, such as decision trees or scenario analysis.
Originality/value: A research gap has been identified: there is a lack of research on uncertainty and unforeseeable events in the flow of information and their impact on logistics processes at operators' logistics centers.
Keywords: uncertainty, IT system, logistics process, logistics operator.
Category of the paper: research paper.

1. Introduction

Modern logistics companies operate in an environment characterized by increased uncertainty and dynamism, which is why they must adapt flexibly to changing external conditions (Kirzner, 2024). In the era of globalization, communication and transportation form a strong foundation for properly functioning international supply chains (Yang et al., 2025). Today, logistics operators should take into account trends indicating a marked increase in the use of intermodal transport, where logistics centers play a crucial role (Vlachos, Polichronidou, 2022).

In an era of economic development based primarily on knowledge and information, the ability to anticipate specific events and adapt a logistics operator's policies accordingly is particularly important. Modern companies operating within supply chains or supply networks face a clear management paradox (Kocabasoglu-Hillmer et al., 2023). On the one hand, the goal is to ensure the greatest possible operational stability in conditions of uncertainty and unpredictability, but on the other hand, to strive for flexibility and constant change manifested through innovation. The key challenge for logistics operators is to achieve the most effective adaptation to the changing environment in order to eliminate the level of unpredictable events that is unacceptable to customers, which then becomes a real problem for the company (Cichosz et al., 2025).

Logistics processes encompass not only the flow of goods, but also the flow of information and financial resources. The ever-expanding scope of logistics increases the number of processes and risk situations that may arise in a company's logistics operations (Lagorio et al., 2023). Uncertainty refers to the probability of an event occurring that could negatively impact a logistics operator's ability to achieve its objectives. In the current economic climate, the systematic identification and analysis of uncertainties affecting business processes and their productivity appears essential to ensuring a company's survival and competitiveness. The efficiency of logistics systems is inextricably linked to uncertainty, which necessitates the continuous development of methods and tools for managing uncertainty. However, in every logistics process, random events occur. This stems primarily from the fact that the economic instability faced by companies does not follow a simple cause-and-effect relationship and cannot be directly equated with the phenomenon of variability. Uncertainty management involves the process of decision-making and implementing actions, including the analysis of unpredictable events and the development of strategies to minimize them in order to achieve planned financial results and create operational conditions for the flow of goods in the supply chain through proper analysis of information within the system. The drive to ensure an adequate level of competitiveness for logistics systems in the challenging conditions of the modern economy has become the driving force behind the development of various concepts for resource conservation and loss minimization, the implementation of which may be hindered by certain barriers, including the high sensitivity of individual logistics processes.

The aim of this article is to assess uncertainty in the IT system used for managing logistics processes in logistics centers and to develop recommendations for improving the methodology of uncertainty analysis based on the use of an IT system registry and a mathematical method. The research problem is formulated as follows: to what extent does uncertainty affect the IT system in the management of logistics processes at logistics centers? The research gap lies in the lack of studies on the state of uncertainty and unpredictable events in the flow of information and their impact on logistics processes at operators' logistics centers.

2. Logistics Centers in Supply Chains: A Literature Review

2.1. Logistics centers as supply chain hubs

A logistics center initiates or supports economic activity, particularly in the field of logistics. The presence of LC leads to the elimination of excessive road transport by increasing the importance and presence of multimodal transport in the region and by gradually centralizing the region's logistics infrastructure around the LC (Kryś, Izdebski, 2019). A LC is a spatially functional facility, complete with infrastructure and organization, where logistics services are provided-related to the receipt, storage, distribution, and release of goods-as well as ancillary services, provided by economic entities independent of the shipper or consignee (Maganawa et al., 2024). A LC is a key hub in the logistics network and constitutes an independent economic entity with a designated area where, on the basis of free competition, several (at least two) companies operate independently of one another, providing logistics services to internal and external customers on an open-service basis, not limited to specific entities (Rai et al., 2022). They should be treated as independent economic entities bringing together all participants in the supply system in one place. Such facilities should be located in close proximity to the areas they serve, which primarily include cities (Ferreira, Esperança, 2025). Systematic joint planning and cooperation among the center's entities should lead to synergistic effects. To achieve this, the logistics center should be managed by an independent and neutral organization responsible for the development and efficient operation of the center as a whole (Novotná et al., 2022). The core activities of a logistics center consist of comprehensive logistics services (including, among others, transportation, warehousing, distribution, freight forwarding, and information management) or their coordination, as well as ancillary services, including, among others, financial or management services.

A LC must have the appropriate infrastructure and superstructure (including roads, yards, parking lots, civil engineering structures, and buildings) to enable it to provide the required services (Raimbekov et al., 2024). Due to the significant growth of intermodal transport, a LC should have access to two or more modes of transport, as well as a transshipment terminal

for combined transport (Talibov et al., 2023). When planning a national network of logistics centers, it should be taken into account that the national intermodal logistics network should consist of intermodal transport hubs in the form of LC as the main nodes of transport corridors, seaports, and independent container terminals cooperating with nearby warehousing centers (Dyczkowska, Reshetnikova, 2022). The primary purpose of a LC is to provide a wide range of logistics services, while competitiveness and entrepreneurship form the basis for improving customer service standards at LC. The tasks of a LC are highly diverse. The primary tasks undertaken by LC are transport and warehousing management. In addition to the tasks that are outsourced by companies, namely transportation and warehousing (Abbasi et al., 2024). From an economic perspective, LC create the conditions for the effective execution of logistics processes by bringing together within their framework many independent companies providing a variety of logistics services; their potential, strengthened by factors of competition and synergy, enables these services to be provided in the most efficient manner (Zabakhshnia et al., 2023). LC located near urban areas coordinate and consolidate the activities of all entities involved in urban logistics services. Logistics operators also expand the scope of their own service offerings by complementing their capabilities with the services of other operators and create a service market that brings together all suppliers and customers (Kramarz, Kmiecik, 2024). These, in turn, benefit from a wide range of logistics services, service prices determined by free market rules, and a high level of service provided by LC. It is very important to take into account the environmental protection requirements formulated and demanded by society (Kmiecik, Wolny, 2022). LCs allow their shippers to focus on production, avoid unnecessary costs associated with building new warehouses, reduce inventory levels, avoid the costs of purchasing transportation vehicles, improve the quality and timeliness of deliveries, lower the costs of physical material flow, and, above all, provide an information system regarding the flow of goods (Cano et al., 2022). Through the IT systems with which they should be equipped, LCs ensure the handling of supply chain information flows; information technologies facilitate cooperation among all entities located within the logistics center and those outside it. LCs represent the most comprehensive solution for optimizing the flow of goods thanks to their appropriately qualified staff and IT systems (Dyczkowska, 2011).

A Logistics Information System (LIS) is an integrated system that combines information from order processing, inventory control, production planning, warehousing, and accounting. LIS offers logistics operators and the LCs they manage improved value chain management through operational processes, automation, and decision support-ranging from strategic to operational-as well as facilitating business transactions (Wu, Sun, 2023). It enables logistics companies to search for, store, and transform data into useful information for the right people at the right time. LIS is essentially a key enabler for the successful delivery of logistics services by increasing information availability and reducing uncertainty for logistics companies in their daily operational processes (Amine, Boujelben, 2024). Value-added activities in the logistics process should therefore be integrated into the system to maximize business value. A thorough

understanding of the differences between logistics companies and the structure of business processes within a given type of company is important for properly designing the LIS project and architecture under conditions of uncertainty in LC logistics areas.

2.2. Logistics processes in supply chains

The fundamental concept in process management is the process. It is a set of interrelated activities (actions, tasks) that transform inputs (I) into outputs (O). Process inputs come from process suppliers (S), and outputs go to process customers (C). Within an organization, the suppliers of inputs and the recipients of outputs are usually other processes. This model is known as the SIPOC model (from: supplier-input-process-output-client) (Min, Sawaya, 2026). Today, logistics processes are understood as integrated material and information flows, and economic processes are viewed through the lens of these flows, the efficiency of their movement, and the costs they entail. This approach to logistics processes also encompasses customer service, its level, quality, and customer satisfaction; in the broadest sense, a "customer" can be a consumer, a manufacturer, a wholesaler, or a retailer-that is, any recipient of products and services (Jahani et al., 2026). The logistics processes carried out within a company are primarily aimed at ensuring the optimal flow of raw materials, materials, finished goods, and related information. Efficient sales are not possible without effective logistics processes, which consist of the individual components of these processes. It appears that the logistical effectiveness of sales process support is primarily influenced by the following elements: transportation processes, warehousing, inventory levels and structure, and the speed of response to customer needs-all of which are ensured by modern information systems (Ferreira, Reis, 2023). Logistics companies strive to deliver shipments at the lowest possible cost for the appropriate quantity of cargo that meets customer expectations regarding quality, delivery time, and delivery location. An important aspect of logistics management is the continuous improvement of processes by the logistics operator in light of the set goal. The pursuit of excellence results in the continuous improvement of the process, taking into account factors critical to quality, delivery costs, safety, and environmental protection (Onukwulu et al., 2023). The reasons why a logistics operator undertakes initiatives to streamline processes can be divided into several groups. The first source of the need for process improvement is growing customer demands. A situation arises in which the recipient of a shipment increases their expectations regarding process outcomes, such as changes in delivery times, as a result of which a process that previously met requirements may become inadequate. The second source of the need for improvements is instability, uncertainty, and excessive process variability, which result in the failure to fulfill the processes required by customers. The third reason for process improvement is the results of benchmarking, the findings of an audit, or the implementation of a new strategy (Cherchata et al., 2022). In all these cases, it is necessary to streamline processes so that they fully meet the set requirements at the lowest possible cost. Supply chain management processes and activities include (Abdullahi, Mohamud, 2023):

- joint planning, forecasting, replenishment, and the monitoring and control of related processes in the supply chain,
- product and network configuration, which involves making key decisions regarding the products and services offered, the organizational structure, and the relationships between the links in the chain,
- product design utilizing the knowledge potential of suppliers,
- forming a production network aimed at selecting and defining production tasks, production locations, and inventory management, which, in line with the concept of deferral, may apply not only to industrial enterprises but also to commercial or logistics companies,
- optimization of supply chain processes related to the physical flow of products and the accompanying flows of information and financial resources,
- unambiguous identification of a product, shipment, or partner's location domestically or globally,
- continuous analysis and tracking of performance indicators and metrics for logistics operators.

The smooth operation of real-world logistics processes depends to a large extent on information. The efficient flow of information, as well as its appropriate scope, structure, completeness, and timeliness, are key factors in ensuring the efficiency and effectiveness of logistics as a whole, both within a company and across supply chains. The dynamic development of information technology in recent years has laid the groundwork for the development and practical application of effective information systems (Samad et al., 2023). The widespread use of information technology has brought a new level of quality to the management of real-world logistics processes. In the field of logistics, given the massive volume of information flows, the scope of information functions performed is particularly broad. Logistics information services generate and utilize data on goods transported within the logistics system. This data includes information about the shipper, consignee, type of goods, order number, quantity, weight, and volume. Logistics information is key to planning, monitoring, and oversight in the provision of actual logistics services. Data-driven logistics activity, closely linked to the core warehousing service, is inventory management.

Additional logistics services include, for example, order picking, palletizing goods for cost-effective shipping (easier loading and transport), additional packaging for protection, identification, and easier handling of goods and products, and repackaging goods from bulk packaging into smaller units.

Complementary information services and additional services can usually be integrated into the core logistics process without requiring increased organizational resources (Lagario et al., 2022). In this way, significant added value can sometimes be created for the logistics service provider. Additional information services may, for example, relate to supplementary

information about goods, such as prices, promotions, and returns. Additional services can be provided at any location, such as a logistics center, during the transport of goods between the point of origin and the destination.

2.3. Uncertainty in the logistics sector

The causes of unforeseen events and changes essentially identify and clearly define the very concept of unpredictability. Unpredictability should therefore be understood as: an endo or exogenous event, or a resulting change in the planned course of a logistics process, which occurred as a result of the above causes, for which it is impossible to predict its occurrence or indicate the possibility of a specific set of consequences, and for which it is generally impossible to determine the direction and magnitude of the impact on the planned logistics process (Liu, 2024). Many organizations strive to reduce uncertainty in their operations by improving their ability to obtain, filter, and analyze relevant information to facilitate decision-making within the company or to share it with other supply chain participants in order to maximize mutual business benefits (Barmuta et al., 2022). Uncertainty in the supply chain refers to a situation where decisions cannot be made within the framework of supply chain operations. One of the main causes of such failure is a lack of information (Jedliński, Marzantowicz, 2016).

In fact, the lower the uncertainty, the less buffer a company needs to build into its internal structure, thereby reducing operating costs. Hence, there is a significant incentive to reduce uncertainty. Uncertainty within a company can be caused internally by business processes or externally by suppliers or customers (Towill et al., 2000). identified four types of uncertainty sources that can cause disruptions in the supply chain. These are: supply-side uncertainty, demand-side uncertainty, process-side uncertainty, and control-side uncertainty.

Time, quality, and costs are, in general terms, the key indicators of the proper execution of logistics processes. The degree of uncertainty depends on the speed at which factors to be included in the predictive analysis are identified. If time is an indicator of the efficiency of a logistics process, then the degree of uncertainty and unpredictability affect that process through (Kalkha et al., 2023):

- extending the lead time in the process schedule,
- prolonging the decision-making process,
- extending the time horizon for resource utilization,
- extending the duration of logistics operations,
- extending the time required for delivery, ordering, production, and distribution.

In logistics, quality means that a company meets the requirements and expectations agreed upon with the customer regarding the following service characteristics: ease of obtaining necessary information and of placing and transmitting orders; timely and reliable delivery of ordered goods; and communication, accurate, complete, and damage-free order fulfillment, error-free documentation, timely and customer-responsive after-sales service, and the accurate and timely exchange of information between functional departments within the company and between the company and its external partners to support planning.

In terms of quality, as a factor influencing the efficiency of the logistics process, the degree of uncertainty and unpredictability are significant because they lead to (Ercan, Çelik, 2022):

- an increase in the number of consequences resulting from uncertainty and unforeseen events due to the inability to respond appropriately,
- an increase in the process's complexity, and consequently, an increase in its intricacy,
- opening the process to excessive and uncontrolled access by external factors, which causes problems with maintaining process discipline,
- disruptions in the flow of materials and information, resulting in, for example, limited availability.

From the very beginning of the implementation of the logistics approach, supply chain optimization has focused on reducing costs, particularly those associated with logistics processes. With regard to costs, uncertainty and unpredictability affect the logistics process in the following ways (Ivanov, Dolguj, 2025):

- profit margins decrease, leading to excessive resource consumption,
- the cost intensity of procurement, production, and distribution processes increases, as well as that of return and reverse logistics,
- it generates additional, unpredictable costs associated with mitigating these effects,
- it contributes to supply uncertainty,
- uncertainty regarding the pace of consumption (production) increases,
- additional unforeseen costs of logistics operations are generated.

Uncertainty regarding value creation by individual functional areas of logistics is, in essence, a risk determined by the degree to which these areas are exposed to uncertainty (to varying degrees) and unpredictability; it depends on the optimal (balanced) interplay of time, quality, and cost in logistics (Wang et al., 2015; Wang, 2024). The goal of logistics and logistics management by a logistics operator is to influence the physical and informational transactions of logistics processes in a manner that meets specific requirements and effectively combines elements and methods, using as few resources as possible and at the lowest cost. Such effective logistics processes can provide a significant competitive advantage for the companies involved.

3. Methodology

Given the management pressure to identify and mitigate so-called bottlenecks in the LC logistics process and to prevent unacceptable deviations from the plan at the planning stage, we must first examine the occurrence of undesirable events themselves. Here, randomness and incidentality play an obvious role, which means that it is not enough to simply make the

logistics process more flexible, but also to anticipate where irregularities will occur by identifying the flow of information through the supply chain via the logistics center. There is therefore a legitimate need to recognize uncertainty as an element of the logistics strategy. Under this assumption, this implies a readiness to make changes in the area of the resulting constraints. The aim of this study is to assess uncertainty in the IT system for managing logistics processes in logistics centers and to develop recommendations for improving the methodology of uncertainty analysis based on the use of an IT systems registry and a mathematical method.

The process-oriented approach adopted in this article sets the direction for considerations regarding the identification of the impact of uncertainty and unpredictability in logistics and their potential consequences. The research problem formulated is to what extent uncertainty affects the IT system in the management of logistics processes in logistics centers (Choy et al., 2007). The following research hypothesis was formulated:

H1: Uncertainty in logistics processes significantly affects the functioning of information systems used in logistics process management at LCs, reducing the efficiency of information flow, the quality of decisions made, and the level of process coordination.

Additionally, the following specific hypotheses were formulated:

H2: The use of an IT system registry and mathematical methods for uncertainty analysis enables more effective identification and mitigation of the effects of uncertainty in the management of logistics processes in LCs.

H3: The higher the level of uncertainty in the logistics processes of a LC, the greater the impact on reducing the effectiveness of IT systems supporting logistics management.

The research methodology is based on the use of general scientific methods, including analysis, generalization, induction, deduction, synthesis, classification, etc. Furthermore, the improvement to the uncertainty analysis method suggested in the study is based on the use of mathematical methods, expert judgment, and uncertainty assessment tools. The change log is used to generate the necessary information about risks that may arise during the implementation of specific processes, to analyze them, and to develop appropriate preventive measures or measures to minimize the consequences of risky events. This tool can be used to identify and assess the uncertainty of a logistics operator as a whole or a LC, as well as to evaluate its information systems, including procurement management, inventory management, product manufacturing, etc. The change log should be regularly reviewed and updated to ensure continuous monitoring. The methodology used enables a comprehensive assessment of the problem of uncertainty in IT systems in logistics and the formulation of conclusions and recommendations regarding risk mitigation and increasing the reliability of systems supporting logistics processes. The information systems used in logistics centers are responsible for planning, monitoring, and controlling warehousing, transportation, and distribution processes. Every action carried out in the system generates specific events, which are recorded and processed to ensure the continuity of logistics processes and to support decision-making.

To assess uncertainty using the method proposed in this study, it is necessary to determine the impact of identified changes on the processes under consideration and the company's business results, using the expert assessment method and the criteria provided in Table 1.

Table 1.
Criteria for determining the impact of uncertainty on logistics processes at LC

Determining the extent of the event's potential negative impact on the effectiveness of LC's operations	Number of points	Impact assessment
Unforeseeable events cause minor delays or disruptions in logistics processes; their consequences can be easily mitigated or ignored.	1	Minor
An unforeseeable event causes minor delays or disruptions in logistics processes; its consequences can be easily resolved.	2	Low
An unforeseeable event results in a minor loss of resources and negatively impacts operational efficiency; when it occurs, it involves a complex process of dealing with the consequences.	3	Moderate
An unforeseeable event results in a significant loss of resources and has a major impact on LC's operations, and its occurrence involves a complex recovery process.	4	High
An unforeseeable event results in a significant loss of resources and has a critical, negative impact on LC's operations; its occurrence involves a long and complex recovery process.	5	Critical

Source: own elaboration.

The second column specifies the number of points assigned based on the extent of uncertainty, ranging from 1 to 4. The significance of uncertainty can be assessed as follows: below 4 points - insignificant, 4-8 points - low, 8-12 points - moderate, 12-16 points - high, above 16 points - critical. Each category is assigned a weight from 0 to 1.

Table 2 presents the criteria for assessing the probability of occurrence of the considered unpredictable and uncertain events.

Table 2.
Criteria for determining the likelihood of unforeseeable events in LC logistics processes

Probability of an unpredictable event occurring [%]	Number of points	Probability assessment
Less than 10%	1	Very low
10-25%	2	Low
26-50%	3	Moderate
51-75%	4	High
More than 75%	5	Very high

Source: own elaboration.

The number of points awarded depends on the percentage probability of the risk occurring. The following formula is used to calculate the materiality factor for an uncertainty event:

$$UE = IE * PE \tag{1}$$

where:

UE - the significance of an unforeseeable event,

IE - the number of points awarded for assessing the total impact of the event on the company's performance,

PE - the number of points awarded for assessing the probability of the event occurring.

Therefore, it is proposed to use the following formula to determine the total impact of unforeseeable logistics process events on LC's operations:

$$IE = (WC_1 * IEPE_1 + WC_2 * IEPE_2 + \cdots + WC_n * IEPE_n) \quad (2)$$

where:

$WC_{1\ldots n}$ – significance coefficients (category weights) of the categories affected by a given event,

$IP_{1\ldots n}$ – the number of points assigned to the assessment of a given event's impact on the category in question.

The method proposed in this study is examined using the example of an analysis of unforeseeable events in logistics processes at a selected logistics center.

4. Results

Uncertainties associated with the management of the LC logistics information subsystem and the use of information technology:

- leaks of confidential information from LC,
- information security issues (regarding customer data security),
- inappropriate selection of methods for collecting, storing, and transmitting data,
- an improperly designed (inefficient) information exchange process during the execution of logistics operations,
- software failures/malfunctions.

Classifying an unpredictable and uncertain IT event in a logistics system into a specific category makes it possible to identify the processes that require special attention when developing a LC logistics strategy, as well as to pinpoint logistics vulnerabilities and additional costs associated with policies for preventing unforeseen situations. The classification presented earlier also enables a transparent analysis of unforeseen events in logistics processes. Table 3 presents a summary of IT-related events in LC logistics processes, compiled based on this classification for a selected LC involved in the flow of goods in a cross-docking system.

Table 3.
Event log for IT systems at a selected LC

Event reference number	Identified event	Probability assessment
E1	Ineffective internal communication	Creating a unified corporate communication platform. Employee survey
E2	Viruses/cyberattacks	Staff training on network security. Antivirus software, software updates.

Cont. table 3.

E3	Delays in communicating delivery information to the relevant parties	Improving the information exchange system among logistics process participants
E4	Leakage of confidential company information	Implementing data leak prevention software
E5	Leakage of customers' personal data	Using a VPN connection

Source: own elaboration.

Table 4 presents the results of the assessment of unforeseen events conducted using expert judgment and mathematical methods, based on criteria for determining the impact and probability of events occurring, as well as formulas (1) and (2). The following activities were assigned specific weights: OC – operating costs (weight -0.22); DE – delivery efficiency (weight -0.28); CR – customer relations (weight -0.29); FR – company reputation (weight -0.21).

Table 4.
Assessment of unforeseen events in the area of information systems for logistics processes at a selected LC

Event reference number	The impact of the event on selected aspects				The overall impact of the event	Probability of the event occurring	Significance of the event
	OC	DE	CR	FR			
E1	3	3	4	3	3.29	3	9.87
E2	5	4	4	4	4.22	2	8.44
E3	3	5	5	4	4.35	4	17.4
E4	4	3	3	4	3.43	3	10.29
E5	4	4	5	5	4.5	3	13.5

Source: own elaboration.

The results of the calculations presented in Table 4 show that, of the five information events in the logistics processes of the analyzed LC, two are characterized by a moderate degree of significance, two are highly significant, and one is critical. In this case, there are no insignificant events. Among the high-significance events, the following risks are particularly dangerous: E3 (critical), as well as E4 and E5. For the LC, the most critical aspect in logistics systems is the immediate transmission of information regarding shipment deliveries to customers, not only through shipment tracking but also by providing additional updates on the situation. It is recommended to develop additional measures to minimize these risks. In the case of E5, the use of a VPN connection may prove insufficient to protect customers' personal data; therefore, it is necessary to account for the costs of a potential IT systems audit, customer data encryption, and the use of modern data protection algorithms. In the case of E4, an audit and training for LC employees are recommended.

The presented results indicate that the use of a multi-criteria expert assessment—which takes into account the impact of events on operating costs, delivery efficiency, customer relations, and the company's reputation—enables the identification of events of the greatest significance to the functioning of information systems for logistics processes. Event Z3 received the highest significance score and was classified as critical, while events Z4 and Z5 were assessed as high-significance risks. The results confirm that the efficient operation of information systems has a direct impact not only on the continuity of logistics processes but

also on the level of customer service and the company's image. A novel aspect of this research is the comprehensive combination of expert assessment with a weighted mathematical evaluation method, which allows for the simultaneous consideration of multiple impact criteria and the probability of events occurring. The proposed approach allows for the prioritization of risks and the identification of areas requiring the implementation of preventive measures. The results can serve as a practical tool to support risk management in logistics centers and aid in decision-making regarding investments in information system security. At the same time, the limitations of the conducted research should be noted. The analysis was based on a single case study of a selected logistics center, which limits the ability to directly generalize the obtained results to other companies. Furthermore, the risk assessment is based on expert opinions, which, despite the use of a structured assessment method, contain an element of subjectivity. Another limitation is the use of fixed weights for individual criteria, whereas their importance may vary depending on the specific characteristics of the company, the industry, or changing market conditions. The study covered only selected incidents related to information systems supporting logistics processes, omitting other potential sources of risk that may occur in practice.

Despite these limitations, the results provide valuable insights for risk management practices. For incident Z5, it is advisable to expand security measures beyond the use of a VPN by conducting regular security audits, encrypting customer data, and implementing modern data protection mechanisms. For incident Z4, systematic process audits and employee training to raise awareness of information security threats are recommended. For incident Z3, however, which is classified as a critical risk, it is necessary to develop comprehensive response procedures and systems for promptly notifying customers of disruptions in delivery.

The effects of supply chain disruptions can also negatively impact logistics processes and the overall operations of a logistics provider; therefore, it is recommended to minimize events related to uncertainty, in this case by developing and regularly updating contingency plans or providing an additional information system. An additional information system in the form of a LIS, designed to reduce events resulting from uncertainty, appears to be a sufficient measure to mitigate the negative impact of this risk. Event logging and analysis enable real-time monitoring of a logistics center's operations, rapid detection of anomalies, and the implementation of corrective actions. Data from ERP, WMS, TMS, and automatic identification systems form the basis for analyzing the efficiency of logistics processes, forecasting risks, and improving work organization. Modern logistics centers are increasingly using solutions based on real-time data analysis, artificial intelligence, and machine learning, which allow them to anticipate potential disruptions and limit the impact of uncertainty on the functioning of the entire supply chain. The analysis also indicates the possibility of cost reduction by the LC, for example by deferring costly mitigation measures for events of low significance in favor of mitigating threats with a high significance factor.

Uncertainty in logistics processes is one of the most significant challenges facing modern logistics centers. It stems from the difficulty in predicting events that affect warehouse, transportation, and distribution processes. Sources of uncertainty can include both internal factors, such as IT system failures, and external factors, including fluctuations in demand, delivery delays, weather conditions, disruptions in supply chains, and changes in legal regulations.

A significant area affected by uncertainty is logistics operating costs. Delivery delays, the need to maintain larger safety stock levels, additional shipments, and the costs of resolving the effects of system failures all lead to increased operating costs. Companies also incur expenses related to securing their IT infrastructure, implementing monitoring systems, and training employees in risk management. Uncertainty also has significant consequences for the functioning of IT systems supporting logistics. Incomplete or outdated data, integration errors between ERP, WMS, and TMS systems, and failures in ICT infrastructure can lead to incorrect operational decisions. The quality of information therefore becomes one of the key elements in reducing uncertainty in logistics management.

5. Discussion

In an environment characterized by increased uncertainty and dynamic external conditions, the importance of assessing uncertainty in information systems within LC logistics processes is growing, as it aims to anticipate potential risks and develop measures to minimize them. Uncertainty management and the analysis of unforeseen situations in logistics are becoming a strategically important subsystem of management in modern organizations (Kubasova, 2018; Cervantes-Cabrera, 2018). It should be emphasized that methods such as sensitivity analysis and uncertainty modeling are often used to analyze unforeseen logistics operations. The application of these methods can be time-consuming for LC. A viable solution for analyzing uncertainty in logistics systems may be the use of continuous event analysis throughout the supply chain, followed by a comparison of the results with management decisions. It is recommended to use the method proposed in this study to identify and mathematically assess the uncertainty of information systems in the supply chain, in combination with other methods, such as decision trees or scenario analysis. It is suggested that the method under consideration be refined by assessing the impact of logistics process uncertainty on various aspects and outcomes of the supply chain.

Certain differences compared to previous studies stem primarily from the scope of the analysis. Most publications focus on risks occurring throughout the entire supply chain or analyze only cybersecurity risks, whereas this study focuses on the uncertainty present in the information systems of a single logistics center and its impact on the execution of logistics

processes. This allowed for a more detailed identification of threats specific to the analyzed company; however, it also limits the ability to fully generalize the obtained results.

The novel contribution of this study is the development of a practical method for assessing the impact of uncertainty on the functioning of information systems supporting logistics processes using a multi-criteria risk assessment. The proposed approach enables logistics companies to prioritize preventive measures and rationally plan investments in IT system security, employee training, and risk management procedures. The results obtained can serve as a basis for developing decision-support models in other logistics centers and as a starting point for further research involving a larger number of companies and utilizing real operational data.

Refining the uncertainty analysis methodology aims to identify opportunities to account for the specific characteristics of the logistics processes under study, as well as their impact on company performance, in order to increase the likelihood of making sound management decisions. Future research should cover other areas, such as partnerships, deliveries to CL, and customer relations.

6. Conclusion

The research objective was achieved by assessing uncertainty in the IT system used for managing logistics processes in logistics centers, and recommendations were developed for improving the methodology of uncertainty analysis based on the use of an IT system registry and a mathematical method. The research problem was solved, as uncertainty and unpredictable events affect the IT system in the management of logistics processes in logistics centers. The hypotheses were verified positively, confirming the assumptions in part of the results.

The results obtained provide an answer to the research question concerning the impact of uncertainty on the functioning of information systems supporting logistics process management in logistics centers. The analysis showed that unforeseen events related to information systems can significantly disrupt the flow of information, affect the timeliness of logistics processes, and degrade the quality of customer service. Events Z3, Z4, and Z5 received particularly high significance scores, indicating the need to prioritize them in the risk management process.

The research results allow for a positive verification of hypothesis H1. The assessment showed that uncertainty in logistics processes significantly affects the functioning of the information systems used to manage those processes. The greatest impact was observed in the areas of information flow efficiency, customer relations, and delivery efficiency. This means that an increase in the level of uncertainty can lead to a deterioration in the quality of operational decisions and a reduction in the level of coordination of logistics processes.

Hypothesis H2 was also confirmed. The use of an event log and the combination of expert assessment with the weighted mathematical evaluation method enabled the systematic identification of risks, their classification by level of significance, and the identification of areas requiring the implementation of risk-mitigation measures. The results indicate that the proposed methodology can serve as a practical tool to support the risk management process in logistics centers.

Analysis of the results also confirms hypothesis H3. Events characterized by a higher level of uncertainty and a greater probability of occurrence received the highest significance index values. This applies primarily to event Z3, which was classified as critical, and to events Z4 and Z5, which are classified as high-risk. The results therefore confirm the relationship between an increase in the level of uncertainty and a decline in the effectiveness of IT systems supporting logistics processes.

The results obtained are consistent with those of previous studies on risk management in logistics, which indicate that the efficiency of information systems is one of the key factors ensuring the resilience and continuity of supply chains. As in previous studies, the importance of timely information flow, data security, and effective communication with customers was emphasized as factors that mitigate the negative effects of disruptions. At the same time, this study expands on previous approaches by employing an integrated method that combines expert assessment with a weighted mathematical evaluation, thereby enabling a quantitative assessment of the significance of individual events and their comparative analysis.

Uncertainty and the unpredictability of events in logistics are closely linked to the management of the flow of goods and information, as well as potential failures in the operation of the logistics system resulting from undesirable events occurring in its subsystems or in the external environment. Managing uncertainty in logistics is hampered by a number of barriers, including the centralization of product distribution, changing consumer expectations, a lack of necessary information, difficulties in managing information flows and outsourcing processes, as well as divergent IT system standards used by partners. Under such circumstances, there is a growing need for effective uncertainty management through the analysis of unpredictable events in logistics, based on processes for identifying and analyzing potential risks. This study presents an improved method for the quantitative assessment of uncertainty, which enables the identification of risks to the execution of logistics processes for LC, as well as the analysis of their impact and significance, in order to make decisions regarding their mitigation. To ensure the comprehensiveness of the analysis, it is recommended to apply the suggested method in combination with other effective uncertainty assessment tools, such as decision trees and scenario analysis. An area for further research is the analysis of methods for assessing and managing uncertainty in information systems within logistics processes in the context of the digital transformation of LC. In summary, uncertainty in logistics processes affects all areas of a logistics center’s operations—from operational efficiency and costs, through customer service quality, to the reliability of IT systems. Systematically identifying sources of uncertainty,

measuring their impact using performance metrics, and implementing appropriate risk management methods can increase an organization's resilience and improve its operational and financial performance.

Uncertainty also affects the quality of customer service. Delays in order fulfillment, picking errors, and product unavailability reduce customer satisfaction and can lead to a loss of trust and customers. In a highly competitive environment, maintaining a high level of reliability in logistics processes becomes one of the key factors in competitive advantage. A topic for further research is the analysis of methods for assessing and managing uncertainty in information systems within logistics processes in the context of the digital transformation of CL.

References

1. Abbasi, S., Sıcakyüz, Ç., Gonzalez, E.D.S., Ghasemi, P. (2024). A systematic literature review of logistics services outsourcing. *Heliyon, 10(13).* https://doi.org/10.1016/j.heliyon.2024.e33374
2. Abdullahi, H.O., Mohamud, I.H. (2023). The impact of ICT on supply chain management efficiency and effectiveness: A literature review. *Journal Européen des Systèmes Automatisés, 56(2),* 309. https://doi.org/10.18280/jesa.560216
3. Amine, F.M., Boujelben, Y. (2024, May). *The Importance of the logistics information system" LIS" for the facilitation of customs control: case of authorized economic operators" AEO".* 2024 IEEE 15th International Colloquium on Logistics and Supply Chain Management (LOGISTIQUA) (pp. 1-7). IEEE. https://doi.org/10.1109/LOGISTIQUA61063.2024.10571499
4. Barmuta, K., Rusakova, N., Malkhasyan, A. (2022). Doskonalenie metody analizy ryzyka procesów logistycznych przedsiębiorstwa. *Transportation Research Procedia, 63*, 737-745. https://doi.org/10.1016/j.trpro.2022.06.069
5. Cano, J.A., Londoño-Pineda, A., Rodas, C. (2022). Sustainable logistics for e-commerce: A literature review and bibliometric analysis. *Sustainability, 14(19),* 12247. https://doi.org/10.3390/su141912247
6. Cervantes-Cabrera, O., Turrent, G. (2018). The importance of risk management assessment: a proposal of an index for listed companies. *Journal of Accounting Research, Organization and Economics, 1*, 122-137. DOI: 10.24815/jaroe.v1i2.11747
7. Cherchata, A., Popovychenko, I., Andrusiv, U., Gryn, V., Shevchenko, N., Shkuropatskyi, O. (2022). Innovations in logistics management as a direction for improving the logistics activities of enterprises. *Management Systems in Production Engineering*. DOI 10.2478/mspe-2022-0002

8. Choy, K.L., Li, C.L., So, S.C., Lau, H., Kwok, S.K., Leung, D. (2007). Managing uncertainty in logistics service supply chain. *International Journal of Risk Assessment and Management, 7(1),* 19-43.
9. Cichosz, M., Aluchna, M., Sońta-Drączkowska, E., Knemeyer, A.M. (2025). Navigating paradoxical tensions in pursuit of sustainable supply chain management: review and guidance for future inquiry. *The International Journal of Logistics Management, 36(7),* 99-136. https://www.emerald.com/insight/0957-4093.htm
10. Dyczkowska, J. (2011). Centra dystrybucyjne i logistyczne Pomorza Środkowego. *Logistyka, 6,* p. 4206.
11. Dyczkowska, J.A., Reshetnikova, O. (2022). Logistics centers in Ukraine: analysis of the logistics center in Lviv. *Energies, 15(21),* 7975. https://doi.org/10.3390/en15217975
12. Ercan, E., Çelik, M. (2022). Logistics flexibility, relationship flexibility, and logistics service quality: The moderating role of environmental uncertainty. *International Journal of Management Studies, 29(1),* 1-36. https://doi.org/10.32890/ ijms2022.29.1.1
13. Ferreira, B., Reis, J. (2023). A systematic literature review on the application of automation in logistics. *Logistics, 7(4),* 80. https://doi.org/10.3390/logistics7040080
14. Ferreira, J.C., Esperança, M. (2025). Enhancing sustainable last-mile delivery: The impact of electric vehicles and AI optimization on urban logistics. *World Electric Vehicle Journal, 16(5)*, 242. https://doi.org/10.3390/wevj16050242
15. Ivanov, D., Dolgui, A. (2025). Tariff shocks, ripple effect, and deep uncertainty in supply chains: we are entering a turbulence zone, please fasten your seatbelts. *International Journal of Production Research, 63(19),* 7305-7317. https://doi.org/10.1080/ 00207543.2025.2520598
16. Jahani, H., Jain, R., Ivanov, D. (2026). Data science and big data analytics: a systematic review of methodologies used in the supply chain and logistics research. *Annals of Operations Research, 359(2),* 1297-1354. https://doi.org/10.1007/s10479-023-05390-7
17. Jedliński, M., Marzantowicz, Ł. (2016). Wpływ niepewności i nieprzewidywalności na procesy logistyczne. *Problemy transportu i logistyki, 1(37),* 171-185. DOI: 10.18276/ptl.2017.37-27
18. Kalkha, H., Khiat, A., Bahnasse, A., Ouajji, H. (2023). The rising trends of smart e-commerce logistics. *IEEE Access, 11*, 33839-33857. DOI: 10.1109/ACCESS. 2023.3252566
19. Kirzner, I.M. (2024). Uncertainty, discovery, and human action: A study of the entrepreneurial profile in the Misesian system. *Modern Austrian Economics, Vol. 1.* Routledge, pp. 41-64.
20. Kmiecik, M., Wolny, M. (2022). Forecasting needs of the operational activity of a logistics operator. *LogForum, 18(2)*, 197-212. http://doi.org/10.17270/J.LOG.2022.713
21. Kocabasoglu-Hillmer, C., Vanpoucke, E., Son, B.G., Roden, S. (2023). Seeing with fresh eyes–the potential of paradox theory to explore persistent, interdependent tensions in supply

chains. *International Journal of Operations & Production Management, 43(11),* 1669-1689. https://doi.org/10.1108/IJOPM-07-2023-0605

22. Kramarz, M., Kmiecik, M. (2024). The role of the logistics operator in the network coordination of omni-channels. *Applied Sciences, 14(12),* 5206. https://doi.org/10.3390/app14125206
23. Kryś, P., Izdebski, W. (2019). Znaczenie centrów logistycznych dla funkcjonowania łańcuchów dostaw. *Gospodarka Materiałowa i Logistyka, 5,* 369-387. DOI http://dx.doi.org/0.33226/1231-2037.2019.5.28
24. Kubasova, T., Tkach, V., Tsvigun, I. (2018). *Priorities of thelogistics risks management in the resource support of construction projects.* MATEC Web of Conferences 212. DOI: 10.1051/matecconf/201821208010.
25. Lagorio, A., Cimini, C., Pinto, R., Cavalieri, S. (2023). 5G in Logistics 4.0: potential applications and challenges. *Procedia Computer Science, 217*, 650-659. 10.1016/j.procs.2022.12.261
26. Lagorio, A., Zenezini, G., Mangano, G., Pinto, R. (2022). A systematic literature review of innovative technologies adopted in logistics management. *International Journal of Logistics Research and Applications, 25(7),* 1043-1066. https://doi.org/10.1080/13675567.2020.1850661
27. Liu, Q. (2024). Logistics distribution route optimization in artificial intelligence and internet of things environment. *Decision Making: Applications in Management and Engineering, 7(2),* 221-239. https://doi.org/10.31181/dmame7220241072
28. Min, H., Sawaya, W. (2026). Lean Six Sigma for fulfilling value-added services in the post-pandemic logistics industry. *International Journal of Services and Operations Management, 53(4),* 458-472. https://doi.org/10.1504/IJSOM.2026.152958
29. Naganawa, H., Hirata, E., Firdausiyah, N., Thompson, R.G. (2024). Logistics hub and route optimization in the physical internet paradigm. *Logistics, 8(2),* 37. https://doi.org/10.3390/logistics8020037
30. Novotná, M., Švadlenka, L., Jovčić, S., Simić, V. (2022). Micro-hub location selection for sustainable last-mile delivery. *Plos one, 17(7),* e0270926. https://doi.org/10.1371/journal
31. Onukwulu, E.C., Fiemotongha, J.E., Igwe, A.N., Ewim, C.P.M. (2023). Transforming supply chain logistics in oil and gas: best practices for optimizing efficiency and reducing operational costs. *Journal of Advance Multidisciplinary Research, 2(2),* 59-76. DOI: https://doi.org/10.54660/.JAMR.2023.2.2.59-76
32. Rai, H.B., Kang, S., Sakai, T., Tejada, C., Yuan, Q.J., Conway, A., Dablanc, L. (2022). 'Proximity logistics': characterizing the development of logistics facilities in dense, mixed-use urban areas around the world. *Transportation Research Part A: Policy and Practice, 166,* 41-61. https://doi.org/10.1016/j.tra.2022.10.007
33. Raimbekov, Z., Syzdykbayeva, B., Rakhmetulina, A., Rakhmetulina, Z., Abylaikhanova, T., Doltes, L., Kinasheva, Z. (2024). Designing and improving the efficiency of placement

of logistics infrastructure for storage, distribution and trade of agri-food products. *Journal of Industrial Engineering and Management, 17(3),* 777-808. https://doi.org/10.3926/jiem.6081

34. Samad, T.A., Sharma, R., Ganguly, K.K., Wamba, S.F., Jain, G. (2023). Enablers to the adoption of blockchain technology in logistics supply chains: evidence from an emerging economy. *Annals of Operations Research, 327(1),* 251-291. https://doi.org/10.1007/s10479-022-04546-1
35. Talibov, A.M., Hashimov, E.G., Sabziev, E.N., Pashayev, A.B. (2023). On the optimal placement of logistics centers. *Baku: Informatics and Control Problems, 43,* 51-58. https://doi.org/10.54381/icp.2023.2.07
36. Towill, D.R., Childerhouse P., Disney, St.M. (2000). Speeding up the progress curve towards effective supply chain management. *Supply Chain Management: An International Journal, Vol. 5, No. 3*, pp.122-130. https://doi.org/10.1108/13598540010338866
37. Vlachos, I., Polichronidou, V. (2022, June). *The role of Third-Party Logistics Providers in managing international supply chain triads.* 2022 IEEE 6th International Conference on Logistics Operations Management (GOL). IEEE, pp. 1-10. http://dx.doi.org/10.1109/GOL53975.2022.9820185
38. Wang, M. (2024). *Logistics capability, supply chain uncertainty and risk, and logistics performance: an Empirical Analysis of the Australian Courier Industry* (Doctoral dissertation, RMIT University). https://doi.org/10.25439/rmt.27596823
39. Wang, M., Jie, F., Abareshi, A. (2015). Evaluating logistics capability for mitigation of supply chain uncertainty and risk in the Australian courier firms. *Asia Pacific Journal of Marketing and Logistics, 27(3)*, 486-498. https://doi.org/10.1108/APJML-11-2014-0157
40. Wu, W., Sun, R. (2023, November). Research and implementation of data mining algorithms based on logistics information systems. *International Conference on Internet of Things and Machine Learning (IoTML 2023), Vol. 12937*. SPIE, pp. 94-101. https://doi.org/10.1117/12.3013620
41. Yang, C., Tian, K., Gao, X. (2025). Supply chain resilience: Measure, risk assessment and strategies. *Fundamental Research, 5(2),* 433-436. https://doi.org/10.1016/j.fmre.2023.03.011
42. Zarbakhshnia, N., Govindan, K., Kannan, D., Goh, M. (2023). Outsourcing logistics operations in circular economy towards to sustainable development goals. *Business Strategy and the Environment, 32(1),* 134-162. https://doi.org/10.1002/bse.3122

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

INTERGENERATIONAL COOPERATION UNDER DEMOGRAPHIC CHANGES – AN EMPIRICAL ANALYSIS OF SMES IN THE POZNAŃ COUNTY

Małgorzata GAJOWIAK

Poznan University of Technology, Faculty of Management Engineering, Institute of Logistics, Department of Enterprises, Investments, and Insurance; malgorzata.gajowiak@put.poznan.pl, ORCID: 0000-0002-5631-7758

Purpose: The paper analyses intergenerational cooperation in enterprises in the context of demographic changes, particularly population ageing and declining fertility rates. It also examines whether younger and older employees differ in their assessment of intergenerational cooperation and willingness to engage in it.
Design/methodology/approach: The study is based on quantitative research conducted in 2022-2023 among 50 small and medium-sized enterprises in Poznań County. The sample included 100 respondents representing two age groups: employees under 50 and employees aged 50 and above. Data were collected using a structured questionnaire and analysed with the Mann-Whitney U test and the chi-square test. The study draws on the literature on demographic change and age diversity management.
Findings: Intergenerational cooperation was common, with over 70% of respondents reporting experience in age-diverse teams. No statistically significant differences were found between the two groups in their assessment of cooperation quality. However, significant differences were identified in willingness to cooperate and the perceived importance of intergenerational cooperation. Older employees showed greater openness to cooperation and attached higher importance to it than younger employees.
Research limitations/implications: The study is limited by its regional scope and relatively small sample, which may reduce the generalisability of the findings. Future research should include larger samples, different regions and sectors, and qualitative methods.
Practical implications: The findings support the implementation of age management practices, including mentoring, reverse mentoring, and initiatives promoting intergenerational collaboration to enhance knowledge transfer and organisational effectiveness.
Social implications: Strengthening intergenerational cooperation may reduce age stereotypes, foster social cohesion, and support policies extending working lives.
Originality/value: The study provides empirical evidence on intergenerational cooperation in SMEs under demographic change and compares perceptions across generational groups, highlighting the importance of age diversity for organisational functioning.
Keywords: intergenerational cooperation; demographic changes; SMEs; age diversity; labour market.
Category of the paper: Research paper.

1. Introduction

Terms such as demographic crisis, demographic bomb, or generational tsunami describe ongoing adverse changes in the age structure of the population from the perspective of the labour market. Population ageing, accompanied by a simultaneous decline in fertility rates, including in developing countries, has become a global trend. This is confirmed by numerous statistical data. According to the World Bank, the share of people aged 60+ in the world population was 5% in 1960, rising to 10% in 2024. In contrast, the share of people aged 0-14 was 37% in the same period, whereas it has currently decreased to 25% (WB, 2025). According to projections of the same institution, this trend will continue to intensify: the share of older people is expected to reach 16% in 2050 and even 22% in 2100. Conversely, the share of children aged 0-14 is projected to amount to 21% and 17%, respectively (UN, 2022).

A similar unfavourable transformation of the demographic structure has also been observed in Poland over recent decades. In 1960, the share of people aged 60+ was 6%, increasing to 20% in 2024. At the same time, the share of the population aged 0-14 more than halved, falling from 33% in 1960 to 15% in 2024 (WB, 2025). Thus, a clear reversal of the population age structure has taken place—from a progressive to a regressive model. In the second half of the twentieth century, the population pyramid had a broad base due to high fertility rates and relatively lower life expectancy (UN, 2022). Currently, a systematic narrowing of the base and widening of the upper age groups can be observed, resulting from declining fertility rates, postponement of reproductive decisions, and increasing life expectancy (Eurostat, 2025). This process leads to population ageing and an increasing share of people in post-working age, which in turn raises the demographic burden on the working-age population (GUS, 2023a). Polish demographic projections do not indicate a reversal of this trend in the future. In 2050, the share of the population aged 65+ is expected to reach 32%, and in 2100 it may rise to 38%. In contrast, the younger population (0–14) is projected to account for 13% both in 2050 and 2100 (GUS, 2023b; Eurostat, 2023a), which results from projected low fertility rates (1.45 in 2050 and 1.5 in 2100) (Notes…, 2025). This means that in both the medium- and long-term perspective, the country will not reach the replacement-level fertility rate of 2.1.

The described transformations have a significant impact on the functioning of the labour market and, consequently, on national economies. In the face of a growing number of older people, there is a real risk of labour shortages. As a result, many countries are either implementing or discussing the extension of the retirement age. However, this raises concerns regarding cooperation between different generations in the workplace. Each generation is characterised by different values, attitudes, and priorities in both professional and private life. Nevertheless, in the context of the above-mentioned demographic changes, intergenerational cooperation ceases to be merely a desirable element of organisational culture and becomes a necessity determining the stability of enterprises and entire economies.

In the context of shrinking labour resources and the growing share of older people, the effective use of the potential of all age groups becomes crucial. The integration of competencies and experiences from different generations may provide a response to challenges related to labour shortages, knowledge transfer, and the continuity of organisational processes (OECD, 2020; Eurostat, 2025). Properly managed age diversity can lead to increased innovation, improved team effectiveness, and higher employee satisfaction (OECD, 2020; Kunze, Boehm, Bruch, 2013). However, there is still a lack of conclusive empirical evidence providing a comprehensive picture of intergenerational relations in organisations and their perception by employees of different generations. Therefore, it is justified to conduct empirical research aimed at identifying the scale, frequency, and quality of intergenerational cooperation, as well as the willingness to cooperate and the perceived importance of such cooperation within two age groups. This allows not only for the verification of theoretical assumptions but also for the formulation of practical recommendations for human resource management (North, Fiske, 2015).

Taking the above into account, this article presents the results of a research project conducted among SMEs in Poznań County, aimed at verifying key aspects of intergenerational cooperation. For this purpose, the following research questions were formulated: 1) Did respondents work in age-diverse teams within the last six months? 2) If so, how do they evaluate this cooperation? 3) Is there a relationship between age/generational group and willingness to engage in intergenerational cooperation? 4) How important is intergenerational cooperation for the respondents? Subsequently, in accordance with quantitative research principles, these questions were transformed into research hypotheses subject to empirical verification. The transformation of research questions into hypotheses enabled the operationalisation of the analysed phenomena and the application of statistical methods to assess relationships between variables. The formulated hypotheses formed the basis for assessing whether intergenerational cooperation can be considered an effective tool for mitigating the negative effects of demographic changes on the labour market.

2. Literature review

Intergenerational cooperation is one of the key aspects of the functioning of contemporary organisations and societies, particularly in the context of dynamic demographic changes such as population ageing and the extension of working life. According to Eurostat data, the median age in the European Union increased from 38.4 years in 2001 to over 44 years in 2023, clearly indicating an ongoing process of population ageing (Eurostat, 2023b). Consequently, the labour market is increasingly characterised by the coexistence of representatives of as many as four or five generations, which necessitates effective age diversity management (EPALE, 2025).

It should be noted that the essence of intergenerational cooperation lies in the synergistic use of the potential of representatives of different generations, who differ in professional experience, competencies, values, and working styles. Older generations, such as Baby Boomers and Generation X, primarily contribute expert knowledge, experience, and well-developed interpersonal skills to organisations. In turn, younger generations, including Generation Y and Z, are characterised by greater proficiency in digital technologies, flexibility, and openness to change (Hays Poland, 2024). This complementarity of resources constitutes the foundation of effective intergenerational cooperation and may lead to increased innovation and organisational competitiveness.

Researches show that age diversity in teams has a significant impact on their effectiveness. As many as 65% of managers indicate that generational diversity fosters innovation and improves problem-solving (EY, 2024). Moreover, organisations that actively manage diversity achieve higher financial performance and demonstrate greater adaptability to market changes (OECD, 2020). Intergenerational cooperation also supports knowledge transfer, which may take the form of both traditional mentoring (where older employees pass knowledge to younger ones) and reverse mentoring, in which younger generations share digital competencies and modern work tools (Harvard Business Review, 2019).

Furthermore, key benefits of intergenerational cooperation include improved quality of decision-making resulting from the inclusion of diverse perspectives and experiences. Diverse teams are also more creative and better at solving complex problems (OECD, 2020). In addition, such cooperation contributes to building an organisational culture based on inclusiveness, mutual respect, and lifelong learning. It is also worth emphasising that employees working in intergenerational teams more often report higher levels of job satisfaction and engagement (EY, 2024).

From the perspective of younger generations, cooperation with older colleagues is often perceived positively. Research indicates that as many as 71% of Generation Z representatives consider such cooperation valuable and development-oriented (Pro Progressio, 2024). At the same time, only 57% of older employees share this opinion, which indicates a certain asymmetry in the perception of intergenerational relations (Pro Progressio, 2024). These differences may stem from varying work expectations, communication styles, and levels of openness to change.

Intergenerational cooperation also creates a number of important development opportunities. First and foremost, it enables the creation of learning organisations in which knowledge is continuously exchanged and developed. This is particularly important in the era of digital transformation and rapid technological progress, where continuous skills updating becomes essential (World Economic Forum, 2023). Moreover, effective use of older employees' potential helps mitigate labour shortages and counteract the professional exclusion of pre-retirement-age workers (OECD, 2020). From a social perspective, intergenerational cooperation also fosters social cohesion and helps reduce stereotypes and age-related prejudice, including ageism.

However, despite numerous benefits, intergenerational cooperation also involves certain challenges and threats. One of the most frequently identified problems is differences in communication styles. Older generations typically prefer direct and formal communication, whereas younger generations more often use digital tools and informal communication (Hays Poland, 2024). This may lead to misunderstandings and reduced efficiency of cooperation.

Another important challenge is intergenerational stereotypes, which may influence perceptions of colleagues. Older employees are sometimes perceived as less flexible and less open to change, while younger employees are seen as less loyal and less committed (Posthuma, Campion, 2009). Such simplifications may lead to conflicts and hinder the development of effective team relationships, potentially negatively affecting organisational performance and financial results.

Differences in digital competencies represent another risk factor. In the context of ongoing digitalisation, insufficient skills may limit cooperation and cause frustration among both older and younger employees (World Economic Forum, 2023). Additionally, differing approaches to work- including work-life balance, hierarchy, and management styles - may lead to tensions within intergenerational teams (EY, 2024).

In conclusion, intergenerational cooperation is a complex, multidimensional phenomenon that brings both significant benefits and challenges. Its effectiveness largely depends on the skillful management of diversity, the promotion of an open organisational culture, and the implementation of solutions supporting integration between generations, such as mentoring programmes, communication training, and initiatives aimed at reducing stereotypes. In the context of demographic change and rapid technological development, intergenerational cooperation will play an increasingly important role in shaping organisational competitiveness and social cohesion.

3. Methods

3.1. Study design

This study employed a quantitative research design to investigate intergenerational cooperation in small and medium-sized enterprises (SMEs) operating in Poznań County, Poland. The research was conducted between 2022 and 2023 as part of the project *Methods of shaping employees' intellectual capital with consideration of age diversity*. The main objective of the study was to examine whether employees representing different generations differed in their perceptions of intergenerational cooperation, willingness to cooperate, and the importance they attached to such cooperation.

3.2. Sample

A purposive sampling strategy was applied. The study involved 50 SMEs located in Poznań County. The selection criteria included: (1) location in Poznań County, (2) classification as a small or medium-sized enterprise, (3) operation within Section C of the Polish Classification of Activities (PKD 2007), and (4) employment of at least four employees aged under 50 and four employees aged 50 years or older.

Initially, 362 enterprises met the selection criteria. Fifty-two organisations agreed to participate, and complete questionnaires were obtained from 50 enterprises. Two respondents from each enterprise participated in the survey - one employee under the age of 50 and one employee aged 50 or above - resulting in a final sample of 100 respondents.

Among the participating enterprises, 64% were small enterprises. The average age of respondents was 33 years in the younger group and 56 years in the older group. Men constituted the majority in both groups. The average job tenure was 9.7 years among younger employees and 30.2 years among older employees.

3.3. Research instrument

Data were collected using a structured questionnaire consisting of 24 questions. Prior to the main study, a pilot survey was conducted to verify the clarity and reliability of the research instrument. The questionnaire included questions concerning respondents' experience of working in age-diverse teams, assessment of the quality of intergenerational cooperation, willingness to cooperate with employees from another age group, and the perceived importance of intergenerational cooperation.

For the purposes of statistical analysis, age was transformed into a categorical variable representing two generational groups: employees under 50 years of age and employees aged 50 years and above.

3.4. Statistical analysis

Descriptive statistics were calculated for all analysed variables. To verify the research hypotheses, both descriptive and inferential statistical methods were applied.

Hypothesis H1 was verified using descriptive statistics presenting the proportion of respondents working in age-diverse teams.

Differences between younger and older employees in the assessment of intergenerational cooperation (H2) and the perceived importance of such cooperation (H4) were analysed using the Mann-Whitney U test for independent samples, as the analysed variables were measured on a five-point Likert scale. The relationship between age group and willingness to engage in intergenerational cooperation (H3) was examined using Pearson's chi-square test of independence.

All statistical analyses were conducted using IBM SPSS Statistics software. The level of statistical significance was set at $\alpha = 0.05$.

4. Results

The main premise of the study was the assumption that age diversity in teams may constitute a significant source of organisational advantage, provided that it is properly managed and fosters cooperation among employees representing different generations. Accordingly, during the implementation of the project, efforts were made to address the following research questions:

1. Did the respondents work in age-diverse teams during the last six months?
2. If so, how did they assess this cooperation?
3. Is there a relationship between age groups and the willingness to engage in intergenerational cooperation?
4. Do respondents consider intergenerational cooperation to be important?

At the stage of preparing the empirical study, the following research hypotheses were formulated:

H1) In the analysed enterprises, more than half of the respondents worked in age-diverse teams during the last six months.

H2) The evaluation of established cooperation is the same across both generations.

H3) There is no statistically significant difference between the younger and older generations in terms of willingness to engage in intergenerational cooperation.

H4) The possibility of engaging in intergenerational cooperation in the workplace is equally important for both younger and older generations.

It should be noted that, for the purposes of inference, the quantitative variable "age" was transformed into a qualitative variable by grouping numerical values into "generation", where 1 denotes the younger generation (individuals under 50 years of age) and 2 denotes the older generation (individuals aged 50 and above).

In order to verify the first research hypothesis, respondents were asked to indicate whether, during the last six months, they had the opportunity to work in age-diverse teams. The collected data show that as many as 70% of respondents declared such cooperation. Therefore, there are no grounds to reject hypothesis H1. Moreover, respondents were also asked to indicate the frequency of such cooperation. It was found that 42 respondents (17 younger and 25 older) reported occasional cooperation, while 28 (including 11 younger and 17 older) indicated its regular occurrence.

The author also sought to determine whether respondents from both generations who had answered positively to the first research question assessed this cooperation in a similar manner. This issue formed the basis for hypothesis H2. Its verification using a statistical test required the formulation of the null hypothesis (H0) and the alternative hypothesis (H1), as follows:

H0: The distribution of cooperation evaluations is the same in both groups of respondents.

H1: The distributions of cooperation evaluations differ between the two groups.

Respondents were asked to assess the quality of the "cooperation" resource using a 5-point Likert scale, where 1 indicates very poor and 5 indicates very good. The distribution of responses provided by 70 respondents, including 28 from the younger generation and 42 from the older generation, is presented below in the Figure 1.

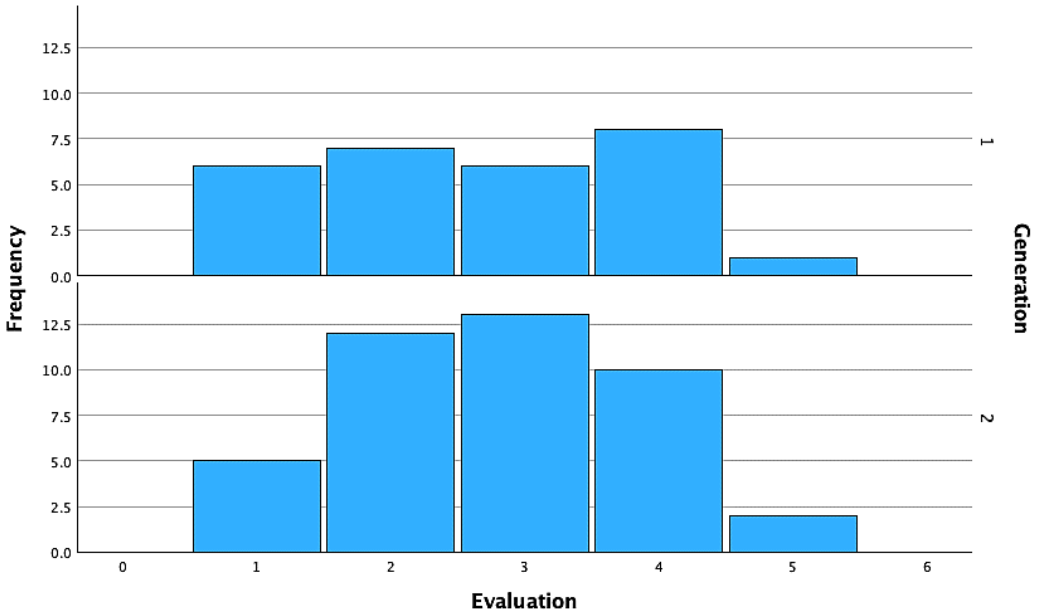


Figure 1. Evaluation of cooperation between generations.

Source: Authors' own study based on IBM SPSS output.

It should be noted that the distribution of ratings in both respondent groups is similar - the median is 3, and the middle 50% of values fall within the range of 2 to 4. In both cases, the full range of the response scale (from 1 to 5) is observed, with no outliers, which indicates the comparable nature of the distributions. In order to empirically verify hypothesis H2, further statistical procedures were conducted. The collected data were analysed using the Mann-Whitney U test for independent samples, at a significance level of $\alpha = 0.05$. The detailed results are presented below.

Table 1.
Mann-Whitney U test results for hypothesis H2

Statistic	Value
Mann-Whitney U	554.000
Wilcoxon W	960.000
Z	-.421
Asymp. Sig. (2-tailed)	.674

Source: Authors' own study based on IBM SPSS output.

The obtained p-value of 0.674, which is higher than the adopted significance level α, indicates that there are no grounds to reject the null hypothesis. This means that there are no statistically significant differences in the evaluation of intergenerational cooperation between the younger and older generations.

A review of the literature and empirical studies provides evidence of widely held stereotypes concerning both younger and older generations. With regard to cooperation, it is often assumed that the younger generation is characterised by individualism, self-centredness, and a lower level of respect towards older employees (Błaszczak, 2025). In contrast, the older generation is perceived as reluctant to share knowledge and as hindering the development of younger employees (Posthuma, Campion, 2009). Against this background, it was considered important, in the author's view, to examine whether the willingness to engage in intergenerational cooperation is related to respondents' age group. To realize this aim, hypothesis H3 was formulated and tested using the Pearson chi-square test of independence, assuming a Type I error risk of 5% (α = 0.05). The analysis used the nominal variable "Willingness", operationalised as a dichotomous response (YES coded as "1" / NO coded as "0") provided by respondents, and the categorical variable "generation", where "1" denotes the younger generation (individuals under 50 years of age) and "2" denotes the older generation (individuals aged 50 and above). The results of the statistical test is presented below in Table 2 and the cross-tabulation of age group and willingness in Table 3.

Table 2.
Pearson chi-square test results for age group and willingness to engage in intergenerational cooperation

Value		df	Symptotoc signicicance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.857	1	.028		
Continuity Correction	4.014	1	.045		
Likelihood Ratio	4.898	1	.027		
Fisher's Exact Test				.045	.022
Linear-by-Libear Association	4.809	1	.028		
N of Valid Cases	100				

Source: Authors' own study based on IBM SPSS output.

Table 3.
Cross-tabulation of age group and willingness to engage in intergenerational cooperation

			Younger Generation	Older Generation	Total
Willingness	**No**	**Count**	32	21	53
		Expected Count	26.5	26.5	53.0
		% within Willingness	60.4%	39.6%	100.0%
		% within Generation	64.0%	42.0%	53.0%
		% of Total	32.0%	21.0%	53.0%
Willingness	**Yes**	**Count**	18	29	47
		Expected Count	23.5	23.5	47.0
		% within Willingness	38.3%	61.7%	100.0%
		% within Generation	36.0%	58.0%	47.0%
		% of Total	18.0%	29.0%	47.0%

Cont. table 3.

Total	**Count**	50	50	100
	Expected Count	50.0	50.0	100.0
	% within Willingness	50.0%	50.%	100.0%
	% within Generation	100.0%	100.0%	100.0%
	% of Total	50.0%	50.0%	100.0%

Source: Authors' own study based on IBM SPSS output.

The p-value of 0.028, which is lower than the adopted significance level α, leads to the rejection of the null hypothesis. This indicates a statistically significant difference between age groups in terms of willingness to cooperate with the opposite age group. Based on the cross-tabulation data from Table 4, it can be concluded that such willingness was reported more frequently by the older generation. These findings, obtained from a sample selected according to the criteria specified in the article, therefore do not confirm the commonly held stereotype concerning older individuals.

The findings prompted the researcher to examine whether intergenerational cooperation in the workplace is perceived as equally important by employees representing different age groups, namely those under and over 50 years of age. This question formed the basis for research hypothesis H4. Its verification using a statistical test required the formulation of a null hypothesis (H0) and an alternative hypothesis (H1), as follows:

H0: There is no statistically significant difference in the assessment of the importance of intergenerational cooperation between the younger and older generations.

H1: There is a statistically significant difference in the assessment of the importance of intergenerational cooperation between the younger and older generations.

Respondents were asked to assess the importance of the “intergenerational cooperation” resource using a 5-point Likert scale, where 1 indicates “not important at all”, 2 - “not important”, 3 - “moderately important”, 4 - “important”, and 5 - “very important”. The frequency of responses, broken down by the two generations, is presented below on the Figure 2.

The responses provided by the respondents constituted the input data for conducting the Mann-Whitney U test for independent samples, at a significance level of $\alpha = 0.05$. The detailed results are presented in table 4.

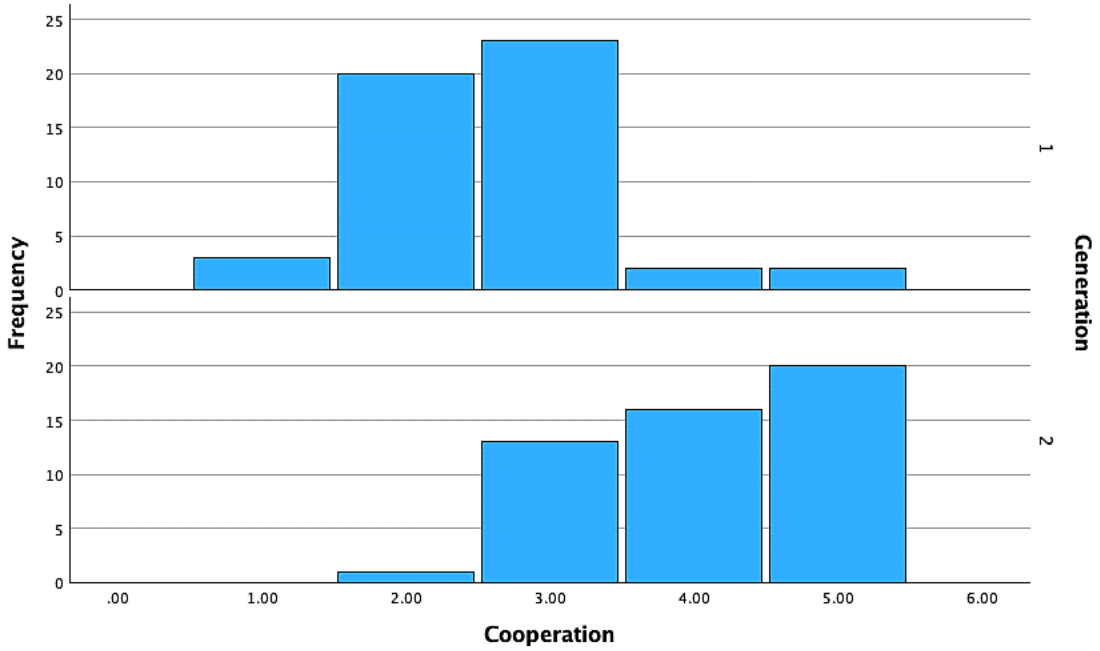


Figure 2. Assessment of the "intergenerational cooperation" resource.

Source: Authors' own study based on IBM SPSS output.

Table 4.
Mann-Whitney U test results for hypothesis H4

Statistic	Value
Mann-Whitney U	306.500
Wilcoxon W	1581.500
Z	-6.753
Asymp. Sig. (2-tailed)	<.001

Source: Authors' own study based on IBM SPSS output.

The obtained p-value of less than 0.001 (i.e., lower than the adopted significance level α) leads to the rejection of the null hypothesis. This indicates that there are statistically significant differences in the assessment of the importance of the "intergenerational cooperation" resource in professional work between the younger and older generations. Moreover, considering the higher mean rank in the group of older respondents (mean rank = 69.37), it can be concluded that individuals aged 50+ attribute greater importance to this resource. The box plot below presents the distribution of responses provided by the younger and older generations to the fourth research question.

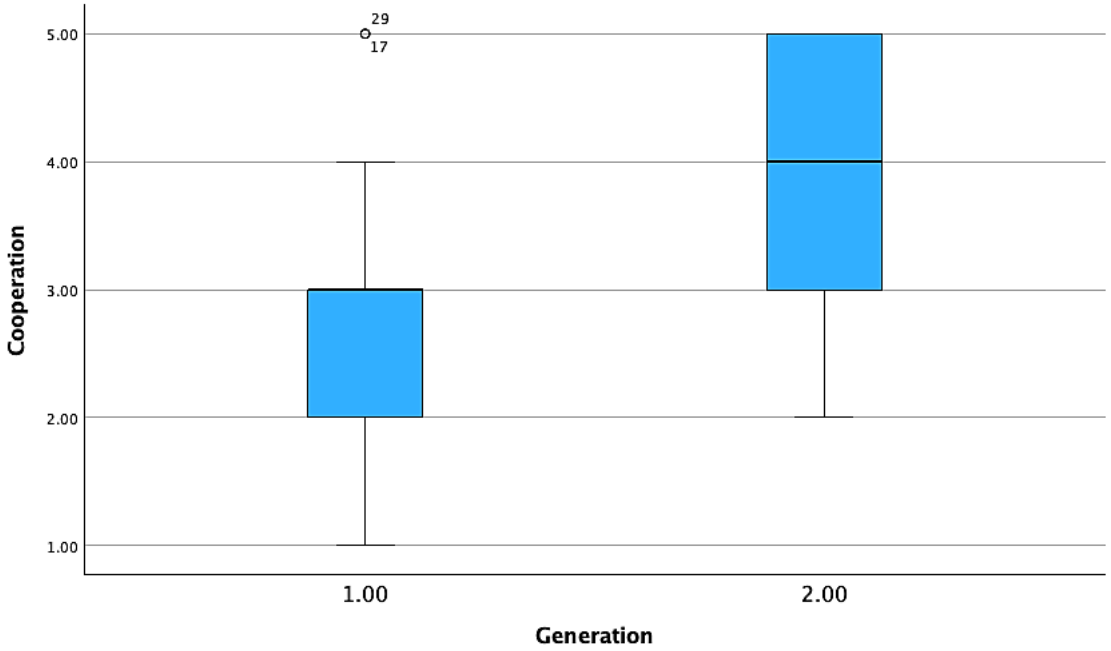


Figure 3. Distribution of responses regarding the assessment of the "intergenerational cooperation" resource.

Source: Authors' own study based on IBM SPSS output.

As can be seen from the above chart, the lowest non-outlier value is "1" in the younger generation and "2" in the older generation. No respondent from the older generation assessed "intergenerational cooperation" as the least important resource in professional work (score of "1"). Furthermore, in the younger age group, 25% of the ratings are below or equal to the first quartile, corresponding to a value of "2", while 75% of responses are above or equal to "2". In the older generation, this threshold is at the level of "3". The median in the younger group is 3, whereas in the older group it is 4. In the younger age group, the upper edge of the box (corresponding to the third quartile) is at the value of "3", which means that 75% of responses in this group are below the level of "3", interpreted as "moderately important". In contrast, in the older group, the upper whisker reaches the value of "5", which is also the highest non-outlier score. This indicates that 75% of responses in this group are less than or equal to "5", corresponding to "very important." Additionally, in the younger generation, two outliers can be observed (upper outliers), both corresponding to a score of "5".

5. Discussion

The present study provides empirical evidence on intergenerational cooperation in small and medium-sized enterprises operating under conditions of demographic change. The obtained results should be interpreted in the broader context of population ageing, declining fertility rates

and the increasing age diversity of the labour market discussed in the literature (OECD, 2020; Eurostat, 2025).

The findings indicate that intergenerational cooperation has already become a common organisational practice. More than 70% of respondents declared having worked in age-diverse teams during the previous six months. This result is optimistic, as it confirms that enterprises are increasingly adapting to demographic changes by employing representatives of different generations. As emphasised by Jurek (2012), intergenerational cooperation facilitates effective knowledge transfer, reduces competency gaps and strengthens team integration. Consequently, the present findings support the view that age-diverse teams may become an important organisational resource rather than merely a consequence of demographic processes.

An important finding of the study is that younger and older employees evaluated the quality of intergenerational cooperation in a similar manner. No statistically significant differences were identified between the analysed groups. This finding suggests that age diversity itself does not negatively affect cooperation quality. It also confirms previous observations that properly managed age diversity may improve organisational effectiveness and innovation (OECD, 2020; Kunze, Boehm, Bruch, 2013). The absence of statistically significant differences may indicate that age-diverse teams are capable of functioning effectively despite differences in experience and work styles. Therefore, the obtained results do not support stereotypes suggesting that generational diversity inevitably leads to poorer workplace relationships or conflicts (Posthuma, Campion, 2009).

However, statistically significant differences were found with regard to employees' willingness to cooperate and the perceived importance of intergenerational cooperation. Older employees demonstrated greater willingness to cooperate with younger colleagues and attached greater importance to intergenerational cooperation than younger respondents. The present findings indicate that experienced employees may constitute an important driving force behind knowledge sharing and organisational continuity. Their greater willingness to cooperate may reflect their broader professional experience and awareness of the benefits resulting from effective knowledge transfer within organisations.

The high importance attached to intergenerational cooperation among older employees may result from their own professional experience and observations of organisational functioning. Employees with longer careers are more likely to recognise the importance of knowledge transfer, mentoring and succession planning. Their attitudes may also reflect an awareness of the approaching end of their professional activity and the need to transfer accumulated experience to younger employees. In contrast, the lower evaluation observed among younger respondents may stem from their more limited professional experience, different expectations towards work, and persisting stereotypes concerning older workers (Posthuma, Campion, 2009). At the early stages of their careers, younger employees may be less aware of the long-term organisational benefits resulting from intergenerational cooperation. Moreover, previous

studies indicate that age-related attitudes and stereotypes may influence mutual perceptions and cooperation between different generations (North, Fiske, 2015; Posthuma, Campion, 2009).

The observed differences between younger and older employees regarding the importance attached to intergenerational cooperation may also reflect differences in work expectations, communication styles and career priorities characteristic of successive generations. According to Hays Poland (2024), younger employees tend to value flexibility, digital communication and rapid professional development, whereas older employees more frequently emphasise organisational loyalty, direct interpersonal communication and the exchange of professional experience. These differences do not necessarily reduce the quality of cooperation, as confirmed by the present study, but they may influence employees' attitudes towards intergenerational collaboration and explain why older respondents attached greater importance to this form of cooperation.

The obtained findings broaden existing knowledge concerning age diversity management. While previous studies have mainly focused on the consequences of demographic ageing, age diversity and age management (OECD, 2020; Kunze et al., 2013), relatively little attention has been paid to differences in the perceptions of intergenerational cooperation between younger and older employees within Polish SMEs. The present study fills this gap by demonstrating that although both age groups evaluate the quality of cooperation similarly, they differ significantly in their willingness to cooperate and in the importance they attach to intergenerational cooperation. These findings complement previous research highlighting both the opportunities and challenges associated with demographic ageing and multigenerational workplaces (OECD, 2020; EY, 2024; World Economic Forum, 2023).

From a practical perspective, the findings indicate that organisations should consciously develop age management strategies supporting cooperation between generations. Mentoring and reverse mentoring programmes, mixed-age project teams, communication training and initiatives aimed at reducing age-related stereotypes may improve knowledge transfer, employee engagement and organisational effectiveness (OECD, 2020; EY, 2024).

Overall, the empirical findings confirmed all four research hypotheses. The study demonstrated that intergenerational cooperation is a common organisational practice, that younger and older employees evaluate the quality of cooperation similarly, and that significant differences exist between the two groups regarding their willingness to cooperate and the importance they attach to intergenerational cooperation.

The study is subject to several limitations. It was conducted exclusively among SMEs located in Poznań County and included a relatively small research sample. Therefore, the findings should be interpreted with caution and cannot be generalised to all enterprises. Future studies should include organisations representing different regions and sectors, involve larger samples and combine quantitative and qualitative research methods to obtain a more comprehensive understanding of intergenerational cooperation.

6. Summary

The study aimed to analyse intergenerational cooperation in SMEs in the context of demographic change and to identify differences between younger and older employees regarding their perception of such cooperation.

The findings confirmed that intergenerational cooperation is already a common phenomenon in the analysed organisations. More than 70% of respondents declared experience in working within age-diverse teams. Although no statistically significant differences were identified in the assessment of cooperation quality, significant differences were found regarding willingness to cooperate and the perceived importance of intergenerational cooperation. Older employees demonstrated greater openness to cooperation and attached greater importance to this form of collaboration than younger respondents.

The study contributes to the existing literature by providing empirical evidence from Polish SMEs and extending current knowledge on age diversity management. Unlike many previous studies focusing primarily on the consequences of demographic ageing, the present research demonstrates that intergenerational cooperation should be perceived not only as a challenge resulting from generational differences but also as a strategic organisational resource supporting knowledge transfer, organisational continuity and sustainable labour market development.

The practical implications of the study indicate that organisations should increasingly implement age management strategies, including mentoring and reverse mentoring programmes, mixed-age project teams and initiatives aimed at reducing age-related stereotypes. Such solutions may contribute to strengthening organisational performance, improving employee engagement and mitigating labour shortages resulting from ongoing demographic changes.

The study has certain limitations related to its regional scope and relatively small sample size. Consequently, future research should include larger and more diverse samples, organisations representing different sectors and regions, and qualitative approaches that would provide a deeper understanding of the mechanisms underlying intergenerational cooperation.

Overall, the obtained findings demonstrate that effective management of age diversity may become one of the key factors supporting organisational competitiveness and labour market stability in ageing societies.

References

1. Błaszczak, A. (2025). Zetki marzą o pracy na stabilnym etacie. *Rzeczpospolita*. Retrieved from: https://www.rp.pl/praca/art42000091-zetki-marza-o-pracy-na-stabilnym-etacie?utm_source=chatgpt.com, 25.03.25.
2. EPALE (2025). *A European snapshot of generational diversity in the workplace*. Retrieved from: https://epale.ec.europa.eu/en/blog/european-snapshot-generational-diversity-workplace.
3. Eurostat (2023a). *Population projections for EU countries*. Retrieved from: https://ec.europa.eu/eurostat, 13.04.2026.
4. Eurostat (2023b). *Population structure and ageing*. Luxembourg: Publications Office of the European Union. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing, 03.04.2026.
5. Eurostat (2025). *Population structure and ageing*. Luxembourg: Publications Office of the European Union. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing, 10.04.2026.
6. EY (2024). *Harnessing age diversity for workplace excellence*. Retrieved from: https://www.ey.com/en_gl/insights/workforce, 11.04.2026.
7. GUS (2023a). *Ludność. Stan i struktura ludności oraz ruch naturalny w Polsce*. Retrieved from: https://stat.gov.pl, 13.04.2026.
8. GUS (2023b). *Prognoza ludności na lata 2023-2060*. Warszawa: GUS.
9. Harvard Business Review (2019). Why Reverse Mentoring Works and How to Do It Right. *Harvard Business Review*, *October 3, 2019*. Retrieved from: https://hbr.org/2019/10/why-reverse-mentoring-works-and-how-to-do-it-right, 13.04.2026.
10. Hays Poland (2024). *Gen Boost. Młodzi na rynku pracy*. Retrieved from: https://www.hays.pl/genboost-2024, 13.04.2026.
11. Jurek, Ł. (2012). *Ekonomia starzejącego się społeczeństwa*. Warszawa: Difin, p. 154.
12. Kunze, F., Boehm, S.A., Bruch, H. (2013). Age diversity, age discrimination climate and performance consequences—A cross organizational study. *Journal of Organizational Behavior*, *No. 34(2),* pp. 264-290. Retrieved from: https://doi.org/10.1002/job.1884, 13.04.2026.
13. North, M.S., Fiske, S.T. (2015). Modern attitudes toward older adults in the aging world: A cross-cultural meta-analysis. *Psychological Bulletin*, *No. 141(5),* pp. 993-1021. Retrieved from: https://doi.org/10.1037/a0039469, 13.04.2026.
14. Notes from Poland (2025). *Poland's population may fall further than forecast as fertility rate hits record low*. Retrieved from: https://notesfrompoland.com/2025/11/07/polands-population-may-fall-further-than-forecast-as-fertility-rate-hits-record-low-warns-stats-agency/, 13.04.2026.

15. OECD (2020). *Promoting an Age-Inclusive Workforce: Living, Learning and Earning Longer*. Paris: OECD Publishing. https://doi.org/10.1787/59752153-en
16. Posthuma, R.A., Campion, M.A. (2009). Age stereotypes in the workplace: Common stereotypes, moderators, and future research directions. *Journal of Management*, *No. 35(1),* pp. 158-188.
17. Pro Progressio (2024). *Zetki a współpraca międzypokoleniowa*. Retrieved from: https://focusonbusiness.eu/pl/raporty/zetki-oceniaja-wspolprace-ze-starszymi-pokoleniami-lepiej-niz-oni-z-mlodymi/34237, 13.04.2026.
18. UN, Department of Economic and Social Affairs, Population Division (2022). *World Population Prospects 2022 (Data set)*. Retrieved from: https://population.un.org/wpp/
19. WB (2025). *Population age 65 and above*. Retrieved from: https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS, 28.05.2025, 13.04.2026.
20. World Economic Forum (2023). *The Future of Jobs Report 2023*. Geneva: World Economic Forum. Retrieved from: https://www.weforum.org/reports/the-future-of-jobs-report-2023/, 13.04.2026.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

EUROPEAN, STATE, LOCAL LEVELS AND STRATEGIES OF POLISH REGIONS

Konrad GŁĘBOCKI

Czestochowa University of Technology, Czestochowa; konrad.glebocki@pcz.pl,
ORCID: 0000-0001-7241-7970

Purpose: The aims of the research were to answer the questions: 1) which of the European, state or local level is dominant in strategies of Polish regions? (2) Are there differences between the strategies of Polish regions in references to the European, State and local levels?
Design/methodology/approach: The objectives were achieved through qualitative literature review and quantitative method was used in empirical studies part. Theoretical scope was shaped around the regional strategic planning and European, State and local levels. In quantitative part all sixteen strategies of Polish regions were examined.
Findings: The answer for the first research question is: the local level is dominant in strategies of Polish regions. The answer for the second research question is that in general there are no differences, almost in case of every Polish region the ranking is as follows: 1) local, 2) European Union, 3) state level.
Research limitations/implications: Limitation was lack of interviews with planners and decision-makers. Suggestion for future research comprise conducting these interviews and conducting similar research in other countries of the UE.
Practical implications: The authorities of regional self-government and staff of regions offices in the EU could analyze the results in the context of their future works on strategies.
Originality/value: The approach to examine the substance of Polish regions strategies is new. The paper is addressed to the authorities of self-government regions in the EU, staff of regions offices and everyone interested in regional development.
Keywords: State, regions, local communities, EU, strategic regional planning.
Category of the paper: Research paper.

1. Introduction

Regions are discussed in a variety of contexts, including regional integration, understood as the process by which a group of states establishes a single organization. A prominent example of such a regional grouping is the European Union (Bonilla-Bolanos, 2021). Regions may also take different forms, including geographical, cultural, and administrative ones. The article focuses on administrative regions at the level directly below the state. In Poland, these

correspond to voivodeships (Polish regions); in Spain, to autonomous communities; in Germany, to federal states (Länder); in the United Kingdom, to regions established as a result of relatively recent processes of regionalization; and in France, to regions. Strategic planning at the regional level is a common practice among regional authorities and is undertaken in all European Union member states, as well as beyond.

Strategic planning is embedded within the broader framework of public management. In terms of the evolution of public administration, regional strategic planning emerged within the paradigm of New Public Management (NPM). A key dimension of NPM is the adoption of practices and theories derived from the private sector (Dawson, Dargie, 1999; Glor, 2001).

Regional strategic planning can also be understood within more contemporary frameworks of public administration, namely New Public Governance and Digital Era Governance. In the former, it has increasingly taken the form of a networked process, involving a wide range of actors rather than solely planners or political decision-makers (Krogh, Triantafillou, 2024). In the latter - Digital Era Governance (Margetts, Dunleavy, 2024) - regional strategic planning benefits from enhanced data foundations, enabling more informed and effective strategic decision-making. More recently, artificial intelligence has also become a significant factor in regional strategic planning.

Strategic regional planning has experienced alternating phases of greater and lesser prominence in both practice and academic theory. In recent years, the field has attracted renewed interest, as evidenced by the scholarly sources cited in this article. At the same time, with regard to its political and practical relevance, many scholars argue that regional planning is losing significance. However, extensive research conducted by Smas and Schmitt (2021) challenges the thesis of declining interest.

The contestation of planning occurs across several dimensions. These include an ideological dimension, reflecting the tension between market liberalism and social redistribution; a material dimension, relating to the spatial allocation of profits; and a cultural dimension, as planning operates across diverse communities. Of key importance is the relationship between the authority of planners and that of other professional groups (Gordon, Champion, 2021). Despite ongoing debates about the contemporary relevance of strategic regional planning and the contestation of its foundations, it continues to develop.

The second part of the article, following the introduction, is about literature review related to strategic regional planning. Next the research methodology employed is outlined. The fourth section presents quantitative results of the research which is followed by discussion, summary and references.

2. Literature review

Regional strategic planning has its core components, typically in the form of regional development strategies. Within this focus, a notable line of inquiry concerns regional identity and its role, particularly in relation to economic development (Borges, 2017). In the case of Swedish regions, there is no strong preference for statutory regional planning. Instead, planning is predominantly conducted within the framework of non-statutory forms of regional planning, an approach that tends to be ineffective unless regions adopt a multi-level perspective. The considerable degree of autonomy associated with non-statutory strategic planning in Swedish regions has been shown to generate conflicts, ambiguity, and uncertainty (Andersson, Schmitt, 2024). Comparative studies of formal regional planning across several European countries have sought to determine the extent and scope of regional planning within the examined states (Smas, Schmitt, 2021). In another line of research, scholars have attempted to understand the extent to which abstract regional planning strategies — conceptualizing spatial imaginaries, following Davoudi et al. (2018) — are capable of addressing constraints and supporting real spatial transformation (Bafarasat et al., 2021). This research focus also encompasses studies on territorial capital, understood as a component of endogenous development. In this context, a multidimensional assessment model has been proposed. In empirical analysis of specific regions, such a model enables the analysis of regional development within the framework of spatial strategic planning (Orsi et al., 2024). The current research is new approach to strategic regional planning.

Regional strategic planning concerns as well peripheral regions. Within this context, a study conducted in Austria and Sweden primarily addresses regional cohesion in these affluent European countries. Notably, regions are treated as functional entities rather than strictly administrative entities (Gruber, Rauhut, Humer, 2019). Similarly, a study concerning North Wales extends beyond the established regional framework in the United Kingdom, as this area is formally situated within the West Midlands region. The North Wales Growth Deal can be considered part of the strategic planning of this region, which is peripheral in nature and where the city-region concept is difficult to apply, given the absence of a dominant agglomeration or even a major urban center (Beel, Jones, Plows, 2020). Issues related to peripheral regions are also addressed in an article on the Northern Ireland Protocol, which may be viewed as a strategic framework encompassing this region—relatively underdeveloped compared to the rest of the United Kingdom (Brownlow, Budd, 2024). In Poland there are some peripheral regions like e.g.: Podlaskie region, Lubelskie region and Podkarpackie region.

Specific research focus concerns the relationship between regions and the state as a whole. In Norway, research has examined regional strategic planning within the framework of the Norwegian Planning and Building Act. These studies focus on the understanding and implementation of regional planning strategies in Norway, as well as their evolution over time

(Hagen, Higdem, 2024). Another line of research examines partnerships between the state and regions in the field of strategic planning (Thom, Steinfeld, 2025). Additional examples of the region-state relationship relevant to regional strategic planning include the following. In Mexico, studies have examined regional disparities in the context of economic development. The primary objective was to assess whether economic growth or degrowth is associated with greater or lesser regional disparities within the country (Nieto, 2021). A distinct line of research examines Wales's participation in the Wellbeing Economy Government, a network of national and regional governments which aims to replace GDP growth as the primary objective of national economies with alternative well-being indicators (Holmstrand, 2025). To date, GDP has been a key indicator, including state and regional level. The introduction of well-being indicators at the regional level would therefore constitute a significant shift. However, such indicators would need to be measurable to enable meaningful comparisons of well-being across regions. And it should be implemented as well on the state level at the same time.

A particularly important research focus for European regions concerns European Union policy in the context of regional planning. For example, studies of regions in Portugal examine the impact of the European Union on regional planning (Marques et al., 2018). Research on local engagement in current European Union regional policy remains limited. One example is research on the theoretical foundations of local involvement in EU regional planning, which may enhance the effectiveness of sustainable regional transformation (Grillitsch et al., 2025). Research on European Union regions, although not strictly focused on regional development strategies, has nonetheless generated important insights relevant to such strategies. This is evident, for instance, in studies on regional vulnerability to the Fourth Industrial Revolution (4IR). The findings highlight a strong need for differentiated, region-specific strategies across the European Union in order to address differences in exposure and capacity to adapt to 4IR. Such strategies must strike a balance between leveraging the transformative potential of 4IR and mitigating its risks, thereby ensuring a more inclusive and equitable transition to a 4IR-based economy within the European Union (Panori, 2025).

Another research focus concerns the interaction between regional strategic planning and local communities. This includes strategic planning in the city-region context. The increasingly prominent city-region research agenda spans urban and regional theory, empirical analysis, and planning practice, as well as public policy. The growing inseparability of the concepts of "city" and "region" is reflected in the emergence of the city-region concept (Soja, 2015). Discursively constructed city-region programs often overlap with existing institutions of regional and local governance, as well as statutory land-use planning systems (Granqvist et al., 2021). Theoretical frameworks have also been proposed to apply of scenario-based planning approaches in strategic land-use and transportation planning, with particular emphasis on the city-region scale (Mäntysalo et al., 2023). Research at the intersection of local communities and regions may examine the impact of regional development strategies on the strategic planning

of local communities across specific policy domains (Bonnett, Birchall, 2023). A case study in a German region examined the conflict between infill development and the preservation of green spaces, demonstrating that regional planning can function as a coordinating mechanism in resolving such conflicts in medium-sized, growing cities (Dörder, 2025). Another example of the interface between regions and local communities is research on mutual learning processes among local and regional actors, aimed at maximizing the benefits of regional investments while managing local expectations. This entails incorporating local knowledge into regional planning processes, as well as institutionalizing local–regional integration and co-designing Transit-Oriented Development initiatives (Björling, Patrao, 2024). Local and regional traditions are also examined in their potential contribution to the quality of development projects. There is a clear need to incorporate local and regional traditions in both urban and regional planning (Skjerven, Martins, 2019).

As analyzed above various relations in the context of strategic regional planning were studied in the literature up to date e.g. between EU and regional level, between state and regions, between regions and local level. However the research gap is that there is a lack of studies which compare the frequency of occurrence in regional strategic planning of all these levels and consequently the research gap is on which level is most important and which levels are less important for regions at least in strategic planning phase.

3. Methods

The article addresses two following research questions: 1) which of the European, state or local level is dominant in strategies of Polish regions? (2) Are there differences between the strategies of Polish regions in references to the European, State and local levels?

Articles for the literature review were identified by searching for the phrase "regional strategic planning" in selected academic databases, namely Taylor & Francis, EBSCO, Wiley, Web of Science and Google Scholar. The aim was to identify articles published in recent years, with a focus on European, state and local level.

The selected articles were subsequently analyzed using a Qualitative Content Analysis (QCA) approach. Similar approaches have been applied in studies analyzing journal content at the intersection of European regional policy and regional planning (Marques et al., 2018).

The PDF search function was used as a tool, to find out how many references to the determined levels are there in the sixteen strategies of the Polish regions (study sample). In course of PDF searching singular, plural and all cases of the searched words were examined. Next there was "hand" confirmation if the words are consistent with the research. Method of data analysis was putting the absolute numbers and changing them into percentages which was facilitated by using the tool of the excel program.

The number of occurrences of specific words constitutes an appropriate indicator of the significance of a given level because it seems obvious that the more words concerning given level used in the text the bigger significance attached to the level by the planners and decision-makers of a given region. What is less important for planners is mentioned less often. The author do not engage into psycholinguistics as it is too far from research discipline and it seems that using words in development strategies is not about emotions but rather about objective view of the world and the needs of a region.

The research procedure can be summarized as follows: identification of recent articles; analysis of the selected publications; analysis of strategies of Polish regions; presenting the results and discussion of the results.

4. Results

In the table 1 sixteen regions are ranked alphabetically from Dolnośląskie region to Zachodniopomorskie region as rows in the table. References in their strategies to European Union, state and local are presented in the columns. The results are presented not only in absolute numbers but also in percentages. This is important because the absolute numbers are not comparable due to different length of strategies of regions. Only percentages can be compared.

Table 1.
References to EU, state and local levels in strategies of Polish Regions

Levels / Regions	EU	%	State	%	Local	%	Total	%
Dolnośląskie	29	48%	6	10%	26	43%	61	100%
Kujawsko-Pomorskie	38	10%	56	14%	298	76%	392	100%
Lubelskie	46	17%	50	19%	173	64%	269	100%
Lubuskie	50	32%	31	20%	76	48%	157	100%
Łódzkie	34	22%	22	14%	98	64%	154	100%
Małopolskie	105	39%	21	8%	142	53%	268	100%
Mazowieckie	47	41%	6	5%	61	54%	114	100%
Opolskie	82	37%	52	23%	89	40%	223	100%
Podkarpackie	119	42%	45	16%	118	42%	282	100%
Podlaskie	58	37%	22	14%	76	49%	156	100%
Pomorskie	42	42%	7	7%	50	51%	99	100%
Śląskie	81	35%	34	15%	115	50%	230	100%
Świętokrzyskie	39	29%	17	13%	78	58%	134	100%
Warmińsko-Mazurskie	32	32%	7	7%	61	61%	100	100%
Wielkopolskie	46	28%	14	8%	107	64%	167	100%
Zachodniopomorskie	28	21%	16	12%	91	67%	135	100%
Total	876	30%	406	14%	1659	56%	2941	100%

The results in the table 1 are presented on the basis of percentages, so proportionately. Only in case of Dolnośląskie region there are proportionately more references to the European Union than to local. In case of Podkarpackie region percentages of the references to the European Union and to local are exactly the same. In cases of other regions percentages of the references (further on "references" will mean "percentages of the references") to local are higher than to European Union. In these cases the rank is the same: 1) local; 2) European Union; 3) state. State in case of every region takes the last place in the rank.

The most of references to local are in the following regions: Kujawsko-Pomorskie (74%), Zachodnio-Pomorskie (67%), Wielkopolskie (64%), Łódzkie (64%). The least references among regions to local are in the following four regions: Opolskie (40%), Podkarpackie (42%), Dolnośląskie (43%), lubuskie (48%).

The most references to European Union are observed in the four regions: Dolnośląskie (48%), Podkarpackie (42%), Pomorskie (42%), Mazowieckie (41%). The least references to the European Union are observed in the following four Polish regions: Kujawsko-Pomorskie (10%), Lubelskie (17%), Zachodnio-Pomorskie (21%) and Łódzkie (22%).

The most references to state are confirmed in the following regions: Opolskie (23%), Lubuskie (20%), Lubelskie (19%) and Podkarpackie (16%). The least references to state are observed in the five regions: Mazowieckie (5%), Warmińsko-Mazurskie (7%), Pomorskie (7%), Wielkopolskie (8%) and Małopolskie (8%).

5. Discussion

The first research question was: which of the European, state or local level are dominant in strategies of Polish regions? The answer is that the local level is dominant in strategies of Polish regions. Only in case of Dolnośląskie region there are more references to the European Union than to local. This is interesting because Dolnośląskie in the ranking of affluency is on the one of the highest position among regions in Poland (Słomski, 2026). One could assume that the richest regions in Poland rather pay less attention to the European level. They are more independent from the European Union funds because they have more own resources. This research in case of Dolnośląskie region proved that *vice versa*. In case of Podkarpackie region the references to the European Union and to local are exactly the same. This region is one of the poorest in Poland (Słomski 2026). So in this case it could be confirmed that the poorest regions pay more attention to the European Union. So in general one could not assume that the richer region the less attention to the EU. Four regions with the most references to the European Union Dolnośląskie (48%), Podkarpackie (42%), Pomorskie (42%), Mazowieckie (41%) is additional confirmation of that.

Local communities cooperate with regions in Poland (Necel, Nosal, 2016). It is interesting that the local in the vast majority was dominant in the strategies of Polish regions. The reason of the focus on local could be that local self-government in Poland is relatively strong. Proportionally in case of financial resources it is much stronger that the regional self-government. The other reason of this focus could be that local community and aspects of its functioning influence greatly what region is and how it is functioning. This relationship is very strong and the results of this research confirm it clearly.

Next important aspect is the weakest position of state in this set of the research. So weak position is despite the fact that state is supporting Polish regions through special contracts (Chaba 2022). Anyway state generally looses its position in the reality of today. The Polish national parliament e.g. is in the vast proportion only transposing the European law. European Union continually increases its competences. In this research this trend is confirmed, state is in case of every region on the last place between examined levels taking into account references in Polish regions strategies. One could draw a conclusion that European Union and local levels are far more important for the Polish regions than the state. The research observed an interesting dependence: poor regions are more dependent of the state like Opolskie (23%), Lubuskie (20%), Lubelskie (19%) and Podkarpackie (16%). The richer regions are less dependent of the state: Mazowieckie (5%), Pomorskie (7%), Wielkopolskie (8%) and Małopolskie (8%).

The second research question was: Are there differences between the strategies of Polish regions in references to the European, State and local levels? The answer is that in general there are no differences: almost in case of every region the ranking of the levels is: on the first place is local level, on the second place is the level of European Union and on the last place is the state. Influence of the EU on strategies of Polish regions in individual cases was commented in various studies (Kawałko 2009). Inside this ranking are bigger and lesser differences. For example in case of local level the differences are as follow. Between the regions with the most references to local: Kujawsko-Pomorskie (74%), Zachodnio-Pomorskie (67%), Wielkopolskie (64%), Łódzkie (64%) and the regions with the least references: Opolskie (40%), Podkarpackie (42%), Dolnośląskie (43%), lubuskie (48%) the difference is substantial.

6. Summary

In course of the research strategies of all sixteen regions were examined. The table 1 shows that in detail. The positive side of the research was examination of all strategies in the group of Polish regions. However additional light could be shed through interviews of planners and decision-makers. It is the limitation of the research. The weakness was lack of comparison with at least strategies of regions of one another country. This limitation and weakness indicate the future possible areas of research. In particular repeating of the same research after some years could show if in the meantime some changes emerge.

The new knowledge is emerging from the answers to research questions. The first research question was: which of the European, state or local levels are dominant in strategies of Polish regions? The answer is that the local level is dominant in strategies of Polish regions.

The second research question was: Are there differences between the strategies of Polish regions in references to the European, State and local levels? The answer is that in general there are no differences: almost in case of every region the ranking of the levels is: on the first place is local level, on the second place is the level of European Union and on the last place is the state. The exemptions were: only in case of Dolnośląskie region there are proportionately more references to the European Union than to local. In case of Podkarpackie region percentages of the references to the European Union and to local are exactly the same.

Giving the answers for the above questions is important for the field of regional management. The local level being most important in strategies of almost all Polish regions could confirm individual regions in putting local first. The role of the state should be strengthened as it is closer level to regions than the EU. That is vital because when Polish regions being more affluent will lose in the future financing of the EU they should have state to lean on. Anyway because of legislation role of the EU it will keep its strong position.

The lessons are: the role of the state in strategic planning of regions should not be so weak. The roles of all three levels should be more balanced.

References

1. Andersson, H., Schmitt, P. (2024). Disclosing the logics of non-statutory regional planning: the case of Sweden. *European Planning Studies, vol. 32, No. 8,* pp. 1696-1715.
2. Bafarasat, A.Z., Oliveira, E., Baker, M. (2021). From concrete to abstract regional planning strategies in North West England: building and legitimizing discourses and mobilizing actors for spatial transformation? *Space and Polity, vol. 25, No. 3*, pp. 283-305.
3. Beel, D., Jones, M., Plows, A. (2020). Urban growth strategies in rural regions: building The North Wales Growth Deal. *Regional Studies, vol. 54, No. 5,* pp. 719-731.
4. Bhatt, J., Jani, O. (2017) Towards sustainable growth by energy reliability. *Bulletin Smart Metropolitan Regional Development - Economic and Spatial Design Strategies, 3/3*, 1st of September.
5. Björling, N., Patrao, C.C. (2024). Strategic planning for a sustainable local-regional transit-oriented development. *Urban Planning and Transport Research, Vol. 12, No. 1,* 2345770.
6. Bonilla-Bolanos (2021). A step further in the theory of regional integration: A look at the South American integration strategy. *Journal of International Development, 33*, pp. 845-873.

7. Bonnett, N., Birchall, S. (2023). The influence of regional strategic policy on municipal climate adaptation planning. *Regional Studies, Vol. 57, No. 1,* pp. 141-152.
8. Borges, L.A. (2017). Using the Past to Construct Territorial Identities in Regional Planning: The Case of Mälardalen, Sweden. *International Journal of Urban and Regional Studies*, pp. 659-675.
9. Brownlow, G., Budd, L. (2024). Place-based industrial strategies in the context of the Northern Ireland Protocol. *Regional Studies, Vol. 58, No. 2*, pp. 409-421.
10. Chaba, D. (2022). *Kontrakt terytorialny*. Warszawa: Wolters Kluwer.
11. Dawson, S., Dargie, C. (1999). New Public Management: An assessment and evaluation with special reference to UK. *Public Management: An International Journal of Research and Theory, Vol. 1, Iss. 4.*
12. Dörder, P. (2025). A regional approach to planning trade-offs in mid-sized towns: the case of Frankfurt Rhine-Main. *Regional Studies, Regional Science, Vol. 12, No. 1,* pp. 836-851.
13. Glor, E.D. (2001). Has Canada adopted New Public Management? *Public Management Review Vol. 3, Iss. 1*.
14. Gordon, I., Champion, T. (2021). Towards a sustainable, negotiated mode of strategic regional planning: a political economy perspective. *Regional Studies, Vol. 55, No. 1,* pp. 115-126.
15. Granqvist, K., Humerb, A., Mäntysaloc, R. (2021). Tensions in city-regional spatial planning: the challenge of interpreting layered institutional rules. *Regional Studies, vol. 55, No. 5*, pp. 844-856.
16. Gruber, E., Rauhut, D., Humer, A. (2019). Territorial cohesion under pressure? Welfare policy and planning responses in Austrian and Swedish Peripheries. *Papers in Regional Science, No. 98*, pp. 115-132.
17. Hagen, A., Higdem, U. (2024). Regional planning strategies: understanding the implementation of a new strategic tool in Norwegian planning law. *European Planning Studies, Vol. 32, No. 12*, pp. 2555-2573.
18. Holmstrand, K. (2025). Planning beyond growth: a case study of wellbeing-oriented planning in Wales. *European Planning Studies*, pp. 1-19.
19. Kawałko, B. (2009). Nowy model formułowania strategii rozwoju województwa lubelskiego wobec wyzwań polityki spójności Unii Europejskiej po 2013 r. *Barometr regionalny, No. 2(16)*, pp. 29-54.
20. Krogh, A.H., Triantafillou, P. (2014). Developing New Public Governance as a public management reform model. *Public Management Review, Vol. 26, No. 10*, pp. 3040-3056.
21. Mäntysalo, R., Granqvista, K., Dumana, O., Mladenovića, M.N. (2023). From forecasts to scenarios in strategic city-regional land-use and transportation planning. *Regional Studies, Vol. 57, No. 4*, pp. 629-641.
22. Margetts, H., Dunleavy, P. (2024). The political economy of digital government: How Silicon Valley firms drove conversion to data science and artificial intelligence in

public management. *Public Money and Management,* https://doi.org/10.1080/09540962.2024.2389915.

23. Marques, T., Saraiva, M., Santinha, G., Guerra, P. (2019). Re-thinking Territorial Cohesion in the European Planning Context. *International Journal of Urban and Regional Research,* pp. 547-572.
24. Necel, R., Nosal, P. (2016). Samorząd województwa a lokalne podmioty polityki społecznej. Wzajemne relacje i ich uwarunkowania. *Acta Universitatis Lodziensis. Folia Sociologica, 57*, pp. 131-149.
25. Nieto, A.T. (2021). Regional disparities in Mexico and the spatially cumulative effects of national development and economic cycles, 1940-2013. *Regional Science Policy and Practice, No. 13*, pp. 1283-1296.
26. Orsi, F., Cavaco, C., Gil, J. (2024). From territorial capital to regional design: a multidimensional model for territorial analysis and scenario evaluation. *Planning Practice & Research, vol. 39, No. 1*, pp. 116-135.
27. Panori, A. (2025). Exploring regional vulnerability to the Fourth Industrial Revolution: a European perspective. *Regional Studies/Regional Science, Vol. 12, No. 1*, pp 867-880.
28. Skjerven, A., Martins, A.N. (2019). Architecture, design and planning towards sustainable development: Regional approaches. *Sustainable Development, 27*, pp. 197-198.
29. Słomski, D. (2026). PKB Polski. Zobacz, które regiony kraju stanowią o sile gospodarki. *Bussines Insider*, https://businessinsider.com.pl/gospodarka/pkb-polski-z-podzialem-na-wojewodztwa-nowe-dane-gus-tabela/bvf341s
30. Smas, L., Schmitt, P. (2021). Positioning regional planning across Europe. *Regional Studies, Vol. 55, No. 5*, pp. 778-790.
31. Soja, E. (2015). Eccentuate the Regional. *International Journal of Urban and Regional Research,* p. 372.
32. Thom, B., Steinfeld, C. (2025). Natural resource management and regional planning: a geographical perspective. *Australasian Journal of Environment Management, Vol. 32, No. 2*, pp. 116-133.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

DIGITAL MATURITY AS DETERMINANT OF ORGANIZATIONAL AGILITY IN THE INDUSTRY 4.0 CONTEXT

Adrian GRACA[1*], Liliana HAWRYSZ[2]

[1] Politechnika Wrocławska, Wrocław; adrian.graca@pwr.edu.pl, ORCID: 0009-0001-8261-1790
[2] Politechnika Wrocławska, Wrocław; liliana.hawrysz@pwr.edu.pl, ORCID: 0000-0002-0357-9930
[*]Correspondence author

Purpose: This study aims to identify and systematize the relationships between digital maturity domains and organizational agility dimensions in the context of Industry 4.0. The study further examines these relationships through a socio-technical perspective to better understand the organizational conditions supporting digitally enabled agility.
Design/methodology/approach: A systematic literature review (SLR) was conducted following the PRISMA protocol to ensure methodological transparency and replicability. The review included 68 studies retrieved from Scopus and ProQuest databases published between 2020 and 2026. The analysis employed a qualitative coding approach based on digital maturity domains, organizational agility dimensions, and socio-technical enablers.
Findings: The findings indicate that digital maturity should be understood primarily as an organizational capability rather than solely a technological condition. Strategic and cultural maturity emerged as the dominant domains supporting organizational agility, while acting agility appeared as the most represented agility dimension, suggesting an execution-oriented understanding of agility in Industry 4.0 environments. Furthermore, the findings reveal a stronger influence of social system enablers (structure and people) compared to technical system factors, emphasizing the importance of socio-technical alignment in translating digital capabilities into adaptive organizational behaviour.
Research limitations: Research limitations/implications: The study is limited to English-language studies indexed in Scopus and ProQuest between 2020 and 2026 and reflects a strong concentration of research conducted in Asian contexts. Future research should explore micro-level organizational mechanisms, sensing agility, market maturity, and empirically validate the proposed conceptual framework.
Practical implications: The findings suggest that organizations should approach digital transformation beyond technology adoption by prioritizing strategic alignment, leadership commitment, employee capabilities, and organizational culture. Managers should focus on aligning technological investments with supportive organizational structures and workforce readiness to strengthen organizational agility.
Originality/value: This study contributes to the literature by systematically integrating fragmented research on digital maturity and organizational agility in Industry 4.0. It introduces a socio-technical perspective and proposes a conceptual framework explaining how digital maturity contributes to organizational agility through socio-technical alignment.

Keywords: Digital maturity, Organizational Agility, Industry 4.0, Digital Transformation, Socio-technical systems.
Category of the paper: Literature Review.

Introduction

With the emergence of Fourth Industrial Revolution, commonly known as a Industry 4.0 the operational and competitive landscape of the contemporary organization has shifted and changed completely. In contrast to the previous industrial changes Industry 4.0 stands out by combining digital technologies and intelligent systems that are capable of autonomous decision making and communication (Castillo-Vergara, et al., 2025; Ghobakhloo, et al., 2026). With the integration of cyber-physical systems, the Internet of Things (IoT), cloud computing, artificial intelligence, robotics, blockchain, and big data analytics organizations are able to establish interconnected ecosystems characterized by real-time information exchange and advanced process automation. At the same time organizations are expected to operate in the environment that is highly dynamic and digitally interconnected since traditional organizational boundaries and methods are becoming more blurred and outdated (Silva, et al., 2025; Senadjki, et al., 2024). Industry 4.0 goes beyond just simple technological advancements instead it reshapes organizational structures where digital technologies no longer functions solely as a operational support tools but increasingly constitute strategic assets that improve productivity and foster customer-centric business models. The increasing pace of technological change introduces substantial complexity and competitive pressure, forcing organizations to reconsider how they develop capabilities necessary for long-term sustainability and resilience. With such situation organizations are compelled to respond more rapidly to market disruptions, personalize products and services through data-driven insights (Franke, et al., 2026; Castillo-Vergara, et al., 2025; Oncioiu, et al., 2025). As a response to the high and fast technological development, digital transformation has emerged as a strategic imperative for organizations seeking to remain competitive in digitally intensive environments. This process involves organizations integrating digital technologies into business operations, organizational structures, and strategic decision-making to create value and improve performance (Pan, et al., 2022; Cuong, et al., 2025). Digital transformation is not only introducing new digital tools but fundamentally changes organizational culture, employee competencies, business models, and managerial approaches. With greater environmental pressure organizations encounter challenges related to organizational resistance, fragmented digital initiatives, insufficient strategic alignment, and limitations in digital competencies. Consequently, firms and researchers recognize that successful digital transformation requires more than isolated technological investments and instead depends on a broader organizational readiness for digital change (Chang, et al., 2025; Abidi, et al., 2025; Yang, et al., 2025).

In order to evaluate organization's readiness and capability to navigate digital transformation effectively the concept of digital maturity (DM) has gained increasing scholarly and managerial attention. Commonly this concept refers to the extent to which organizations are able to systematically adopt, integrate, and leverage digital technologies to achieve strategic and operational objectives (Zheng, 2025; Kaszás, et al., 2023). Digitally mature organizations are characterized not only by advanced technological adoption but also by their ability to continuously adapt, innovate, and derive business value from digital initiatives. The concept became highly important thanks to its influence on organizational performance and transformation success. Research on DM suggests that organizations with higher levels of this concept are more likely to achieve operational efficiency, innovation capacity, enhanced customer engagement, and competitive advantage. With fast evolving technologies, DM helps businesses to respond better and quicker to environmental changes with data-driven decision-making, cross-functional collaboration, and organizational flexibility (Tortora, et al., 2024; Çallı, et al., 2022; Mick, et al., 2024). As Industry 4.0 keeps changing the landscape of traditional organisations DM is rising to the point of being a prerequisite for successful capitalization of digital opportunities while minimizing risks associated with technological disruption. However, despite the popularity and benefits, many firms fails to achieve high levels of DM and remains a big challenge for many of them. It is important to understand that the concept of DM is inherently multidimensional and hard to grasp fully due to the complexity of collaboration between important technological, strategic, cultural, and organizational factors (Sánchez-Rodríguez, et al., 2025; Kwiotkowska, 2025). Many organisations struggle to comprehend those elements at the same time because of their fragmented digital strategies, insufficient managerial commitment, resistance to organizational change, inadequate employee digital skills, and limited integration between technological capabilities and business objectives. Additionally, implementation of transformational initiatives if different from one department to another since DM prerequisites differ across departments. This suggest that the concept should be viewed as an evolving organizational capability that need continuous adaptation and strategic alignment rather than a static end-state (Haryanti, et al., 2023; Zhao, et al., 2023; Orero-Blat, et al., 2024).

While DM reflects an organization's capability to adopt and leverage digital technologies effectively just being prepared alone is not enough to ensure sustained competitiveness in highly dynamic environment. The concept of organizational agility (OA) has emerged as a critical capability enabling organizations to adapt, innovate, and sustain performance in turbulent business environments. It allows organisations respond to the increasing complexity, uncertainty, and volatility associated with Industry 4.0 that require the development of digital capabilities rapid responsiveness to changing internal and external conditions. Overall, OA refers to organisation's ability to sense environmental changes, make timely and informed decisions, and rapidly implement appropriate responses to emerging opportunities and threats (Cuong, et al., 2025; Akkoca, 2025). Agile organizations are capable of identifying shifts in

customer expectations, technological advancements, and competitive dynamics while simultaneously adapting strategies, structures, and operational processes accordingly. As a result, OA is increasingly recognized as an essential capability that supports organizational responsiveness, innovation, and long-term competitiveness in digitally transformed environments. In the context of digital transformation and DM, OA gains crucial importance. Although organizations may possess advanced technological infrastructures and digitally enabled processes, the absence of agility may limit their ability to effectively exploit these capabilities. This means that even thou DM provides organisations with technological reediness and strategic alignment, OA is the element that determines whether such resources can be transformed into adaptive actions and sustained business value (Asghar, et al., 2026; AlNuaimi, et al., 2022; Nyamboga, 2025). The development of both DM and OA is influenced by a broader set of organizational mechanisms rooted in socio-technical theory. Those enablers emphasize the interdependence between technological and social elements within organizations and may include leadership support, organizational culture, employee competencies, technological infrastructure, collaborative processes, and governance mechanisms that collectively facilitate organizational adaptability and digital capability development. Those element may play a critical role in strengthening the relationship between DM and OA by fostering alignment between technological capabilities and organizational behaviour (Dubey, et al., 2024; Cardoso, et al., 2025; Mele, et al., 2024).

Although prior studies acknowledge the importance of DM and OA in the context of Industry 4.0, the interrelationships between DM domains and OA dimensions remain underexplored. Existing findings are dispersed across diverse conceptual and empirical perspectives, limiting theoretical integration and a comprehensive understanding of how DM contributes to OA. Therefore, this study aims to identify and systematize the relationships between DM domains and OA dimensions in Industry 4.0 through a systematic literature review following the PRISMA protocol.

1. Methodology

This study adopts a systematic literature review (SLR) to identify and synthesize the relationships between DM and OA in the context of Industry 4.0. To ensure a rigorous, transparent, and replicable research process, the review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This approach provides a structured procedure for literature identification, screening, eligibility assessment, and final study selection, thereby enhancing the credibility and methodological transparency of the review (Figure 1).

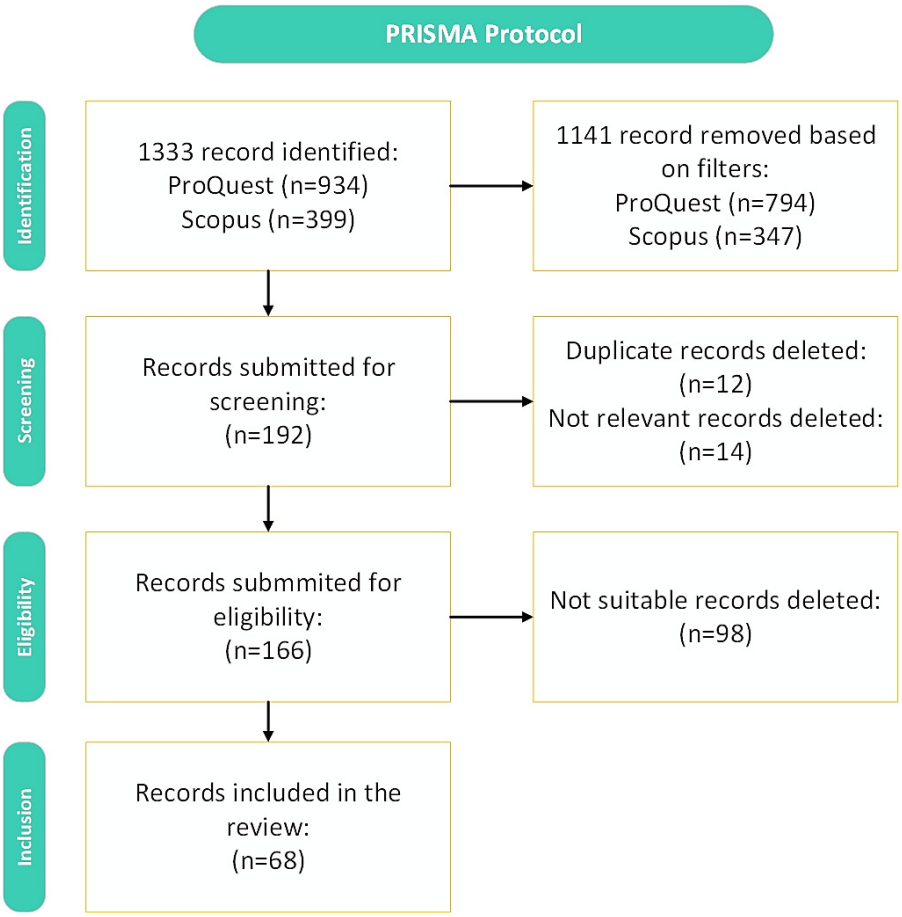


Figure 1. PRISMA Protocol Showcasing the Analysis of the Articles.

Source: Own elaboration.

Figure 1 illustrates the complete study selection process conducted in accordance with the PRISMA protocol. The final dataset reflects a carefully filtered body of literature that satisfies the predefined eligibility criteria. Consequently, the review is based exclusively on studies directly relevant to the research scope.

1.1. Identification

At this stage, the literature search was conducted across two major academic databases, ProQuest and Scopus, selected due to their broad coverage of high-quality, peer-reviewed research in management, organizational studies, and digital transformation. The search strategy involved the use of a keyword string designed to capture studies addressing the relationship between DM and OA within the context of Industry 4.0. The final search query was formulated as: (“Digital Maturity”) AND (“Organizational Agility”), yielding an initial total of 399 records from Scopus and 934 from ProQuest. To ensure alignment with the scope of the study, several database-specific filters were applied. First, the publication period was restricted to studies published between 1st January 2020 and 14th of May 2026, reflecting the growing scholarly attention devoted to digital maturity and organizational agility in recent years. Additional filters included document type, restricting the sample to articles, review papers, and conference

papers, while only studies written in English and available in full-text or open-access format were considered. Furthermore, subject-related restrictions were introduced to enhance the contextual relevance of the retrieved literature. In Scopus, results were limited to the Business, Management and Accounting subject area and refined using keywords such as Digital Transformation, Industry 4.0, Digital Maturity, and Organizational Agility, ensuring consistency with the research focus. Similarly, in ProQuest, topic-based filters were applied, restricting the search to studies related to Industry 4.0 and Digital Transformation, as more specific filters concerning DM and OA were not available at this stage. After applying all filters and restrictions, the number of retrieved studies was reduced to 52 records from Scopus and 140 from ProQuest, resulting in a final pool of 192 studies eligible for the subsequent screening stage. The literature search was conducted using Scopus and ProQuest databases due to their complementary coverage and strong representation of interdisciplinary research related to management, organizational studies, digital transformation, and Industry 4.0. While Scopus provides extensive indexing of high-impact peer-reviewed journals and international scientific output, ProQuest offers broader access to multidisciplinary full-text publications, conference proceedings, dissertations, and applied management research that are often underrepresented in Web of Science. The choice of ProQuest was particularly justified by the interdisciplinary and practice-oriented nature of the analysed topic, combining digital transformation, OA, socio-technical systems, and Industry 4.0. Previous studies indicate that research concerning DM and OA is dispersed across multiple domains, including management, information systems, organizational behaviour, innovation studies, and technology management. Therefore, relying exclusively on Web of Science could potentially limit the retrieval of relevant studies published in emerging or practice-oriented sources. Moreover, ProQuest enables broader access to recent publications and management-oriented research outputs, which was particularly important given the rapidly evolving nature of digital transformation and Industry 4.0 research. Consequently, the combination of Scopus and ProQuest allowed for a more comprehensive and contextually diverse identification of relevant literature while maintaining the quality and scientific rigor of the review process

1.2. Screening

The next stage involved exporting all retrieved records into a single Microsoft Excel file to facilitate the screening process and eliminate duplicate entries. During this procedure, 12 duplicate records were identified and removed. The remaining studies subsequently underwent title and abstract screening to assess their relevance to the scope and objectives of the review. At this stage, studies were excluded if they clearly fell outside the focus of the research. Specifically, articles were removed when they focused exclusively on either DM or OA without considering their interrelationship, did not address the context of Industry 4.0, digital transformation, or digitally intensive organizational environments, focused on purely technical or engineering-related aspects without organizational or managerial implications,

or lacked sufficient conceptual relevance based on the title and abstract assessment. The purpose of these criteria was to ensure that only studies relevant to both constructs and their organizational implications in the context of Industry 4.0 were retained for further analysis. Following the application of these exclusion criteria, 14 studies were removed, leaving 166 records eligible for the subsequent eligibility assessment stage.

1.3. Eligibility

Following the title and abstract screening, the remaining 166 studies underwent a full-text eligibility assessment to determine their suitability for inclusion in the final review. At this stage, articles were examined in greater depth to evaluate their conceptual relevance, research focus, and alignment with the objectives of the study. Studies were excluded if, after full-text examination, they did not provide a meaningful discussion of the relationship between DM and OA, addressed the concepts only superficially or indirectly, lacked sufficient relevance to the organizational context of Industry 4.0 or digital transformation, or focused primarily on technical implementations without meaningful managerial or organizational implications. Additionally, studies were excluded when the full text revealed inconsistencies with the research scope that were not apparent during the title and abstract screening stage. As a result of the eligibility assessment, 98 studies were excluded, leaving a final sample of 68 articles for inclusion in the systematic literature review and subsequent qualitative analysis.

1.4. Inclusion

Following the eligibility assessment, a final sample of 68 studies meeting all predefined inclusion criteria was retained for the systematic literature review. The selected articles represent diverse organizational contexts, methodological approaches, and research perspectives related to DM and OA in the context of Industry 4.0. This final body of literature served as the basis for the subsequent qualitative analysis and coding process aimed at identifying relationships between DM domains and OA dimensions.

1.5. Dimensions categorization

To ensure consistency in the analysis of the reviewed literature, the dimensions of DM and OA were categorized using conceptually grounded classification schemes derived from prior research. Since both constructs are characterized by fragmented and multidimensional interpretations in the literature, a unified categorization framework was required to enable systematic comparison across studies.

The categorization of DM domains was conceptually informed by the work of van Tonder et al. (2024), who synthesized the core dimensions frequently appearing across DM models. These dimensions collectively reflect an organization's preparedness to leverage digital technologies for transformation and competitive adaptation. However, rather than directly adopting the original framework, this study consolidates and reorganizes these dimensions into broader analytical domains to better align with the objectives of the review and facilitate cross-study comparison. Accordingly, five overarching domains of DM were identified: strategic maturity, incorporating elements related to organizational strategy and leadership; cultural maturity, encompassing organizational culture, people, and structural readiness for digital transformation; process maturity, associated with the digitalization and optimization of organizational processes; technological maturity, referring to technological capabilities and digital infrastructure; and market maturity, including customer orientation, products, and market-related digital responsiveness. The conceptual foundations underlying this categorization are illustrated in Figure 2.

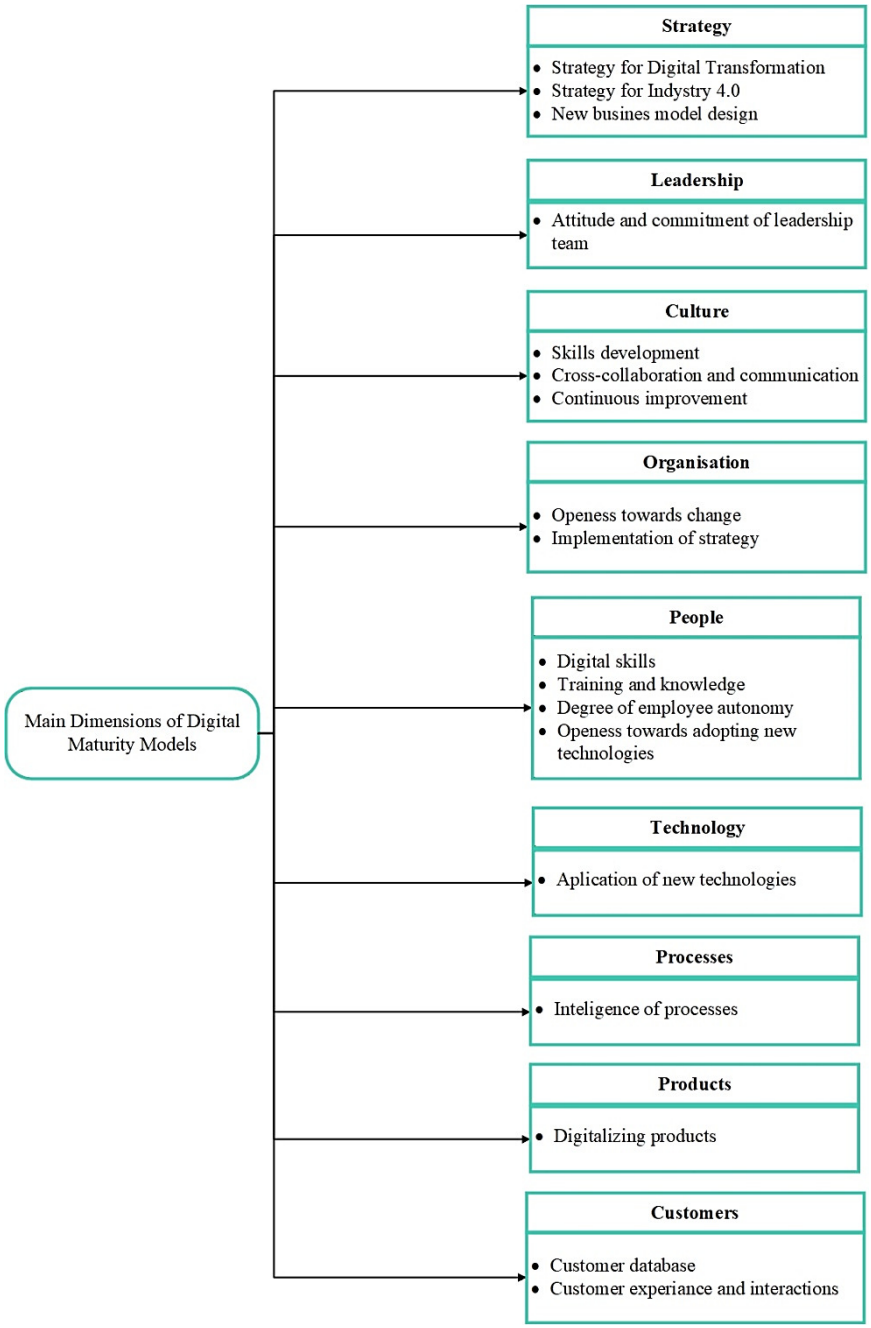


Figure 2. Main Dimensions of Digital Maturity Models.

Source: Van Tonder C. et al. (2024). Key dimensions that measure the digital maturity levels of Small and Medium-Sized Enterprises (SMEs). *Journal of Technology Management & Innovation, 19(1),* pp. 110-130. https://doi.org/10.4067/s0718-27242024000100110.

Similarly, the categorization of OA dimensions was informed by the multidimensional conceptualization proposed by Siddique & Asif khan (2022) where they conceptualized OA as an organizational capability that enables firms to sense environmental changes and respond rapidly and effectively to dynamic market conditions. According to this perspective, OA consists of three interrelated dimensions: sensing agility referring to the capability to identify and anticipate environmental changes, decision-making agility describing the ability to evaluate information and respond through timely decisions, and acting agility reflecting the

organization's capacity to implement adaptive responses effectively. The reviewed literature conceptualizes these dimensions as complementary organizational capabilities enabling environmental adaptation. Following this conceptual foundation, the present study adopts these three agility dimensions as analytical categories for classifying the OA perspective employed in the reviewed literature. Since the reviewed studies operationalize OA differently, these dimensions were used as a harmonized interpretive lens rather than as directly adopted measurement constructs. The conceptual basis for these dimensions is presented in Figure 3.

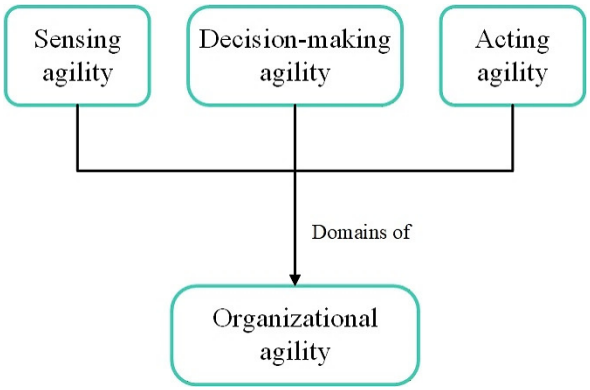


Figure 3. OA Domains.

Source: Siddique, A. & Asif khan, M. (2022). The Association between Organization Agility and Quality of Work Life in Small and Medium Enterprise of Punjab Pakistan. *International Journal of Social Science & Entrepreneurship, 2(1)*, pp. 1-15. https://doi.org/10.58661/ijsse.v2i1.15.

This conceptualization establishes a common reference point for examining the role of organizational agility across the reviewed studies. It also supports a more coherent interpretation of findings derived from diverse research contexts and methodological approaches.

1.6. Analytical Framework

To ensure consistency in the interpretation and synthesis of the reviewed literature, this study employed an analytical framework grounded in two complementary perspectives: the contextual lens of Industry 4.0 and the socio-technical perspective. While the relationship between DM and OA constituted the primary analytical focus, these perspectives provided an interpretive basis for understanding how digital capabilities and responsiveness emerge within digitally intensive environments.

Since the reviewed studies predominantly investigate organizational transformation under conditions of increasing digitalization, automation, and technological disruption, the findings were interpreted within the broader context of Industry 4.0. In this study, it served as a contextual lens and is considered as the broader technological and organizational context within which DM and OA evolve. Prior research conceptualizes Industry 4.0 through a set of enabling technologies that facilitate digitally integrated, data-driven, and adaptive organizational systems. The most frequently identified technologies include cyber-physical systems (CPS), the Internet of Things (IoT), big data analytics, artificial intelligence, cloud

computing, robotics, digital twins, system integration, additive manufacturing, and cybersecurity. These technologies collectively support real-time connectivity, process integration, automation, and organizational responsiveness, thereby creating conditions conducive to higher DM and agility. However, Industry 4.0 was not employed as a formal coding category or analytical dimension. Instead, it provided the contextual background for interpreting organizational responses to environmental turbulence, technological complexity, and digital transformation challenges.

To provide an additional interpretive perspective for analysing the reviewed literature, this study adopts the socio-technical systems perspective proposed by Richard P. Bostrom and J. Stephen Heinen. According to this perspective, organizational effectiveness and successful system implementation emerge from the alignment between social and technical organizational subsystems rather than from technological development alone. The socio-technical perspective distinguishes between two interdependent systems. The social system refers to organizational and human-related components and was categorized into two analytical dimensions: structure and people. While the technical system captures operational and technology-related components and was divided into technology and tasks. Since prior studies rarely classify organizational enablers explicitly according to socio-technical categories, the assignment of identified enablers to the four socio-technical dimensions was conducted interpretively based on the conceptual characteristics and descriptions provided within each study. This perspective enabled a more structured understanding of how organizational conditions support the relationship between DM and OA (Table 1).

Table 1.
Socio-technical enablers

Socio-technical system	Dimension	Example of enablers
Social system	Structure	governance, organizational design, leadership
Social system	People	employee competencies, digital skills, culture
Technical system	Technology	digital infrastructure, analytics, AI, ERP
Technical system	Tasks	process redesign, workflow integration, automation

Source: Own elaboration.

To systematically synthesize findings across the reviewed literature, a qualitative coding approach was employed. Each study included in the final sample was manually analysed and classified according to three analytical categories: DM domains, OA dimensions, and socio-technical enablers. Studies were examined to identify whether particular dimensions were explicitly or implicitly addressed within the research findings, conceptual discussions, or empirical analyses. The coding process was conducted using a binary classification logic, where the presence of a given dimension or enabler within a study was recorded and subsequently aggregated to identify recurring relationships and patterns across the literature. Since many studies addressed multiple dimensions simultaneously, individual articles could be assigned to more than one category within each analytical perspective. An example of the coding matrix applied during the literature analysis is presented in Table 2.

Table 2.
Example of the coding matrix applied in the literature analysis

Study	DM Domain	OA Dimension	Socio-Technical Enabler
AI-Enabled Strategic Transformation and Sustainable Outcomes in Serbian SMEs	Strategic, Technological, Culture	Acting, Decision-making	People, Technology, Structure
Strategizing in a digital world: Overcoming cognitive barriers, reconfiguring routines and introducing new organizational forms	Strategic, Process, Market, Culture	Sensing, Decision-making, Acting	Structure, People, Task
Unpacking Digital Transformation: Identifying key enablers, transition stages and digital archetypes	Strategic, Process, Technological, Culture	Acting, Decision-making	People, Structure, Task, Technology

Source: Own elaboration.

As illustrated in Table 2, individual studies were categorized according to the DM domains addressed, the OA dimensions identified, and the socio-technical enablers evident within the study context. This approach enabled a systematic comparison of heterogeneous studies and facilitated the identification of recurring patterns regarding how different dimensions of DM contribute to OA in Industry 4.0 environments.

2. Results

2.1. Paper characteristics

The final sample of 68 articles was first analysed according to the year of publication to identify temporal patterns in the development of research on DM and OA in the context of Industry 4.0. As presented in Table 3, the distribution of publications indicates a clear increase in scholarly attention over time, particularly from 2023 onwards.

Table 3.
Distribution of articles by year of publication

Year	Number of articles	Percentage
2020	4	~6
2021	1	~1
2022	5	~7
2023	6	~9
2024	13	~19
2025	28	~41
2026	11	~16

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

The results show that research activity was relatively limited between 2020 and 2022, with only 10 articles published during this period. A gradual increase can be observed in 2023, followed by a substantial rise in 2024 and especially in 2025, which accounts for the largest share of the sample. This trend suggests that the relationship between DM and OA has gained increasing relevance in recent years, likely reflecting the growing importance of digital transformation, technological turbulence, and Industry 4.0-related organizational challenges. Although the number of publications in 2026 is lower, the data collection ended on 14 May 2026 and therefore does not represent the full publication year. However, high number of articles published in 2025 indicates that the topic is still emerging and actively developing. Following the temporal analysis, the reviewed studies were classified according to the geographical region in which the research was conducted (Table 3).

Table 4.
Distribution of articles by research region

Region	Number of articles	Percentage
Europe	12	~18
Asia	28	~41
Australia	1	~1
Africa	1	~1
South America	4	~6
North America	1	~1
Not Specified	21	~31

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

This classification aimed to identify regional patterns in the investigation of DM and OA and assess the geographical concentration of existing research. The findings indicate that Asia dominates the existing body of literature, accounting for approximately 41% of the reviewed studies. This strong representation may reflect the increasing emphasis placed on digital transformation, smart manufacturing, and Industry 4.0 implementation across rapidly developing and highly industrialized Asian economies. Europe constitutes the second most represented region, contributing approximately 18% of the analysed studies, suggesting a growing scholarly interest in organizational digitalization and agility within European contexts. A considerable proportion of studies (31%) were categorized as Not Specified. This category includes systematic literature reviews, studies conducted from a global or cross-country perspective, and articles that did not explicitly identify a geographical research setting. The prevalence of such studies indicates that the relationship between DM and OA is increasingly examined from a broader conceptual perspective rather than being limited to a single regional context. In contrast, North America, South America, Australia, and Africa remain substantially underrepresented, each accounting for only a marginal proportion of the reviewed literature, suggesting that existing research remains geographically concentrated and may indicate opportunities for future studies. The reviewed studies were also classified according to the research level at which DM and OA were examined (Table 5).

Table 5.
Distribution of articles by research level

Research level	Number of articles	Percentage
Micro (actors & roles)	0	0
Meso (organizational structure & functions)	57	~84
Macro(ecosystems &platform)	11	~16

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

Following a multilevel organizational perspective, studies were categorized into micro, meso, and macro levels to better understand the dominant analytical focus within the existing literature. The results demonstrate that the overwhelming majority of studies (84%) investigate DM and OA at the meso level, focusing primarily on organizational structures, managerial capabilities, internal processes, and firm-level transformation mechanisms. This finding is consistent with the conceptual foundations of both constructs, as DM and OA are predominantly understood as organizational capabilities requiring strategic, cultural, technological, and process alignment. A smaller proportion of studies (16%) adopted a macro-level perspective, examining broader ecosystems, inter-organizational networks, digital platforms, or industry-wide transformation dynamics. These studies typically emphasize external collaboration, ecosystem responsiveness, and broader digital transformation environments rather than internal organizational capabilities. Interestingly, no studies were identified at the micro level, indicating a lack of research focusing on individual actors, employee roles, or behavioural mechanisms associated with DM and OA. This gap suggests an opportunity for future research to explore. The reviewed studies were further classified according to research method and research tool to identify dominant methodological approaches in the existing literature (Table 6).

Table 6.
Distribution of articles by research method and research tool

Research method	Research tool	Number of articles	Percentage
Quantitative	Survey	33	~49
	PLS-SEM	5	~7
Qualitative	Case Study	3	~4
	Models analysis + Case study	1	~1
	Case study + Interview	2	~3
Mixed	Survey + Case study	3	~4
	Delphi method	1	~1
	Survey + Focus Groups	1	~1
	fsQCA	2	~3
	Survey + Interview	2	~3
	PLS-SEM + Interview	1	~1
Other	Systematic Literature Review	13	~19
	Literature Synthesis	1	~1

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

The results indicate that quantitative methods dominate the literature, representing approximately 56% of the reviewed studies, with survey-based research being the most frequently applied methodological approach (49%). Additionally, several studies employed PLS-SEM to examine relationships between DM and OA and test structural relationships between organizational variables. Qualitative approaches accounted for a smaller proportion of the sample and were primarily represented by case study research, often combined with interviews or model analysis to provide context-specific insights into digital transformation and organizational adaptation processes. A number of studies adopted mixed methods, combining surveys with interviews, focus groups, or fuzzy-set qualitative comparative analysis (fsQCA) to capture both quantitative relationships and contextual organizational dynamics. Finally, studies categorized as other were predominantly represented by systematic literature reviews, accounting for approximately 19% of the sample. This finding highlights the increasing scholarly effort to synthesize fragmented knowledge concerning DM and OA in digitally intensive environments.

2.2. Main Results

The first stage of the main analysis focused on identifying the frequency with which individual DM domains appeared in the reviewed literature. Since a single article could address more than one DM domain, the results are presented as frequencies of occurrence rather than as the number of unique articles. This approach enables a more accurate representation of the multidimensional character of DM in the analysed studies (Table 7).

Table 7.
Frequency of DM domains identified in the reviewed literature

DM Domain	Frequency	Percentage
Strategic	55	~31
Culture	49	~27
Process	32	~18
Technological	34	~19
Market	9	~5

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

The results indicate that strategic maturity was the most frequently identified domain, appearing 55 times and accounting for approximately 31% of all coded occurrences. This strong representation suggests that the reviewed literature consistently positions DM as a strategically driven organizational capability rather than solely a technological condition. Studies frequently emphasize the importance of digital vision, leadership commitment, strategic alignment, and governance mechanisms in enabling organizations to navigate Industry 4.0-related transformation (Suwandi, et al., 2026; Luu, et al., 2026; Peter, et al., 2020). In particular, the literature highlights that organizations exhibiting higher levels of DM tend to integrate

digital initiatives into broader business strategies, align transformation efforts with organizational goals, and actively involve top management in digital decision-making. Furthermore, leadership is frequently portrayed as a critical mechanism for coordinating digital transformation efforts and reducing organizational resistance to change. As a result, strategic maturity is commonly framed as the foundational domain through which organizations mobilize digital resources and foster organizational adaptability (Cardoso, et al., 2025; Sagala & Őri, 2024).

The second most frequently represented domain was cultural maturity, with 49 occurrences (approximately 27%). The literature consistently stresses that successful digital transformation extends beyond technological implementation and depends heavily on organizational culture and employee readiness. Studies frequently associate cultural maturity with organizational openness to change, experimentation, collaboration, learning orientation, and employee empowerment (Orero-Blat, et al., 2024; Rubio-Andrés, et al., 2025). Moreover, digitally mature organizations are often characterized by stronger digital competencies, greater workforce adaptability, and leadership practices encouraging innovation and cross-functional cooperation. A recurring pattern visible across the reviewed studies is the emphasis placed on people-related capabilities, suggesting that employee engagement and organizational mindset are essential for translating digital initiatives into agile organizational behaviours. Together, strategic and cultural maturity represent the dominant focus of the literature, indicating that DM is primarily conceptualized as an organizational and managerial capability rather than merely a technological condition (Zhao, et al., 2023; Chen, et al., 2025; Senadjki, et al., 2024).

Technological maturity and process maturity were also strongly represented, accounting for approximately 19% and 18% of coded occurrences, respectively. The literature commonly describes technological maturity in terms of digital infrastructure, information systems, data analytics capabilities, artificial intelligence, cloud technologies, and digital integration mechanisms that support organizational responsiveness. However, rather than being treated as independent drivers of transformation, technological capabilities are often portrayed as enabling mechanisms facilitating faster information flows, decision-making, and operational flexibility (Ragmoun & Aloulou, 2026; Castillo-Vergara, et al., 2025). Similarly, process maturity is frequently linked to workflow integration, process automation, operational redesign, and process standardization, which collectively enhance organizational efficiency and adaptive capacity. The comparatively lower frequency of these domains suggests that the literature increasingly recognizes that technological advancement alone is insufficient unless accompanied by strategic direction and organizational readiness (Malik, et al., 2025; Silva, et al., 2025).

By contrast, market maturity appeared least frequently, with only 9 occurrences (approximately 5%). This limited representation indicates that customer orientation, product digitalization, external responsiveness, and market-facing capabilities remain relatively underexplored within the literature connecting DM and OA. While some studies emphasize the

importance of digitally enabled customer engagement and market responsiveness in turbulent environments, these aspects are substantially less prominent compared to internally oriented dimensions such as strategy, culture, and organizational processes. This pattern may suggest that current research tends to conceptualize DM primarily through an internal organizational lens, leaving external market-related capabilities comparatively overlooked (Almajali, et al., 2025; Aloulou, et al., 2024; Honigsberg, et al., 2026). The reviewed studies were subsequently analysed according to the frequency of OA dimensions addressed in the literature (Table 8).

Table 8.
Frequency of OA dimensions identified in the reviewed literature

OA Dimensions	Frequency	Percentage
Sensing	25	~21
Decision-making	35	~30
Acting	58	~49

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

The findings reveal that acting agility was by far the most frequently represented dimension, accounting for 58 occurrences (approximately 49%) of all coded agility dimensions. The strong emphasis on acting agility suggests that the reviewed literature primarily focuses on organizations' ability to translate digital capabilities into concrete organizational responses through resource reconfiguration, process redesign, strategic adaptation, and rapid operational implementation. Studies frequently associate acting agility with organizations' capacity to rapidly implement digital initiatives, modify internal workflows, introduce new digitally enabled products and services, and respond flexibly to disruptions emerging from dynamic environments (Yang, et al., 2025; Akkoca, 2025). Within Industry 4.0 contexts, acting agility is commonly portrayed as a capability allowing organizations to operationalize transformation efforts and maintain responsiveness amid technological turbulence and increasing environmental uncertainty. Moreover, many studies emphasize that digitally mature organizations tend to exhibit greater implementation speed and adaptive capacity due to stronger coordination mechanisms and digitally integrated processes. Consequently, the literature frequently conceptualizes agility through an execution-oriented perspective, emphasizing how organizations respond rather than merely how they perceive change (Ueasangkomsate, 2025; Forliano, et al., 2023). The decision-making agility dimension was represented with 35 occurrences (approximately 30%). Studies addressing this dimension frequently emphasize the role of information processing, rapid interpretation of environmental signals, evaluation of opportunities and threats, and timely managerial responses to dynamic business environments. In particular, the literature highlights how digitally mature organizations increasingly rely on data-driven decision-making, real-time information flows, analytics capabilities, and digitally enabled managerial coordination to support organizational responsiveness (AlNuaimi, et al., 2022; Çallı, et al., 2022). Decision-making agility is often

discussed in relation to organizations' ability to shorten decision cycles, reduce uncertainty, and improve strategic responsiveness under rapidly changing market and technological conditions. Several studies further suggest that DM contributes to decision-making agility by improving information accessibility and enhancing managerial capacity to evaluate complex organizational environments more effectively (Orero-Blat, et al., 2025; Cuong, et al., 2025). On the other hand, sensing agility appeared least frequently, accounting for 25 occurrences (approximately 21%). This dimension concerns organizations' ability to monitor environmental developments, identify emerging opportunities, anticipate market shifts, and detect technological disruptions before they materialize into operational challenges. The reviewed literature commonly associates sensing agility with environmental scanning, market intelligence, customer insights, competitor monitoring, and technological foresight capabilities. However, compared to acting and decision-making agility, sensing mechanisms receive substantially less scholarly attention. One possible explanation visible across the literature is that many studies focus more heavily on organizational adaptation after change occurs, rather than on anticipatory capabilities enabling organizations to proactively identify emerging trends and risks. As a result, sensing agility appears comparatively underrepresented despite its theoretical importance for maintaining competitiveness in Industry 4.0 environments (Ge, et al., 2026; Awad1 & Martín-Rojas, 2024; Ghobakhloo, et al., 2026). This distribution may indicate a tendency within existing research to conceptualize agility primarily through organizational action rather than through the full cycle of sensing, decision-making, and acting. To further explore the relationship between DM and OA, a cross-dimensional matrix was developed to identify how individual DM domains are associated with specific OA dimensions across the reviewed literature (Table 9).

Table 9.
Matrix of relationships between DM domains and OA dimensions

DM Domain	Sensing Agility	Decision-making Agility	Acting Agility	Total
Strategic	22	29	50	101
Culture	17	26	45	88
Process	9	20	32	61
Technological	10	18	29	57
Market	5	6	9	20

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

Since a single study could simultaneously address multiple domains and agility dimensions, the matrix presents the frequency of co-occurrence rather than the number of unique articles. This approach enabled the identification of dominant patterns in how digitally mature organizations develop agility capabilities in the context of Industry 4.0. The results reveal a clear pattern in which acting agility emerges as the dominant OA dimension across all DM domains. The fact that it received the highest frequency of occurrence suggest that digitally

mature organizations primarily leverage their capabilities to enhance executional responsiveness and organizational adaptation. The strongest relationship identified in the reviewed literature concerns strategic maturity and acting agility (50 occurrences), indicating that organizational strategy and leadership are most frequently associated with the implementation of adaptive responses and transformation activities. Rather than merely supporting digital transformation conceptually, strategic maturity appears to function as a mechanism translating digital ambitions into coordinated organizational action. Across the reviewed studies, organizations characterized by clear digital strategies and strong leadership involvement are frequently described as more capable of rapidly reconfiguring resources, aligning transformation initiatives across organizational units, and implementing strategic responses to environmental disruption. Particularly in Industry 4.0 contexts, where technological turbulence and competitive pressures are intensified, strategic maturity appears closely linked with an organization's ability to execute change effectively rather than simply formulate digital objectives (Aljehani, et al., 2026; Chen, et al., 2025; Pan, et al., 2022). At the same time, the relatively strong presence of decision-making agility (29 occurrences) suggests that strategic maturity also facilitates information processing and timely managerial responses to environmental change. The literature frequently portrays digitally mature leadership structures as facilitating quicker strategic adjustments, stronger coordination between departments, and more informed decision processes supported by digital information systems (Fachrunnisa, et al., 2020; Zheng, 2025).

Cultural maturity demonstrated the second strongest relationship with OA, particularly in relation to acting agility (45 occurrences) and decision-making agility (26 occurrences). In contrast to strategic maturity, which emphasizes formal alignment and leadership direction, cultural maturity appears to strengthen agility through behavioural and organizational conditions enabling responsiveness. The reviewed literature repeatedly highlights that organizational cultures characterized by openness to experimentation, learning orientation, employee autonomy, and collaboration tend to facilitate faster organizational adaptation. In many studies, digitally mature cultures are portrayed as reducing resistance to change and improving organizational flexibility by encouraging cross-functional cooperation and knowledge exchange. This suggests that cultural maturity contributes to agility not necessarily through formal mechanisms but through the development of organizational mindsets supporting adaptive behaviour (Duvivier & Gupta, 2023; Alshammari & Alshammari, 2026; Chang, et al., 2025).

Both process maturity and technological maturity exhibit similar relational patterns, with the strongest associations observed for acting agility (32 and 29 occurrences, respectively). However, the literature reveals important distinctions in the mechanisms through which these domains contribute to OA. Process maturity is commonly associated with organizational standardization, workflow integration, operational flexibility, and process redesign, enabling organizations to react more effectively to changing demands and disruptions. Studies frequently

suggest that organizations with digitally integrated and optimized processes are better positioned to implement rapid organizational adjustments and maintain operational continuity under dynamic conditions (Oncioiu, et al., 2025; Alaskar, 2025). In contrast, technological maturity is primarily portrayed as an enabling infrastructure supporting agility-related capabilities. The reviewed studies frequently emphasize technologies such as data analytics, digital platforms, cloud computing, enterprise systems, and artificial intelligence as facilitating faster information exchange, coordination, and managerial responsiveness. However, technological capabilities alone are rarely portrayed as sufficient drivers of agility. Instead, the literature consistently suggests that technology contributes to OA only when embedded within supportive organizational strategies, cultures, and processes. The relatively limited occurrence of sensing agility within technological maturity (10 occurrences) further suggests that digital technologies are more frequently leveraged for organizational coordination and execution rather than proactive sensing of environmental change (Islam, et al., 2023; Sagala & Őri, 2026; Alrub & Sánchez-Cañizares, 2025).

Although market maturity appeared least frequently in the literature, its strongest relationship was also observed with acting agility (9 occurrences). The reviewed studies commonly associate market maturity with customer responsiveness, digitally enabled products and services, and organizations' capability to adjust offerings according to changing market demands. However, unlike internally oriented domains such as strategy or culture, market maturity is more frequently discussed in terms of external adaptation and customer-facing responsiveness. The relatively limited representation of this domain may indicate that the relationship between DM and OA is still predominantly examined through an internal organizational lens, while market-oriented agility mechanisms remain comparatively underexplored (Volberda, et al., 2021; Franke, et al., 2026; Priyono, et al., 2020). The findings indicate that the literature conceptualizes the relationship between DM and OA primarily through organizational execution and implementation capabilities, rather than through sensing and anticipation mechanisms. Across all DM domains, acting agility consistently emerges as the dominant dimension, suggesting that digitally mature organizations are predominantly portrayed as organizations capable of translating digital capabilities into adaptive organizational action. To complement the analysis of DM and OA, the reviewed literature was further examined through the lens of socio-technical enablers (Table 10).

Table 10.
Frequency of socio-technical enablers identified in the reviewed literature

Socio-Technical Enabler	Frequency	Percentage
People	51	~29
Structure	55	~31
Technology	37	~21
Task	32	~18

Note: The data presented in this table reflect the state of the literature as of 14 May 2026, corresponding to the completion of the database search.

Source: Own elaboration.

Following the socio-technical systems perspective introduced in the methodological framework, studies were analysed to identify whether the conditions supporting the relationship between DM and OA were primarily associated with social system factors (people and structure) or technical system factors (technology and tasks). Similar to previous analyses, multiple socio-technical enablers could be assigned to a single study; therefore, the results are presented as frequencies of occurrence rather than as the number of unique articles. The findings indicate that structural enablers were the most frequently identified category, accounting for 55 occurrences (approximately 31%) of all coded socio-technical enablers. The reviewed literature consistently emphasizes the role of organizational governance, leadership arrangements, coordination mechanisms, structural flexibility, and decision-making structures in enabling organizations to effectively translate DM into OA. Studies frequently suggest that digitally mature organizations require organizational structures capable of facilitating cross-functional collaboration, reducing bureaucratic rigidity, and supporting rapid responses to environmental change. In particular, leadership support and governance mechanisms are often portrayed as essential for coordinating digital initiatives and aligning transformation efforts across organizational units. This finding suggests that organizations seeking to enhance agility through DM frequently rely on structural alignment mechanisms that facilitate organizational responsiveness and adaptive implementation rather than technological development alone (Damnjanović, et al., 2025; Tortora, et al., 2024; Leso, et al., 2022).

Similarly, people-related enablers demonstrated strong representation within the reviewed literature, accounting for 51 occurrences (approximately 29%). However, unlike structural enablers, people-related factors are predominantly discussed in terms of organizational capabilities and behavioural readiness supporting digital transformation and agile adaptation. The literature frequently highlights employee digital competencies, leadership involvement, workforce adaptability, organizational culture, learning orientation, and openness to change as critical determinants of organizational responsiveness. Many reviewed studies suggest that DM contributes to agility most effectively when employees possess the necessary digital skills and are willing to engage with transformation initiatives. Furthermore, organizations characterized by collaborative cultures and employee empowerment are frequently portrayed as better positioned to respond rapidly to environmental disruptions and organizational uncertainty (Kaszás, et al., 2023; Kő, et al., 2022; Asghar, et al., 2026).

By contrast, technology-related enablers accounted for 37 occurrences (approximately 21%), reflecting the continued importance of digital infrastructure, analytics capabilities, automation technologies, enterprise systems, cloud solutions, and information technologies in supporting organizational adaptation. The literature commonly describes technological enablers as mechanisms facilitating faster communication, improved information accessibility, operational visibility, and enhanced coordination across organizational processes. However, technological capabilities are rarely portrayed as independent determinants of agility. Instead, reviewed studies repeatedly emphasize that technology alone is insufficient to generate

organizational responsiveness unless accompanied by supportive leadership, employee readiness, and organizational structures. This comparatively lower representation suggests that the literature increasingly conceptualizes technology as an enabling infrastructure supporting agility, rather than as the central driver of adaptive organizational behaviour (Wang, et al., 2025; Abidi, et al., 2025; Sánchez-Rodríguez, et al., 2025).

Finally, task-related enablers appeared least frequently (32 occurrences; approximately 18%). These enablers are primarily associated with workflow redesign, process integration, task flexibility, operational reconfiguration, and process automation, all aimed at supporting digital transformation initiatives. The reviewed studies commonly discuss task-related mechanisms in relation to organizations' ability to redesign operational routines and improve internal efficiency in response to changing environmental demands. Nevertheless, compared to people and structural enablers, task-related factors are less frequently conceptualized as standalone organizational conditions supporting agility. Instead, they are often portrayed as consequences of broader digital transformation efforts, emerging after technological and organizational changes have already been implemented (Konopik, et al., 2022; Mick, et al., 2024; Nyamboga, 2025).

Overall, the findings suggest that the reviewed literature places stronger emphasis on social system enablers (structure and people) than on technical system enablers (technology and tasks) in explaining how DM contributes to OA. This pattern highlights that successful organizational adaptation in Industry 4.0 environments is not driven exclusively by technological advancement but rather depends on the alignment between organizational structures, human capabilities, and supporting technological mechanisms. In this regard, the findings provide empirical support for a socio-technical perspective on digital transformation and agility, emphasizing the interdependence between organizational and technological conditions in fostering adaptive capability (Gillani, et al., 2024; Karadağ, et al., 2026; Zhang, et al., 2025).

3. Discussion

One of the central findings emerging from this review concerns the evolving conceptualization of DM as a multidimensional organizational capability rather than a condition determined solely by technological advancement. Although technological readiness remains an important prerequisite for digital transformation, the reviewed studies consistently indicate that strategic and cultural dimensions of maturity play a more decisive role in shaping organizations' ability to navigate digitally intensive environments (Mulyana, et al., 2024; Mick, et al., 2024). This pattern suggests that DM is increasingly understood not simply as the adoption of advanced digital technologies, but as an organization's capacity to strategically coordinate, integrate, and leverage digital initiatives across multiple organizational levels.

The findings of this systematic literature review further indicate that this interpretation is not driven by isolated studies but represents a consistent pattern across the reviewed literature. The predominance of strategic and cultural maturity domains over technological maturity suggests that researchers increasingly conceptualize digital maturity as an organizational capability embedded in managerial and organizational practices rather than as a measure of technological sophistication alone.

Across the reviewed literature, organizations exhibiting higher levels of DM are consistently characterized by stronger strategic alignment, leadership commitment, governance mechanisms, employee readiness, and organizational adaptability. These findings reinforce the broader argument within digital transformation research that technological investments alone rarely produce sustainable organizational outcomes unless embedded within supportive managerial and organizational conditions (Senadjki, et al., 2024; Gillani, et al., 2024). Rather than functioning as an isolated technological state, DM appears to emerge from the interaction between organizational structures, managerial capabilities, cultural readiness, and technological resources. The work of Konopik et al. (2022) reinforce this interpretation by conceptualizing DM as an evolving capability configuration supporting transformation processes. Research grounded in dynamic capability theory emphasizes that organizations require distinct organizational capabilities at different stages of digital transformation, including sensing, seizing, and transforming activities. Similarly, Haryanti et al. (2023) conceptualizes DM as a multidimensional organizational capability rather than a purely technological condition, highlighting the importance of organizational structure, strategy, employee preparedness, and process integration, while positioning technology as a necessary but insufficient enabler of transformation. Evidence from more recent empirical studies like Orero-Blat et al. (2025) and Tortora et al. (2024) also suggests that digitally mature organizations are better positioned to translate managerial data-driven orientations into operational capabilities, particularly when supported by cohesive organizational cultures and leadership commitment. Taken together, the findings challenge technology-centric interpretations frequently associated with digital transformation and Industry 4.0 (Dubey, et al., 2024; N'Dri & Su, 2024; Alajmi, 2026).

Although technologies such as artificial intelligence, analytics, automation, and cloud-based systems are repeatedly identified as important transformation mechanisms, they are rarely portrayed as independent drivers of organizational responsiveness. Instead, technological capabilities are consistently framed as enabling mechanisms whose effectiveness depends on alignment with organizational culture, strategic intent, leadership, and managerial coordination (Forliano, et al., 2023; Kolog, et al., 2020). Volberda et al. (2021) and Chen et al. (2025) examine organizational transformation processes further demonstrate that firms derive value from digital technologies primarily when they are capable of redesigning routines, overcoming cognitive barriers, and integrating digital resources into broader organizational processes. This interpretation is further supported by research examining advanced technological capabilities in digitally transforming organizations like Ragmoun & Aloulou (2026) and Sagala

& Őri (2025). The authors are focusing on artificial intelligence and digital platform capabilities indicating that technological sophistication alone rarely translates directly into resilience, innovation, or adaptive capacity. Instead, organizational outcomes appear to depend on the presence of broader dynamic capabilities enabling firms to reconfigure resources, adapt decision-making structures, and integrate digital initiatives into existing organizational systems. This findings challenge technology-centric narratives frequently associated with Industry 4.0 and suggest that organizational transformation is primarily dependent upon the organization's ability to orchestrate strategic, cultural, and technological elements simultaneously. Consequently, DM may be better understood as an organizational transformation capability, reflecting the extent to which organizations successfully align strategic, cultural, structural, and technological elements to support adaptation in dynamic environments (Zhang, et al., 2025; AlNuaimi, et al., 2022).

The findings reveal a clear tendency within the reviewed literature to conceptualize OA through an execution-oriented perspective, with acting agility emerging as the dominant agility dimension. Scholarly attention appears to focus primarily on how organizations operationalize responses to environmental turbulence, implement digital initiatives, and reconfigure internal processes following disruption rather than on how they proactively anticipate change (Damnjanović, et al., 2025; Karadağ, et al., 2026). This suggests that OA in digitally intensive environments is frequently understood as a capability rooted in rapid execution, organizational responsiveness, and adaptive implementation. This study shows the predominance of acting agility indicating that the current body of research places considerably greater emphasis on organizations' ability to implement change than on their ability to anticipate it. This suggests that agility is operationalized through observable implementation outcomes rather than through the complete cycle of sensing, decision-making, and acting. Across the reviewed studies by Akkoca (2025), Duvivier & Gupta (2023), and Fachrunnisa et al. (2020) acting agility is consistently associated with capabilities such as rapid decision-making, flexible resource deployment, process redesign, operational responsiveness, and implementation speed. Research on digital agility and organizational adaptation repeatedly emphasizes organizations' capacity to respond swiftly to technological disruptions, changing market conditions, and emerging operational challenges through resource reconfiguration and organizational adjustment. Rather than emphasizing opportunity recognition or anticipatory strategic behaviour, the dominant conceptualization portrays agility primarily as an adaptive execution capability enabling organizations to sustain performance under uncertainty. In practice, OA is therefore frequently portrayed through capabilities such as resource reconfiguration, process redesign, operational flexibility, implementation speed, and adaptive execution, all of which support organizational responsiveness under conditions of uncertainty (Asghar, et al., 2026; Rubio-Andrés, et al., 2025).

The comparatively lower representation of sensing agility introduces an important theoretical observation. Existing conceptualizations of OA commonly assume that adaptive capability emerges through a dynamic process involving environmental sensing, managerial interpretation, and organizational action. However, the reviewed literature demonstrates a stronger emphasis on organizational reaction after change has occurred rather than on proactive opportunity recognition and anticipation of disruption (Almajali, et al., 2025; Ge, et al., 2026). This imbalance suggests that contemporary digital transformation research may privilege observable implementation-related capabilities over less tangible anticipatory mechanisms. The finding of Kolog et al. (2020) and Ghobakhloo et al. (2025) emphasize that organizations operating in Industry 4.0 environments frequently face continuous technological turbulence, shortened innovation cycles, and elevated competitive pressure, encouraging a stronger emphasis on immediate responsiveness than on long-term foresight. Studies examining SMEs and digitally transforming firms suggest that organizations often prioritize operational adaptation, restructuring, skills development, and process implementation to address immediate technological and market disruptions. Under such conditions, responsiveness may be perceived as more valuable than proactive sensing because organizations are required to adapt continuously to rapidly evolving environments. the predominance of acting agility may also reflect methodological tendencies within empirical research. Execution-related capabilities, such as process adaptation, implementation speed, resource flexibility, and organizational restructuring, are generally more observable and measurable than sensing mechanisms associated with managerial cognition, environmental scanning, or strategic foresight (Priyono, et al., 2020; Sagala & Őri, 2026; AlNuaimi, et al., 2022). As a result, empirical studies may unintentionally overrepresent acting agility while underestimating the strategic role of sensing capabilities in enabling organizations to recognize opportunities and disruptions before they materialize. This imbalance has important implications for how OA is currently understood in digital transformation research. By predominantly emphasizing acting agility, the literature risks conceptualizing agility primarily as an adaptive implementation capability, while underestimating the strategic importance of sensing mechanisms required to anticipate technological and market shifts proactively. From an Industry 4.0 perspective, this distinction appears particularly relevant, as digitally interconnected environments increasingly require organizations not only to respond rapidly to disruption but also to anticipate emerging technological developments and competitive changes before they fully materialize.

The relationship between DM and OA appears to be strongest when digital capabilities are successfully translated into adaptive organizational action. Across the reviewed studies, strategic and cultural dimensions of DM consistently demonstrate the strongest associations with acting agility, suggesting that organizational responsiveness depends less on technological sophistication alone and more on managerial alignment, organizational preparedness, and change-oriented capabilities. (Çallı, et al., 2022; Karadağ, et al., 2026). In this regard,

digitally mature organizations appear better equipped to convert technological investments into adaptive responses because they possess the structural and cultural conditions necessary to implement change effectively. Kwiotkowska (2025) as well as Kaszás et al. (2023) argues that the organizational conditions through which DM strengthens agility. Research consistently demonstrates that organizations characterized by coherent digital strategies, committed leadership, employee preparedness, collaborative cultures, and long-term managerial orientation exhibit stronger adaptive capabilities and greater responsiveness to environmental change. Rather than emerging automatically from investments in digital technologies, agility appears to depend on organizations' ability to align technological initiatives with organizational culture, managerial commitment, and employee capabilities. This finding reinforces the broader argument that digital transformation is fundamentally an organizational process requiring strategic coordination and readiness for change rather than a purely technological undertaking. It can be said that organizations characterized by clear digital strategies, committed leadership, collaborative cultures, and employee readiness appear more capable of implementing rapid organizational responses and sustaining agility under conditions of uncertainty. This research demonstrates that the relationship between DM and OA is not limited to a single digital maturity domain. Acting agility was the dominant agility dimension across all five maturity domains, indicating a remarkably consistent pattern throughout the reviewed literature. This consistency strengthens the argument that digital maturity contributes primarily to organizations' execution capabilities irrespective of the specific maturity dimension being examined.

At the same time, technological and process maturity appear to play a complementary, though still important, role in strengthening agility-related capabilities. Integrated workflows, process standardization, automation, and digitally enabled infrastructures improve information exchange, cross-functional coordination, and the speed of organizational decision-making, thereby facilitating organizational responsiveness (Castillo-Vergara, et al., 2025; Forliano, et al., 2023). Empirical evidence of Wang et al. (2025) argue that system integration reduces fragmentation, improves cross-functional coordination, and enhances the quality and consistency of organizational data, creating the technological foundation necessary for faster adaptation and more responsive decision-making. Oncioiu et al. (2025) also suggests that technological integration enhances transformation outcomes particularly when accompanied by employee resilience, organizational flexibility, and supportive managerial practices, enabling organizations to respond more effectively to environmental turbulence. However, the reviewed literature consistently indicates that technological and process maturity function primarily as enabling rather than independent sources of agility. Although digital infrastructures, automation systems, and artificial intelligence capabilities may facilitate adaptation, their contribution appears contingent upon supportive organizational arrangements and strategic alignment. Technologies improve organizational responsiveness when embedded within coherent managerial frameworks that enable coordination, interpretation, and implementation of digital initiatives. Consequently, agility should not be viewed as a direct consequence of technological

advancement, but rather as the outcome of organizational conditions that allow technological resources to be mobilized effectively (Mele, et al., 2024; Haryanti, et al., 2023). Taken together, the findings suggest that the relationship between DM and OA is both organizationally embedded and predominantly execution oriented. DM strengthens agility not through technological advancement alone, but through the interaction of strategic alignment, cultural readiness, organizational preparedness, process integration, and technological support mechanisms that collectively enhance adaptive capability in Industry 4.0 environments. This interpretation further explains why strategic and cultural maturity consistently demonstrate stronger relationships with acting agility than technological maturity alone.

The socio-technical perspective offers a more comprehensive explanation of how DM translates into OA in Industry 4.0 environments. The findings reveal a clear predominance of social system enablers over purely technical enablers, indicating that agility is shaped more strongly by organizational and human-related conditions than by technology alone. The study revealed that the difference between social and technical enablers was systematic rather than incidental. Across the reviewed studies, structural arrangements, leadership involvement, governance mechanisms, employee capabilities, collaborative cultures, and organizational flexibility emerge as more consistently represented determinants of adaptive capability than technological infrastructure itself. This pattern aligns closely with the assumptions of socio-technical systems theory, according to which organizational effectiveness results from the alignment between social and technical subsystems rather than from technological advancement in isolation (Chen, et al., 2025; Gillani, et al., 2024). From this perspective, the findings challenge deterministic interpretations of Industry 4.0 that portray digital technologies as the principal drivers of competitiveness and agility. Although digital infrastructures, analytics capabilities, automation systems, and AI-enabled technologies undoubtedly facilitate organizational responsiveness, the reviewed studies rarely conceptualize them as sufficient conditions for agility on their own. Instead, organizations appear capable of deriving value from technological investments only when supported by organizational structures and human capabilities that enable interpretation, coordination, and implementation of digital initiatives (Ghobakhloo, et al., 2026; Ragmoun & Aloulou, 2026). Consequently, DM contributes to agility not through a direct technology-performance relationship, but through a broader process of socio-technical alignment in which technological capabilities are embedded within supportive organizational contexts. The socio-technical interpretation also provides an important explanation for the predominance of acting agility identified across the reviewed literature. Acting agility may represent the most visible organizational manifestation of successful socio-technical alignment, emerging when organizations combine enabling structures, digitally competent employees, and integrated technological systems to support rapid adaptation and effective execution. By contrast, sensing agility depends more strongly on anticipatory capabilities such as environmental scanning, managerial cognition, and strategic foresight, which are generally more difficult to operationalize and empirically capture (Zhang,

et al., 2025; Malik, et al., 2025). Given the increasing pace of technological disruption, shortened innovation cycles, and growing competitive pressure characteristic of Industry 4.0 environments, organizations may naturally prioritize immediate responsiveness and implementation over long-term anticipation. As a result, acting agility appears to dominate both organizational practice and scholarly attention because it constitutes the most observable expression of adaptive capability in digitally intensive contexts (Tortora, et al., 2024; Ueasangkomsate, 2025; Peter, et al., 2020). Overall, the findings suggest that OA should not be understood as a technologically determined capability, but rather as the outcome of organizational alignment across people, structures, technologies, and operational arrangements. DM strengthens OA when technological resources are integrated with strategic intent, organizational readiness, and human capabilities that collectively support adaptive action. This perspective strengthens the explanatory value of the identified relationships between DM and OA while emphasizing that successful adaptation in Industry 4.0 environments depends fundamentally on socio-technical coherence rather than technological sophistication alone.

Based on the findings of this systematic literature review, a conceptual framework was developed to synthesize the identified relationships between DM, OA, and socio-technical enablers within Industry 4.0 environments. Since the reviewed literature frequently examined these constructs separately or emphasized only selected relationships, the proposed framework aims to provide a more integrated explanation of how DM contributes to OA and, ultimately, organizational performance. Figure 4 presents the proposed conceptual framework derived from the synthesis of the reviewed studies. The framework conceptualizes OA as an outcome enabled by DM and facilitated through socio-technical alignment, while simultaneously acknowledging the contextual influence of Industry 4.0 conditions.

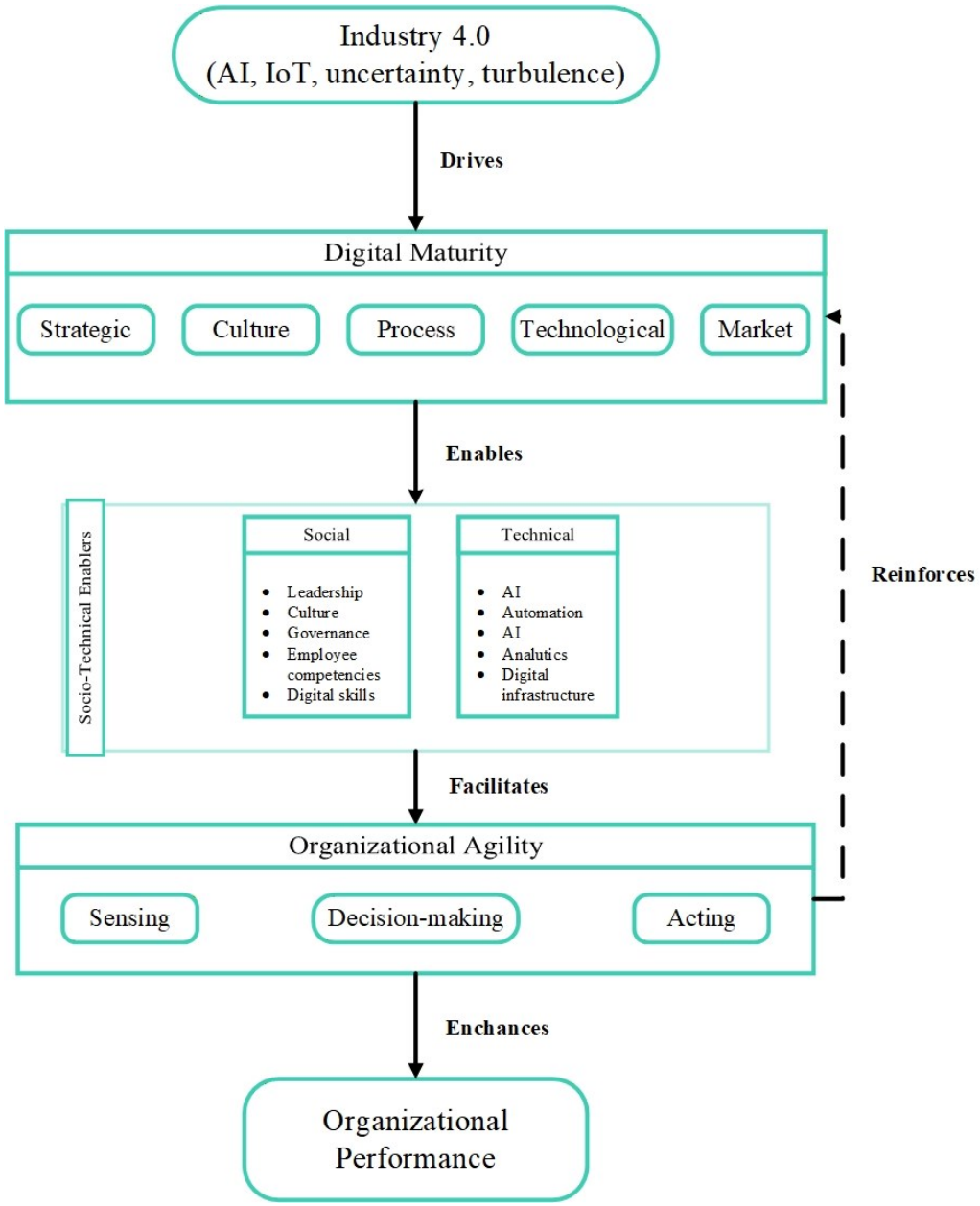


Figure 4. Proposed conceptual framework of the relationship between DM and OA in Industry 4.0 environments.

Source: Own elaboration.

The framework positions Industry 4.0 as the contextual driver shaping organizational transformation efforts towards higher levels of DM. The increasing technological turbulence creates pressure for organizations to develop digital capabilities, redesign processes, and strengthen strategic and cultural readiness. In this context, DM emerges as an organizational response to the technological and competitive demands of digitally intensive environments. At the organizational level, DM is conceptualized as a multidimensional capability composed of strategic, cultural, process, technological, and market maturity. The framework assumes that DM enables the development and alignment of socio-technical enablers required for effective organizational transformation. As organizations become more digitally mature, they are more likely to establish supportive leadership, governance structures, employee competencies,

and digital cultures while simultaneously investing in technological infrastructures such as analytics, automation, AI, and digital systems. Thus, DM creates the organizational conditions necessary for socio-technical integration. The framework further proposes that the relationship between DM and OA is facilitated through socio-technical enablers by translating digital capabilities into adaptive organizational behaviour. The literature consistently suggests that technologies alone rarely generate agility unless combined with complementary organizational conditions such as leadership, employee competencies, governance mechanisms, and supportive culture. Agility therefore emerges through the alignment of social and technical systems rather than through technological investments in isolation. Importantly, the framework does not assume that technological advancement alone directly produces agility. Instead, it proposes that OA emerges through the alignment of technological capabilities with supportive organizational structures and people-related capabilities. Through sensing, decision-making, and especially acting agility, organizations become more capable of maintaining responsiveness, operational continuity, innovation, and competitive performance. The literature further suggests that agility contributes to performance not merely through flexibility, but through execution-oriented adaptation. Additionally, the proposed reinforcing relationship between OA and DM reflects the possibility that organizations capable of agile adaptation may further strengthen their DM over time through organizational learning, accumulated digital capabilities, and continuous transformation efforts. Overall, the findings suggest that the relationship between DM and OA is considerably more organizational than technological in nature. Although advanced digital technologies constitute an important prerequisite for Industry 4.0, the reviewed evidence indicates that organizations derive agility primarily through strategic alignment, organizational culture, leadership, and employee capabilities.

This study contributes to the literature, by providing a structured synthesis of the fragmented relationship between DM and OA in Industry 4.0 contexts by identifying how specific DM domains relate to distinct agility dimensions. In particular, the findings suggest that DM should be conceptualized primarily as an organizational capability rather than solely a technological condition, as strategic and cultural maturity emerged as the dominant domains supporting agility. The findings also extend OA literature by demonstrating a clear predominance of acting agility, suggesting that agility in digitally intensive environments is increasingly conceptualized through an execution-oriented perspective focused on implementation and organizational responsiveness. The comparatively lower representation of sensing agility also indicates the need for greater theoretical attention to anticipatory capabilities. By applying a socio-technical perspective, this study highlights that OA emerges through the alignment between people, structures, and technologies, rather than through technological advancement alone. The proposed conceptual framework therefore contributes to a more integrated understanding of digitally enabled organizational adaptation. From practical point of view the findings suggest that managers should avoid approaching digital transformation primarily through technology investments. Although digital infrastructure and

advanced technologies remain important, OA appears to depend more strongly on leadership, culture, governance mechanisms, and employee capabilities supporting adaptive responses. The strong relationships between strategic and cultural maturity and acting agility further indicate that organizations seeking greater responsiveness should prioritize strategic alignment, employee readiness, and collaborative organizational cultures alongside digital implementation efforts. From a socio-technical perspective, the findings imply that OA is most likely to emerge when technological capabilities are aligned with supportive structures and people-related competencies. Consequently, managers should focus not only on adopting digital technologies but also on integrating them into organizational routines, decision-making processes, and workforce development efforts.

Despite providing a comprehensive synthesis of the relationship between DM and OA, this study is subject to several limitations that should be acknowledged. The review included only studies indexed in Scopus and ProQuest, limited to English-language publications from 2020–2026, which may have excluded relevant research from other databases and contexts. Additionally, the reviewed literature was strongly concentrated in Asian regions, while other geographical contexts remained underrepresented, limiting the broader generalizability of the findings. Although the review followed the PRISMA protocol, the categorization of socio-technical enablers required interpretive assessment, as reviewed studies rarely explicitly classified organizational conditions into socio-technical dimensions. Furthermore, as a systematic literature review, this study synthesizes existing evidence rather than empirically testing causal relationships between DM and OA. Future research could further explore the relationship between DM and OA at the micro level, particularly focusing on employee and managerial capabilities. Greater attention should also be devoted to market maturity and sensing agility, which appeared relatively underrepresented in the literature. Finally, future empirical studies may validate and further refine the proposed conceptual framework, particularly across different regional and organizational contexts.

4. Conclusion

This study examined the relationship between DM and OA in the context of Industry 4.0 through a systematic literature review conducted under the PRISMA protocol. By synthesizing findings from 68 studies, the review identified how different domains of DM contribute to distinct dimensions of OA and explored these relationships through a socio-technical perspective. The findings indicate that DM should be understood primarily as an organizational capability rather than solely a technological condition. While technological and process-related capabilities remain important, the reviewed literature places stronger emphasis on strategic and cultural maturity, highlighting the importance of leadership, organizational readiness, employee

capabilities, and governance mechanisms in supporting digital transformation. Similarly, OA was predominantly conceptualized through an execution-oriented perspective, with acting agility emerging as the dominant dimension, suggesting that existing research focuses more strongly on organizational responsiveness and implementation than on anticipatory capabilities. The study further demonstrates that the relationship between DM and OA is strengthened through socio-technical alignment, where organizational structures, people-related capabilities, and technological systems collectively support adaptive organizational behaviour. In this regard, the findings challenge technology-centric assumptions frequently associated with Industry 4.0 and suggest that OA emerges not from technology adoption alone, but from the organization's capability to align digital resources with supportive organizational conditions. By integrating fragmented findings and proposing a conceptual framework linking DM, socio-technical enablers, and OA, this study contributes to a more comprehensive understanding of digitally enabled organizational adaptation. As organizations continue to face increasing technological turbulence and competitive pressures, understanding how DM supports agility may become increasingly important for sustaining long-term organizational performance in Industry 4.0 environments.

Authors contribution

Conceptualization: A.G; Methodology: A.G; Formal analysis: A.G; Investigation: A.G; Validation: A.G; Visualization: A.G; Writing-original draft: A.G; Writing-review & editing: A.G., L.H; Supervision: L.H.

References

1. Abidi, O., Richet, J.-l., Vitari, C. (2025). Digital Transformation and Resilience: Dimensions and Interactions. *Journal of Global Information Management*, *33(1)*.
2. Akkoca, Y. (2025). The Impact of Organizational Agility on Innovation Performance: The Key Role of Digital Transformation. *Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi*, *Iss. 3,* pp. 1280-1297.
3. Alajmi, N.H. (2026). Resource-Centered Transformation Paths: The Role of Digital Transformation in Optimizing SME Resources for Sustainable Entrepreneurship. *Business Strategy and the Environment*, pp. 1-23.

4. Alaskar, T. H. (2025). Integrated AI and Business Analytics for Sustaining Data-Driven and Technological Innovation: The Mediating Role of Integration Capabilities and Digital Platform. *Sustainability*, *Vol. 17,* p. 8749.
5. Aljehani, S.B. et al. (2026). Digital Transformation in SMEs: Governance Performance Mediated by AI-Enabled Analytics and Process Integration. *Systems*, *Vol. 14*.
6. Almajali, H., Thuneibat, N., Qatawneh, N. (2025). Investigation of the Antecedents of Digital Transformation and Their Effects on Operational Performance in the Jordanian Manufacturing Sector. *Journal of Risk and Financial Management*, *18(8)*.
7. AlNuaimi, B.K. et al. (2022). Mastering digital transformation: The nexus between leadership, agility, and digital strategy. *Journal of Business Research*, *Vol. 145,* pp. 636-648.
8. Aloulou, W.J., Alsadi, A.K., Ayadi, F.M., Alaskar, T.H. (2024). Exploring the Effects of Entrepreneurial and Digital Orientations on the Competitive Advantage of Saudi Firms: Is Strategic Agility the Missing Link? *Administrative Science*, *Vol. 14*.
9. Alrub, Y.A., Sánchez-Cañizares, S.M. (2025). Dynamic Capabilities and Digital Transformation: Toward Strategic Planning in the Digital Age—Evidence from Palestine. *Administrative Science*, *15(1)*, p. 21.
10. Alshammari, K.H., Alshammari, A.F. (2026). From Digitalization to Knowledge Innovation: Integrated Model of AI Knowledge Agility and Organizational Learning Culture. *Systems*, *Vol. 14*.
11. Asghar, J., Kanbach, D.K., Kraus, S. (2026). Toward a multidimensional concept of organizational agility: a systematic literature review. *Management Review Quarterly*, *Vol. 76,* pp. 885-911.
12. Awad1, J.A.R., Martín-Rojas, R. (2024). Digital transformation influence on organisational resilience through organisational learning and innovation. *Journal of Innovation and Entrepreneurship*, *13(69)*.
13. Çallı, B.A., Özşahin, M., Coşkun, E., Arık, A.R. (2022). Do Generative Leadership and Digital Literacy of Executive Management Help Flourishing Micro and Small Business Digital Maturity?. *International Journal of Organizational Leadership*, *Vol. 11*, pp. 307-332.
14. Cardoso, A., Figueiredo, J., Oliveira, I., Pocinho, M. (2025). From Crisis to Opportunity: Digital Transformation, Digital Business Models, and Organizational Resilience in the Post-Pandemic Era. *Administrative Sciences*, *15(6)*.
15. Castillo-Vergara, M. et al. (2025). Digital capabilities of SMEs: driving the Industry 4.0 revolution and measuring its innovative effects. *Academia Revista Latinoamericana de Administración*, *38(1)*, pp. 74-105.
16. Chang, C.-H., Chen, Y.-S., Tseng, C.-W. (2025). Digital transformation anxiety: absorptive capacity, dynamic capability, and digital innovation performance. *Management Decision*, *63(3)*, pp. 734-755.

17. Chen, K.-Z., Wang, I.K., Seidle, R.J. (2025). Navigating digital transformation: the role of management innovation in achieving digital maturity. *The Learning Organization*, *32(3)*, pp. 391-417.
18. Chen, M., Sun, X., Liu, M. (2025). Critical Success Factors in Agile-Based Digital Transformation Projects. *Systems*, *Vol. 13.*
19. Cuong, N.K., Ngoc-Long, N., Dung, H.T., Hai, T.V. (2025). Digital transformation, organizational agility, and firm performance in emerging markets: Evidence from Vietnam's machinery sector. *Problems and Perspectives in Management*, *23(3)*, pp. 342-357.
20. Damnjanović, A.M. et al. (2025). AI-Enabled Strategic Transformation and Sustainable Outcomes in Serbian SMEs. *Sustainability*, *Vol. 17,* p. 8672.
21. Dubey, R. et al. (2024). Alliances and digital transformation are crucial for benefiting from dynamic supply chain capabilities during times of crisis: A multi-method study. *International Journal of Production Economics*, *Vol. 269*, p. 109166.
22. Duvivier, F., Gupta, G. (2023). Unleashing Digital Agility: A Review of Literature on Agile Responses to Digital Challenges. *Journal of Global Information Management*, *31(8)*.
23. Fachrunnisa, O., Adhiatma, A., Lukman, N., Majid, M.N.A., 2020. Towards SMEs' digital transformation: The role of agile leadership and strategic flexibility. *Journal of Small Business Strategy*, *30(3)*, pp. 65-85.
24. Forliano, C., Orlandi, L.B., Zardini, A., Rossignoli, C. (2023). Technological orientation and organizational resilience to Covid-19: The mediating role of strategy's digital maturity. *Technological Forecasting & Social Change*, *Vol. 188*, p. 122288.
25. Franke, T.K., Oguji, N., Bhatti, W.A. (2026). Digital maturity as startup internationalization process enabler. *Critical Perspectives on International Business*, *22(2),* pp. 141-173.
26. Ge, Z. et al. (2026). Achieving Sustainable Manufacturing Through Digital Leadership: The Mediating Roles of Knowledge Management and Resilience. *Journal of Organizational and End User Computing*, *38(1)*.
27. Ghobakhloo, M. et al. (2026). Adaptive social manufacturing: a human-centric, resilient, and sustainable framework for advancing Industry 5.0. *International Journal of Production Research*, *64(3),* pp. 1127-1160.
28. Gillani, F. et al. (2024). Unpacking Digital Transformation: Identifying key enablers, transition stages and digital archetypes. *Technological Forecasting & Social Change*, Vol. 203, p. 123335.
29. Haryanti, T., Rakhmawati, N.A., Subriadi, A.P. (2023). The Extended Digital Maturity Model. *Big Data and Cognitive Computing, Vol. 7.*
30. Honigsberg, S. et al. (2026). The impact of digital platform introduction on business models in SMEs—The interplay of efficiency and innovation orientation. *Journal of Strategic Information Systems*, *Vol. 35*, p. 101967.
31. Islam, S. et al. (2023). Digital Transformation in SMEs: Unlocking Competitive Advantage through Business Intelligence and Data Analytics Adoption. *Journal of Business and Management Studies*, *5(6)*, pp. 177-186.

32. Karadağ, H., Şahin, F., Karamollaoğlu, N., Saunila, M. (2026). Disentangling the dynamic digital capability, digital transformation, and organizational performance relationships in SMEs: a configurational analysis based on fsQCA. *Information Technology and Management*, *Vol. 27*, pp. 141-157.
33. Kaszás, N., Ernszt, I., Jakab, B. (2023). The Emergence of Organizational and Human Factors in Digital Maturity Models. *Journal of Contemporary Management Issues*, *28(1)*, pp. 123-135.
34. Kő, A. et al. (2022). Digital Agility, Digital Competitiveness, and Innovative Performance of SMEs. *Journal of Competitiveness*, *14(4)*, pp. 78-96.
35. Kolog, E., Anim-Yeboah, S., Boateng, R., Odoom, R. (2020). Digital Transformation Process and the Capability and Capacity Implications for Small and Medium Enterprises. *International Journal of E-Entrepreneurship and Innovation*, *10(2)*, pp. 26-44.
36. Konopik, J. et al. (2022). Mastering the digital transformation through organizational capabilities: A conceptual framework. *Digital Business*, *Vol. 2,* p. 100019.
37. Kwiotkowska, A. (2025). Impact of AI capability, digital strategy, and digital maturity on organisational performance. *Engineering Management in Production and Services*, *17(4)*, pp. 15-28.
38. Leso, B.H., Cortimiglia, M.N., Ghezzi, A. (2022). The contribution of organizational culture, structure, and leadership factors in the digital transformation of SMEs: a mixed-methods approach. *Cognition, Technology & Work*, *Vol. 25*, pp. 151-179.
39. Luu, T.D., Huynh, T.T., Ha, V.H., Nguyen, V.N. (2026). Going international by going digital and green: the effects of digitalisation and green economy practices on nternationalisation of SMEs. *Review of International Business and Strategy*, *36(7),* pp. 217-238.
40. Malik, M., Andargoli, A., Tallon, P., Wickramasinghe, N. (2025). An organizational sensemaking theorizing of how firms construct digitally enabled strategic agility. *Information & Management*, *Vol. 62,* p. 104130.
41. Mele, G., Capaldo, G., Secundo, G., Corvello, V. (2024). Revisiting the idea of knowledge-based dynamic capabilities for digital transformation. *Journal of Knowledge Management*, *28(2)*, pp. 532-563.
42. Mick, M.M.A.P., Kovaleski, J.L., Mick, R.L., Chiroli, D.M.d.G., 2024. Developing a Sustainable Digital Transformation Roadmap for SMEs: Integrating Digital Maturity and Strategic Alignment. *Sustainability*, *Vol. 16,* p. 8745.
43. Mulyana, R., Rusu, L., Perjons, E. (2024). Key ambidextrous IT governance mechanisms for successful digital transformation: A case study of Bank Rakyat Indonesia (BRI). *Digital Business*, *Vol. 4,* p. 100083.
44. N'Dri, A.B., Su, Z. (202)4. Successful configurations of technology–organization–environment factors in digital transformation: Evidence from exporting small and medium-sized enterprises in the manufacturing industry. *Information & Management*, *Vol. 61*, p. 104030.

45. Nyamboga, T.O. (2025). Enhancing Strategic Agility and Real Time Decision-Making in the Technology Sector: Exploring the Role of AI and e-HRM Systems. *F1000Research*, *Vol. 14,* p. 1238.
46. Oncioiu, I., Mândricel, D.A., Hojda, M.H. (2025). Artificial Intelligence-Enabled Digital Transformation in Circular Logistics: A Structural Equation Model of Organizational, Technological, and Environmental Drivers. *Logistics*, *Vol. 9*, p. 102.
47. Orero-Blat, M., Rodríguez, A.L.L., Palacios-Marqués, D. (2024). The strategic advantage of innovative organizational culture: An exploratory analysis in digital transformation and big data analytics capabilities. *Journal of Management & Organization*.
48. Orero-Blat, M., Rodríguez, A.L.L., Palacios-Marqués, D. (2025). Orchestrating the digital symphony: the impact of data-driven orientation, organizational culture and digital maturity on big data analytics capabilities. *Journal of Enterprise Information Management*, *38(2)*, pp. 679-703.
49. Pan, J., Lin, J., Wang, S. (2022). A Delphi-based index system for digital transformation capability of retailers. *Journal of Business Economics and Management*, *23(5)*, pp. 1106-1132.
50. Peter, M.K., Kraft, C., Lindeque, J. (2020). Strategic action fields of digital transformation An exploration of the strategic action fields of Swiss SMEs and large enterprises. *Journal of Strategy and Management*, *13(1)*, pp. 160-180.
51. Priyono, A., Moin, A., Putri, V.N.A.O. (2020). Identifying Digital Transformation Paths in the Business Model of SMEs during the COVID-19 Pandemic. *Journal of Open Innovation: Technology, Market, and Complexity*, *Vol. 6,* p. 104.
52. Ragmoun, W., Aloulou, W.J. (2026). Artificial Intelligence Capabilities, Sustainable Innovation and SMEs' Resilience: A Serial-Parallel Mediation Model of Dynamic and Digital Platform Capabilities. *Sustainability*, *Vol, 18*, p. 4320.
53. Rubio-Andrés, M., Linuesa-Langreo, J., Sastre-Castillo, M.Á. (2025). Tackling digital transformation strategy: how it affects firm innovation and organizational effectiveness. *The Journal of Technology Transfer*, *Vol. 50*, pp. 1893-1918.
54. Sagala, G.H., Őri, D. (2024). Toward SMEs digital transformation success: a systematic literature review. *Information Systems and e-Business Management*, *Vol. 22*, pp. 667-719.
55. Sagala, G.H., Őri, D. (2025). Exploring digital transformation strategy to achieve SMEs resilience and antifragility: a systematic literature review. *Journal of Small Business & Entrepreneurship*, *37(3),* pp. 495-524.
56. Sagala, G.H., Őri, D. (2026). Resilience and digital transformation: a small to medium enterprise resilience framework. *Management Decision*, *64(13)*, pp. 126-161.
57. Sánchez-Rodríguez, A. et al. (2025). Navigating Uncertainty Through AI Adoption: Dynamic Capabilities, Strategic Innovation Performance, and Competitiveness in Ecuadorian SMEs. *Administrative Science*, *15(12),* p. 468.

58. Senadjki, A., Yong, H.N.A., Ganapathy, T. (2024). Unlocking the potential: the impact of digital leadership on firms' performance through digital transformation. *Journal of Business and Socio economic Development*, *4(2)*, pp. 161-177.
59. Siddique, A., Asif khan, M. (2022). he Association between Organization Agility and Quality of Work Life in Small and Medium Enterprise of Punjab Pakistan. *nternationalJournal of Social Sciences and Entrepreneurship*, *2(1),* pp. 1-15.
60. Silva, N., Nakandala, D., Yang, R. (2025). A Novel Lean-Centric Readiness Model for Harnessing Lean Capabilities in Industry 4.0 Digital Technology Adoption. *Journal of Industrial Engineering and Management*, *18(3)*, pp. 459-494.
61. Suwandi, S. et al. (2026). Agile human resource strategy and leadership for innovation performance in the digital era. *SA Journal of Human Resource Management*, *24,* p. a3350.
62. Tortora, D. et al. (2024). Boosting intellectual capital and digital maturity of SMEs: an investigation of enterprises in an Italian Southern tourist district. *Journal of Intellectual Capital*, *25(7)*, pp. 176-198.
63. Ueasangkomsate, P. (2025). Empowering Thai SMEs through IT competency, digitalization and digital transformation for new product development. *Cogent Business & Management*, *12(1)*, p. 2458758.
64. van Tonder, C., Bossink, B., Schachtebeck, C., Nieuwenhuizen, C. (2024). Key dimensions that measure the digital maturity levels of Small and Medium-Sized Enterprises (SMEs). *Journal of Technology Management & Innovation*, *19(1),* pp. 110-130.
65. Volberda, H.W. et al. (2021). Strategizing in a digital world: Overcoming cognitive barriers, reconfiguring routines and introducing new organizational forms. *Long Range Planning*, *Vol. 54,* p. 102110.
66. Wang, J., Wu, Z., Wang, T. (2025). Data Quality Improvement Supports Digital Transformation in Industry 5.0. *Sustainability*, *Vol. 17,* p. 11183.
67. Yang, Z., Dong, M., Guo, H., Peng, W. (2025). Empowering resilience through digital transformation intentions: synergizing knowledge sharing and transformational leadership amid COVID-19. *Journal of Organizational Chang Management*, *38(1),* pp. 59-81.
68. Zhang, X. et al. (2025). How Digital Orientation Affects Innovation Performance? Exploring the Role of Digital Capabilities and Environmental Dynamism. *Systems*, *Vol. 13*, p. 346.
69. Zhao, L., He, Q., Guo, L., Sarpong, D. (2023). Organizational digital literacy and enterprise digital transformation: Evidence from Chinese listed companies. *IEEE Transactions on Engineering Management*.
70. Zheng, X. (2025). Digital Maturity and Business Model Evolution in Service Firms: A 3D Synergy Framework. *International Journal of Information Systems in the Service Sector*, *16(1)*.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE PRESENCE OF WOMEN ON COMPANY BOARD OF DIRECTORS - ANTECEDENTS, BENEFITS AND FUTURE RESEARCH

Magdalena HOFMAN-KOHLMEYER[1*], Ewa CZYŻ-GWIAZDA[2], Katarzyna ŻAK[3], Katarzyna OLEJKO[4]

[1] University of Economics in Katowice; magdalena.hofman-kohlmeyer@ue.katowice.pl, ORCID: 0000-0001-9201-3308
[2] University of Economics in Katowice; ewa.czyz-gwiazda@ue.katowice.pl, ORCID: 0000-0003-3013-4248
[3] University of Economics in Katowice; katarzyna.zak@ue.katowice.pl, ORCID: 0000-0002-9212-7206
[4] University of Economics in Katowice; katarzyna.olejko@ue.katowice.pl, ORCID: 0000-0003-2093-8269
* Correspondence author

Purpose: Corporate boards and senior management play a central role in shaping organizational strategy, governance, and performance. Because limited presence of women on top-level position in management and growing number of available research in this area present paper is aimed on answering a questions: what influence the presence of women in high management positions, what are the benefits of women participation, what is the state of knowledge in this field and what are the directions of future research.
Methodology: A systematic literature review was conducted covering studies published between 2015 and 2025. Articles were identified using the Scopus database, with the analysis limited to top-tier journals listed in AJG 2020.
Findings: The literature analysis indicates the following antecedents: gender stereotypes, structure of nomination processes, informal networks, size of company, image of women as manager, normative solutions. According to available literature the benefits of presence of women on company board of directors can be categorized into eight distinct areas, namely: governance quality and risk control, Corporate Social Responsibility (CSR), sustainability and ESG outcomes, board decision processes, strategic orientation (long-term balance), transparency and disclosure quality, legitimacy, reputation and stakeholder trust, leadership pipelines and succession, and financial performance. Future research is most frequently recommended to examine the long-term, context-dependent effects of women's representation in boards and senior management, focusing on governance processes, decision-making, leadership dynamics, CSR/ESG outcomes, promotion and succession, and the interaction of gender with institutional, cultural, and organizational factors.
Research limitations: The review is limited to Scopus-indexed publications in AJG 2020 journals. Future studies should extend the evidence base by examining underexplored contexts and longitudinal effects.
Practical implications: The findings provide guidance for companies and policymakers by identifying both the drivers and barriers to women's advancement and demonstrating the organizational value of greater female representation in senior management.

http://dx.doi.org/10.29119/1641-3466.2026.253.8 http://managementpapers.polsl.pl/

Social implications: Increasing women's representation in senior management contributes to equal opportunities, more inclusive labor markets, stronger trust in business institutions, and more responsible and sustainable organizational decision-making.
Originality/value: This paper provides a comprehensive synthesis of recent research on women in senior managerial positions by integrating evidence on promotion barriers, organizational conditions, and organizational outcomes, while identifying key directions for future research.
Keywords: women presence, board of directors, management, antecedents, benefits.
Category of the paper: Literature review.

1. Introduction

The composition of corporate management boards has become an attractive research topic in recent years. Managers exert a significant influence on company performance through monitoring and advising (Chow et al., 2023). Directors contribute various resources to companies such as knowledge, guidance, liaisons with key stakeholders, external relations enhancement, and participation in strategy formulation. One of the bases of demographic differences is gender. Gender influences norms, attitudes, beliefs, and perspectives. Women are frequently associated with empathy, participation, cooperation, and communication skills (Islam et al., 2022). These attributes may lead to improvement of different company capabilities such as financial reporting quality, the promotion of good business practices and strategic decisions (Gallego-Álvarez, Pucheta-Martínez, 2020).

The lack or limited presence of women within these teams, as well as efforts to increase diversity, are frequently recognized (Chow et al., 2023). Women constitute only 8.2% of CEO positions at S&P 500 companies and 10.4% at the world's largest businesses in the Fortune Global 500. Women are not present only in top executives positions but also at lower management levels. It suggests that currently women's management careers are still more complex than careers of men (Bonesso and Cortellazzo; Fortune 500, 2024). Many researchers also noticed differences in men's and women's path to promotion to top management positions. Despite similar aspirations and competencies, women encounter numerous organizational and psychological barriers. Despite numerous studies, limited attention is drawn to the cultural and national context (Taser-Erdogan, 2022).

Although it can be observed the slight increase in the number of women in board positions, women are still vastly underrepresented on boards of directors. This problem raises serious ethical considerations and motivated legislators to introduce requirements aimed at increasing the presence of women on boards of directors (Rixom et al., 2023). Quotas representing board gender diversity have become law in many countries, such as Norway, France, India, and Israel (Cumming, Leung, 2021).

In the literature, the issue of women taking up managerial positions was omitted until the 1990s. In the last decade, scientific publications with various studies in this field have begun to appear, but knowledge is still relatively fragmented. The vast majority of these studies analyzed the relationship between gender and managerial position in very limited contexts, e.g. schools and universities or male-dominated organizations. The other research has formulated conclusions related to women's barriers to promotion to senior management positions and benefits of women leadership (Bonesso, Cortellazzo; Fortune 500, 2024).

More recently, Griffin, Li and Xu (2021) confirmed that a gender-diverse board focuses more on long-term goals and creates a culture that promotes innovation. Similarly research conducted by Joecks, Pull, Scharfenkamp (2023) and Vafaei, Henry, Ahmed, Alipour (2021) showed that a high percentage of women in top management positions favors the development of innovation. Contemporary literature contains research showing that gender diversity in top management teams is associated with better financial performance (Opstrup, Villadsen, 2015; Srivastava et al., 2023) and financial reporting is of lower quality in companies that discriminate against women in high-ranking positions (Lara et al., 2017). Noteworthy are also studies confirming the positive impact of appointing women to top positions in a company on improving the assessment of the company's CSR activities (McGuinness et al., 2017). When boards are comprised of women rather than men, the following effects have been observed: stronger community bonds, stronger corporate governance, and stronger environmental concerns (Cook, Glass, 2018).

Despite the substantial growth of research on women's representation in corporate boards and senior management over the last decade, the existing literature remains highly fragmented. Previous studies have predominantly focused on individual outcomes, such as financial performance, corporate governance, innovation, or CSR, while relatively little attention has been paid to integrating evidence on the antecedents of women's representation, its organizational consequences, and future research directions within a single comprehensive framework. Moreover, prior empirical findings remain inconclusive. While numerous studies report positive effects of board gender diversity, others identify weak, insignificant, or context-dependent relationships, suggesting that the impact of women on corporate boards is contingent upon institutional, cultural, and organizational conditions rather than being universally applicable. Consequently, there is a need for an up-to-date systematic literature review synthesizing the rapidly expanding body of research published in recent years and identifying emerging research directions.

The present paper is aimed at organizing and synthetically presenting the current research results on the presence of women in higher managerial positions, with particular emphasis on barriers to promotion, organizational conditions and potential positive consequences for the functioning of the organization. The aim is also to identify research gaps and indicate potential directions for further research on women in managerial positions. To meet the assumed goal the authors conducted systematic literature review.

This article is structured as follows. In the first part the authors present the research method, especially study and report eligibility criteria as well as search strategy and record selection. In the second part, the authors report results of systematic literature review, namely methods used by scholars, antecedents of presence of women on company board of directors and impact of presence of women on company board of directors on company performance. The paper ended with final conclusions.

2. Research method

2.1. Study and report eligibility criteria

In order to answer a research question a systematic literature review was applied. Systematic review of the available literature in a specific area allows for a deepened understanding of the scope of conducted research and establishes research gaps (Xiao, Watson, 2017). It enables formulate research questions and plan future research (Torres-Carrión et al., 2018). Systematic literature review is based on replicable and transparent steps. In compliance with PRISMA procedure, it is required to use study eligibility and report eligibility criteria (Voorberg et al., 2015).

Study eligibility criteria

1) *Type of studies* – The papers should focus on the presence of women on supervisory boards and boards of directors. The composition of corporate management boards has become an attractive research topic in recent years. Managers exert a significant influence on company performance through monitoring and advising. The lack or limited presence of women within these teams is frequently indicated and efforts to increase diversity are proposed (Chow et al., 2023). Articles should include research on the antecedents of women's presence at higher levels of management, especially focused on the reasons for and various factors determining the appearance of women on boards of directors. Many researchers point to differences in men's and women's career paths and their path to promotion to top management positions. Despite similar aspirations and competencies, women encounter numerous organizational and psychological barriers along the way (Taser-Erdogan, 2022). The analysis also included research on barriers to the presence of women on management boards. In contemporary literature, there are studies showing that gender diversity in top management teams affects the financial results of companies (e.g. Opstrup, Villadsen, 2015; Lara et al., 2017; Srivastava et al., 2023) and other dimensions of the company's performance, such as CSR (McGuinness et al., 2017). When boards are comprised of women rather than men, the following effects have been observed: stronger community

bonds, stronger corporate governance, and stronger environmental concerns (Cook, Glass, 2018). Thus scientific articles on the impact of women on the broadly understood performance of the company were also included into analysis.

2) *The type of position held by women* – Current literature offers a wide range of papers investigating women and their career path at various stages of professional development and advancement. Only publications that considered the presence of women in top positions in companies, supervisory boards and boards of directors, were included in the analysis. To search for relevant studies, the following phrases were used: "management", "supervisory", "board of director" and "corporate board".
3) *Study design* – only empirical studies are eligible. The author included all types of research conducted in the field of women at higher levels of management.

Report eligibility criteria

1) *Language* – only English written papers were selected. The choice of the English language allowed for the inclusion in the analysis of works that have been internationally assessed and function in the international scientific circulation (Czakon et al., 2019).
2) *Publication status* – peer-reviewed journals article from well-established publishers form AJG 2020 list with 4*, 3 and 2 ranks were considered.
3) *Year of publication* – literature review was made at the beginning of 2015 so papers published by the end of 2025 March were included.

Clearly defined study and report eligibility criteria are essential to ensure a transparent, systematic, and reproducible literature review process. They minimize selection bias, improve the consistency of study inclusion, and enhance the reliability and credibility of the review findings (Page et al., 2021).

2.2. Search strategy and record selection

At the first stage in a systematic review the authors established the subject of research, i.e. they selected the Scopus database and determined the keywords. The choice of the Scopus database was driven by its advanced capabilities for selecting publications based on criteria such as journal type and the inclusion of publications from the fields of business and management literature. At the same time, the Scopus database provided a sufficient number of publications for analysis. In order to avoid searching for articles from a different scientific field and too many texts not related to the topic, keywords were created in the form of word associations, not individual words (Czakon, 2011). The author chose the following key words. Key words related to research question, namely: "advantages", OR "benefits" OR "factors" AND "company" OR "firm" OR "enterprise" OR "organization" OR "corporation". Key words indicating top-level position are: "management" OR "supervisory" OR "board of director" OR "corporate board". In order for the publications to address the issue of gender equality in

employment, the following keywords were included: “gender” OR “women” OR “inclusion” OR “equality” OR “man” OR “sex”.

The texts were searched by titles, abstracts and keywords. It allows to omit searching anywhere in the text where key words may appear accidentally or accessory (Czakon et al., 2019). The analysis covered publications that were published between January 1, 2015 and the end of March 2025 in peer-reviewed journals in the final stage of publication. Figure 1 shows the number of publications over the years. The growing trend, especially in 2023 and 2024, indicates the growing interest of scholars in the presence of women on management boards.

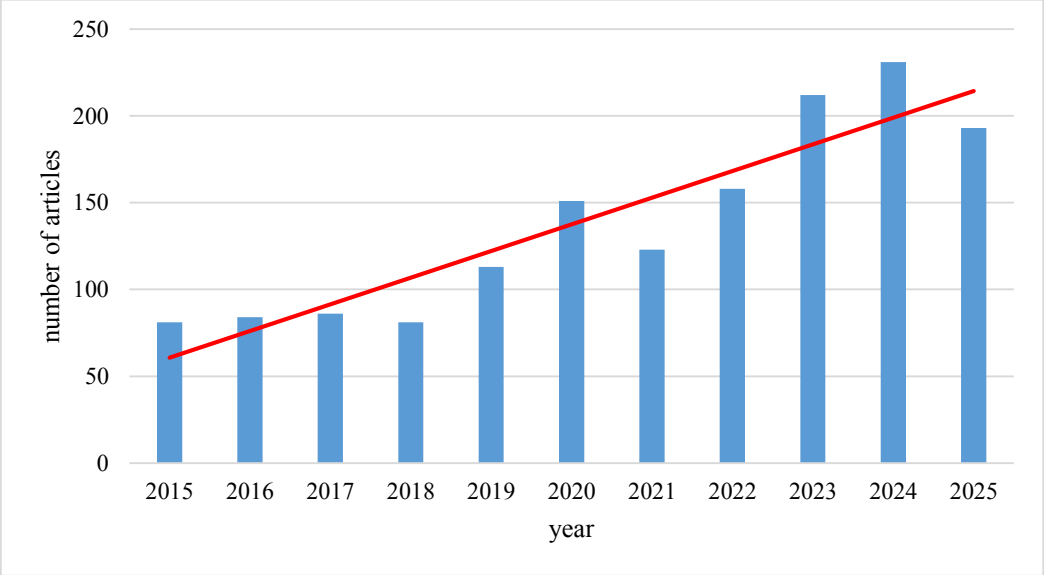


Figure 1. Number of articles published in journals between January 1, 2015 and the end of March 2025.

Next, the search was limited to quality journals within the business and managerial literature fields by use the Chartered Association of Business Schools Academic Journal Guide (ABS journal list) (Akter et al., 2021; Leonidou et al., 2020; Mitrega et al., 2022; Pereira et al., 2021). The author include top tier journal form AJG 2018 list with 4*, 3 and 2 ranks. Finally, 206 papers were obtained from journals such as Strategic Management Science, Management Journal, Business and Society, Corporate Governance: An International Review, European Management Journal. Limiting searches to journals from the ABS ranking ensured a consistently high standard of scientific quality, as the guide evaluates journals using a combination of peer review, citation-based indicators, and expert editorial judgment. This approach increased the credibility and methodological rigor of the literature review (Hiebl, 2023; Tranfield et al., 2003; Mingers, Yang, 2017).

After that, the author analyzed abstracts of gathered articles and according to screening criteria removed all irrelevant papers. Additionally, duplicated papers were also removed. The screening of all articles allows to receive 89 papers. Figure 2 shows the process of searching appropriate research papers.

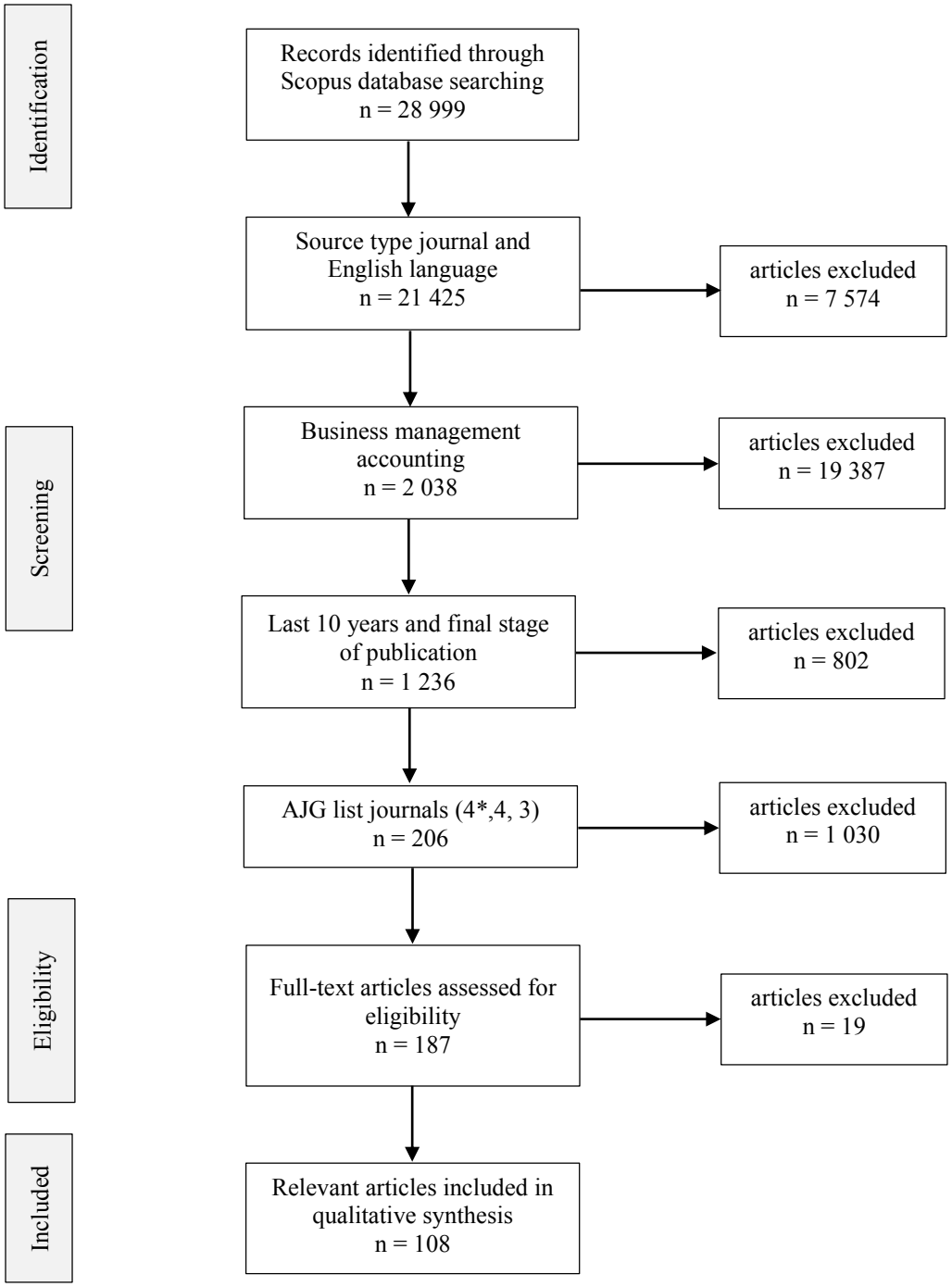


Figure 2. Literature search process.

Source: Based on Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*, *151(4)*.

3. Results of systematic literature review

The present literature review is aimed on organizing and synthetically presenting the result of available research on the presence of women in higher managerial positions. With use of study eligibility and report eligibility criteria the authors identified 108 research papers for analysis. The authors noticed that the studies are not very diverse in terms of methodology (Figure 3).

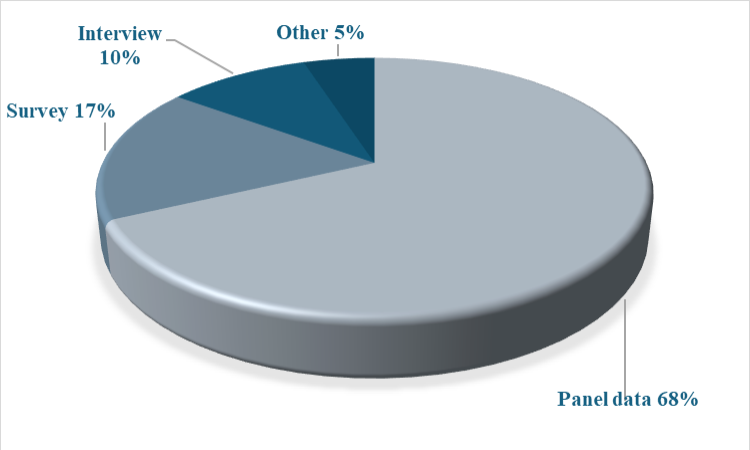


Figure 3. Research method.

The vast majority of papers represent research that examined large numbers of data (68%) collected from different sources for example career histories of the top 10 executives in the largest corporations in the United States identified based on the Fortune 100 companies between 2001 and 2011 (Bonet et al., 2020), information about the companies' CEOs, ownership, firm performance, and other accounting information (Li, Tong, 2023), identifying new director appointments from 2004 to 2018 by using BoardEx data and firm characteristics with use Compustat, Center for Research in Security Prices (CRSP), and Audit Analytics (Cunningham, Ereddia, 2023). Data on the number of women in high positions has been collected and compared with data such as stock returns are obtained from the Center for Research in Security Price (Shan et al., 2017), firm performance and accounting information like profitability, capital structure, and operating efficiency (Lim Tong, 2023) or firm innovations (Foss et al., 2022) and customer orientation (Srivastava, Kashmiri, Mahajan, 2023). Some researchers decided to conduct a survey study (17%), e.g. Bednar, Westphal and McDonald (2022) conducted a longitudinal survey of evaluations of director candidates, Ruiz-Jiménez, Fuentes-Fuentes and Ruiz-Arroyo (2016) include into the study population of SMEs belonging to the sector of Spanish technology-based firms. Less often, scientists use in-depth interviews (10%) as a research method to investigate the presence of women in company boards. For example Cooper, Baird, Foley and Oxenbridge (2021) combined an interviews with key informants who were employed in senior professional roles in investment management industry bodies and businesses, an online survey of women working in specific investment occupations, and long

interviews with women subjects employed as investment management professionals in the roles of investment analyst, portfolio manager, and head of investment functions. Kirsch (2022) conducted 60 interviews with women and men who serve on the supervisory boards of German stock-listed companies. It can also be found other research (5%) such as case studies (e.g. Moura, 2015; Taser-Erdogan, 2022) or quasi-experiment (Wang et al., 2024).

4. Antecedents of presence of women on company board of directors

An analysis of the factors limiting women's participation in the highest decision-making bodies of large companies leads to conclusions that are multidimensional and ambiguous. Despite the belief, well-established in the literature on the subject, that diversity in the composition of corporate bodies, particularly in terms of gender, has positive effects, there are also structural, cultural, and organizational barriers that limit the actual influence of women on decision-making processes and can lead to tensions in the functioning of these bodies.

In practice, women continue to be viewed through the prism of gender stereotypes, which attribute characteristics considered inadequate for decision-making functions to them (Segovia-Pérez et al., 2019, Kroes et al., 2025). Behaviors that could potentially improve the quality of decision-making processes, such as cognitive multi-perspectivity or increased sensitivity to social context and risk, are sometimes interpreted as factors that destabilize the cohesion of company bodies. In this context, it is reasonable to consider whether the established patterns of functioning of bodies with a strongly masculinized structure do not lead to the construction of a specific "organizational norm" against which women's differences are assessed as deviations requiring correction or neutralization (Isidro and Sobral 2015).

An important factor influencing the limited participation of women in corporate bodies remains the structure of nomination processes. The overwhelming predominance of men among those who nominate candidates contributes to the perpetuation of a mechanism that reproduces homogeneous personnel patterns. In the literature, this phenomenon is described in terms of the similarity effect (homophily), which consists in preferring candidates who are perceived as similar in terms of social and cultural characteristics (Gregorič et al., 2017). Although differences between women and men are objective in nature, they should not be used as criteria for assessing competence or determining the ability to perform decision-making functions. In practice, however, they influence selection mechanisms and the level of representation of women in company bodies, reinforcing the existence of informal barriers to promotion, referred to in the literature as the 'glass ceiling' (Ciancetta, Roch, 2021; Ferrary, Déo, 2023).

Informal networks based on shared professional experiences and similar interests also play a significant role, fostering the consolidation of male groups of influence and limiting women's access to key information and decision-making channels (Baker et al., 2019; Clark et al., 2022).

Although this phenomenon is natural at the level of informal relationships, its effects spill over into the sphere of formal personnel procedures (Simon, 2019). This justifies the need for institutional instruments that could limit the influence of non-merit-based factors on the filling of positions in company bodies.

Stereotypical characteristics attributed to women do not have to be negative. The problem arises when they are interpreted as obstacles to effective cooperation within gender-diverse corporate bodies. Cognitive multithreading and a tendency to consider the broader decision-making context can be an asset that improves management quality and reduces strategic risk. From the perspective of capital owners, diversity of experience and analysis promotes more balanced decision-making and strengthens the potential for long-term value creation (Rixom et al., 2023). In this sense, capital owners can be seen as potential beneficiaries of increasing diversity in the composition of corporate bodies.

However, tensions arise in situations where women present positions that differ from those prevailing in decision-making bodies, leading to the need to work out compromise solutions. Such situations are sometimes interpreted as a disruption of the existing decision-making order and as a reduction in the efficiency of the body. As a consequence, attempts may be made to marginalize women by attributing to them attitudes that are confrontational or overly problematizing the decision-making process.

Research also points to differences in the working styles of women and men in corporate bodies. Statistically, women are characterized by a higher level of involvement in the work of bodies, including higher attendance at meetings, and greater preparatory work. This may be due to the pressure of having to constantly prove their competence in a male-dominated environment (Li, Tong, 2023). Paradoxically, however, a different style of functioning, when confronted with established organizational practices, may contribute to the perception of women as disrupting the existing model of the body's operation.

According to the prevailing narrative, women, thanks to the experience they often gain in operational positions in smaller companies, bring practical knowledge about real management problems to corporate bodies. Although empirical observations confirm this thesis, it is sometimes used as an argument against the presence of women in decision-making bodies by presenting them as entities that destabilize established decision-making patterns.

The mechanisms described above contribute to perpetuating the negative image of women as incapable of compromise and effective cooperation within collegial bodies. Women's assertiveness is sometimes interpreted as aggression or inflexibility, while similar behavior in men is considered a trait of effective leadership. In turn, women's withdrawal from active participation in discussions leads to the confirmation of stereotypes about their lesser ability to make decisions. As a result, women function in conditions of permanent tension between the expectation of activity and the pressure of conformity, which can negatively affect both their professional situation and the effectiveness of the entire body.

The introduction of normative solutions aimed at increasing the participation of women in corporate bodies therefore seems necessary, but it is associated with an increased risk of perpetuating the phenomenon of tokenism (Rixom et al., 2023, Gregorič et al., 2017, Isidro, Sobral, 2015). This concept was formulated by Rosabeth Moss Kanter in her work Men and Women of the Corporation (1977). The author described the mechanism of symbolically including representatives of minority groups in organizational structures while denying them any real influence on decision-making processes. According to the author, this phenomenon leads to the isolation of individuals, their excessive visibility, and the perpetuation of stereotypical roles instead of real integration into decision-making processes. In such cases, the dominant entity can create an image of an organization that pursues equality, while the actual decision-making power remains concentrated in the hands of the majority (Elms, Kent, 2024). This mechanism perpetuates the stereotype of women as passive participants in decision-making processes and as persons incapable of taking responsibility for management decisions.

Attempts by women affected by tokenism (Rixom et al., 2023) to counteract this phenomenon can often lead to their complete marginalization or exclusion from the organization on the grounds of an inability to cooperate. As a result, mechanisms that limit the actual implementation of the idea of increasing women's participation in corporate bodies encourage another dangerous phenomenon, namely women giving up further promotion and active decision-making after reaching a certain level in their professional careers. What is more, such women actively participate in creating narratives that normalize existing disparities and recognize them as the result of objective factors, leading to the reproduction of the dominant narrative about the “natural” nature of inequality in access to top decision-making positions.

5. Impact of presence of women on company board of directors on company functioning

Based on a thorough review of the academic literature, gender diversity on corporate boards is identified as a source of multiple organizational benefits. A systematic synthesis of the literature indicates that these benefits can be categorized into eight distinct areas aligned with specific organizational objectives. All these areas are interrelated and sometimes indicate a strong correlation which is manifested by the fact that it is difficult to assign the benefit to one category. All benefit categories (benefit areas) emerged after detailed analysis of individual benefits, and after the creation of a preliminary list of areas. The evidence allows to identify benefits concentrated on eight aspects: governance quality and risk control, Corporate Social Responsibility (CSR), sustainability and ESG outcomes, board decision processes, strategic orientation (long-term balance), transparency and disclosure quality, legitimacy, reputation and stakeholder trust, leadership pipelines and succession, and financial performance. The benefits associated with each area are presented below.

5.1. Governance Quality & Risk Control

First, gender diversity at the highest level of corporate governance is associated with substantial improvements in board processes and overall governance quality. It enhances psychological safety (Tang et al., 2021), counteracts masculinized decision norms (Cooper et al., 2021), and stabilizes governance preferences (Ciancetta, Roch, 2021), thereby reducing strategic myopia (Bednar et al., 2022) and improving the quality of collective decision making (Ho et al., 2015), particularly in complex and high stakes contexts. These process-level mechanisms strengthen board monitoring (Wang et al., 2024), enhance risk awareness (Özbilgin et al., 2016), and strengthen the mitigation of agency problems (Li, Tong, 2023), leading to more effective corporate governance (Cook, Glass, 2018; Srivastava et al., 2023; López-Cabarcos et al., 2023). Additionally, gender diverse boards can deliver added strategic and governance value through diverse managerial resources, especially in complex and dynamic environments (Baker et al., 2019; Rixom et al., 2023).

These process level improvements translate into more effective risk management and better governance of large financial resources (Cooper et al., 2021). Evidence shows that gender diverse boards are associated with higher risk aversion, more conservative financial and accounting profiles (Brenner, 2015), improved budgetary control, and greater financial discipline (Opstrup, Villadsen, 2015), especially under conditions of heightened uncertainty or scrutiny. Such boards demonstrate lower likelihoods of financial misconduct, fewer accounting restatements, reduced fraud related reporting failures (Wahid, 2019), and stronger compliance with regulatory and governance expectations, regardless of baseline governance quality (Özbilgin et al., 2016). Moreover, gender diversity reduces the risk of impression management in sustainability reporting (García-Sánchez et al., 2019), limits unintended knowledge leakage (Raza-Ullah et al., 2023), and enhances governance alignment with global value chains and transnational regulatory frameworks (Özbilgin et al., 2016).

Beyond internal governance outcomes, gender diversity at the board level generates important leadership, legitimacy, and market related benefits. Gender diverse boards are better able to identify hidden biases that undermine governance talent pipelines (Ciancetta, Roch, 2021), reduce perceived bias in CEO appointments, improve the recruitment of female CEOs, and lower severance costs associated with executive hiring (Klein et al., 2021). These effects contribute to higher and more sustainable female representation on boards (Clark et al., 2022) and signal stronger governance support to external stakeholders (Klein et al., 2021). As a result, firms benefit from increased organizational legitimacy (Gregorič et al., 2017), reduced reputational and ESG related downside risk—including perceived sexual misconduct risk—(Gregorič et al., 2017; Billings et al., 2022) and more favorable investor valuation during periods of heightened social and legal uncertainty (Billings et al., 2022), ultimately enhancing formal governance changes that support equality (Kirsch, 2022) and the overall effectiveness of corporate governance (Wahid, 2019).

5.2. CSR, Sustainability & ESG Outcomes

Second, gender diversity on corporate boards is consistently associated with stronger corporate social responsibility (CSR) and sustainability outcomes (Cook, Glass, 2018; McGuinness et al., 2017; Wang et al., 2024; Byron, Post, 2016; Ali, Konrad, 2017; García-Sánchez et al., 2019; Monteiro et al., 2022; Saeed et al., 2022; Isidro, Sobral, 2015; Moreno-Ureba et al., 2022; Valls Martínez et al., 2022; Todorović et al., 2016; López-Cabarcos et al., 2023). Firms with greater female board representation demonstrate higher corporate social performance (Byron, Post, 2016; Cook, Glass, 2018; McGuinness et al., 2017; Monteiro et al., 2022), stronger environmental sustainability, including lower carbon emissions (Valls Martínez et al., 2022; Cook, Glass, 2018), more effective environmental decision-making (Moreno-Ureba et al., 2022), and stronger human rights performance (Monteiro et al., 2022) as well as ethical and social compliance across operations and supply chains (Isidro, Sobral, 2015). Gender-diverse boards also enhance corporate transparency (Wang et al., 2024) by improving the reliability, credibility, and comparability of sustainability disclosures (García-Sánchez et al., 2019; Ali, Konrad, 2017), thereby reducing information asymmetry and impression management (McGuinness et al., 2017). Moreover, such boards tend to produce sustainability reports of higher quality (García-Sánchez et al., 2019). These outcomes generate more favorable social reputations (Byron, Post, 2016), signal credible social and ethical commitment to investors and stakeholders (Monteiro et al., 2022), mitigate negative social reactions and ESG-related downside risk (Saeed et al., 2022), and contribute to broader social development (Todorović et al., 2016; López-Cabarcos et al., 2023), with evidence indicating that CSR effects are more robust and consistent than financial performance effects and strengthen as female representation increases (Cook, Glass, 2018). Eventually, board gender diversity increases environmental innovation, but only conditionally - minimum three female directors on board, and enhances environmental innovation impact – also conditionally: only in highly innovative firms (Moreno-Ureba et al., 2022). Notably, the literature emphasizes that these effects are often stronger and more consistent than those observed for financial performance, while remaining sensitive to institutional and industry contexts.

5.3. Board Decision Processes

Third, gender diversity on corporate boards enhances decision-making processes by improving cognitive balance, informational breadth, and the quality of group dynamics at the highest governance level. Empirical evidence indicates that gender-diverse boards exhibit lower overconfidence and reduced reliance on aggressive strategic behaviors, leading to more disciplined judgment (Cooper et al., 2021), improved capital structure management (Li, Tong, 2023), and higher-quality strategic and financial decisions, particularly in project-based and high-scrutiny contexts (Bednar et al., 2022; Özbilgin et al., 2016; Baker et al., 2019; Wahid, 2019; López-Cabarcos et al., 2023; McGuinness, 2018). Diversity in expertise and perspectives

broadens board deliberations (Bednar et al., 2022; Özbilgin et al., 2016; Gregorič et al., 2017), strengthens evidence-based decision making (Li, Tong, 2023), and improves information processing capacity for complex strategic issues (Heyden et al., 2024), while also reducing interpersonal conflict and dysfunctional boardroom dynamics (López-Cabarcos et al., 2023). These mechanisms facilitate more effective translation of female executive influence into strategy (Srivastava et al., 2023), greater internal decision consistency (Chow et al., 2023), and stronger alignment between leadership values and organizational systems (Ali and Konrad, 2017). Beyond decision quality, gender-diverse boards contribute to organizational learning and the creation of organization-specific, human resource capabilities (Joo et al., 2023) by identifying and correcting systemic feedback bias and supporting bias-aware evaluation and retention systems (Ciancetta, Roch, 2021). Improved board-level governance processes enhance leadership effectiveness, support better-informed hiring and succession decisions (Li, Tong, 2023), and enable more efficient use of women's economic, creative, and entrepreneurial potential (Calinaud et al., 2021; Todorović et al., 2016). Gender diversity further strengthens boards' ability to safeguard sensitive knowledge, preserve competitive advantage, and manage competitively sensitive inter-firm relationships, particularly in knowledge-intensive and high-risk strategic environments (Raza-Ullah et al., 2023). Overall, the literature suggests that gender-diverse boards achieve greater effectiveness in decision making through process improvements rather than automatic performance gains, with outcomes contingent on institutional context, regulatory conditions, and the extent to which diversity is substantively integrated into governance structures (Özbilgin et al., 2016; Byron, Post, 2016; Raza-Ullah et al., 2023).

5.4. Strategic Orientation (Long-Term Balance)

Fourth, the literature documents a positive association between gender diversity on boards and stronger strategic orientation, particularly in terms of long-term balance (Heyden et al., 2024). Notably, gender diversity on corporate boards is associated with higher-quality strategic interaction and a stronger ambidextrous strategic orientation, enabling firms to balance exploration and exploitation more effectively (Tang et al., 2021; Heyden et al., 2024; Ferrary, Déo, 2023). These findings indicate that gender-diverse boards are more likely to adopt ambidextrous strategies that simultaneously pursue exploration and exploitation, thereby improving the firm's ability to manage strategic paradoxes. Evidence further suggests that such boards are better equipped to balance short-term pressures with long-term objectives. However, these effects are frequently conditional upon contextual factors such as board structure, psychological safety, and directors' workload (Heyden et al., 2024; Tang et al., 2021). Additionally, empirical evidence indicates that women directors contribute to improved customer orientation (Srivastava et al., 2023), enhanced execution of business strategy (Ferrary, Déo, 2023), and a shift toward long-term strategic balance rather than short-term bias (Heyden

et al., 2024; Gregorič et al., 2017). When a critical mass of women is present, board gender diversity is further linked to stronger product development (Cook, Glass, 2018), higher innovation and creativity at the organizational level (Özbilgin et al., 2016; Cook, Glass, 2018), and more effective translation of diverse strategic perspectives into firm outcomes, generating economic benefits for minority investors (McGuinness, 2018).

5.5. Transparency & Disclosure Quality

Fifth, gender diversity on corporate boards is related to increased transparency and improved disclosure quality (Wang et al., 2024; García-Sánchez et al., 2019; Monteiro et al., 2022; Wahid, 2019; Ho et al., 2015). In particular, gender diversity on corporate boards is associated with improved financial reporting quality (Wahid, 2019), stronger ethical leadership in reporting (Ho et al., 2015), and more extensive voluntary disclosure to capital markets, i.e. greater likelihood of publication and more frequent publication of management earnings forecasts (MEFs) per year, as well as higher quality of disclosed information, i.e. "greater forecast accuracy, more detailed and disaggregated forecast items, more disclosure of bad news" (Wang et al., 2024). Empirical evidence indicates that the presence of women directors enhances the quality, credibility, and effectiveness of disclosed information - particularly when female directors contribute relevant expertise - and leads to meaningful improvements in transparency even in previously all male boards (Wang et al., 2024). The empirical literature documents that gender-diverse boards engage in more frequent and higher-quality voluntary disclosure, thereby reducing information asymmetry between firms and their stakeholders (Wang et al., 2024).

These effects manifest through more informative and decision useful disclosures (Wang et al., 2024), greater transparency despite increased report length (García-Sánchez et al., 2019), and indirect firm value enhancement resulting from reduced information asymmetry and stronger reporting discipline (Monteiro et al., 2022). Studies exploiting board gender diversity reforms provide causal support for these findings, linking increased female representation to strengthened monitoring reflected in disclosure practices and board activity.

5.6. Legitimacy, Reputation & Stakeholder Trust

Sixth, a substantial body of research highlights legitimacy, reputation, and stakeholder trust as key benefits of gender-diverse boards. These studies emphasize symbolic and institutional effects, showing that gender diversity enhances organizational legitimacy and alignment with societal, institutional, and regulatory expectations (Rixom et al., 2023; Clark et al., 2022). Firms with gender-diverse boards tend to enjoy stronger reputations among investors and regulators and face lower reputational risk (Bednar et al., 2022; Bonet et al., 2020; Özbilgin et al., 2016; Saeed et al., 2022; López-Cabarcos et al., 2023). Importantly, these benefits are documented even in the absence of measurable financial performance gains.

Prior research shows that gender-diverse boards demonstrate a greater consideration of diverse stakeholder interests (Byron and Post, 2016), enhanced understanding of customers and communities (Cooper et al., 2021), and stronger stakeholder orientation and accountability (Monteiro et al., 2022), which translate into improved corporate reputation (Bonet et al., 2020; López-Cabarcos et al., 2023), increased trust among employees, investors, customers, and regulators (Saeed et al., 2022; Özbilgin et al., 2016; López-Cabarcos et al., 2023), and more positive overall firm perceptions (Rixom et al., 2023). The presence of women on boards sends a credible signal of inclusive corporate culture (Billings et al., 2022; Calinaud et al., 2021) and commitment to gender equality (Stainback et al., 2024; Kirsch, 2022; Scheibmayr, Reichel, 2024; Saeed et al., 2022), reducing perceptions of tokenism (Billings et al., 2022; Rixom et al., 2023) and enabling firms to demonstrate diversity in a cost-effective manner without requiring extensive structural change (Bonet et al., 2020).

These symbolic and substantive effects support compliance with institutional pressures (Bonet et al., 2020), gender quota regulations (Clark et al., 2022; Rixom et al., 2023), and broader diversity and equality objectives (Valls Martínez et al., 2022), while reducing reliance on punitive enforcement mechanisms (Clark et al., 2022) and increasing the likelihood of sustained institutional compliance (Gregorič et al., 2017). Gender-diverse boards are also associated with improved access to financial resources (Kalnins, Williams, 2021), enhanced credibility in capital markets (Saeed et al., 2022), stronger customer support (Kalnins, Williams, 2021), and greater acceptance and legitimacy in stakeholder-facing markets (Saeed et al., 2022; Kalnins, Williams, 2021; Valls Martínez et al., 2022). By reducing negative gender stereotypes in resource allocation (Kalnins, Williams, 2021) and improving the perceived legitimacy of executive compensation and promotion systems (Kroes et al., 2025), board gender diversity fosters informal influence, cultural change (Kirsch, 2022; Ali, 2016), and more robust diversity and equality management systems (Ali, Konrad, 2017), ultimately contributing to sustainable competitive advantage (Ferrary, Déo, 2023), enhanced investor protection (Ho et al., 2015), and stronger conformity with global norms, including the UN Sustainable Development Goals (Valls Martínez et al., 2022; Saeed et al., 2022; Gregorič et al., 2017; Chow et al., 2023).

5.7. Leadership pipelines & Succession

Seventh, gender diversity at the board level supports the development of stronger leadership pipelines and governance continuity (Stainback et al., 2024; Ciancetta, Roch, 2021; Klein et al., 2021; Kalnins, Williams, 2021; Bonet et al., 2020; Kirsch, 2022; Özbilgin et al., 2016; Ali, Konrad, 2017; Scheibmayr, Reichel, 2024; Kroes et al., 2025; Baker et al., 2019; Calinaud et al., 2021). In particularly, gender diversity on corporate boards is associated with stronger leadership pipelines and more effective succession processes by expanding access to highly qualified executive talent (Bonet et al., 2020; Özbilgin et al., 2016; Kroes et al., 2025; Baker et al., 2019) and reducing gender inequality within internal promotion systems (Stainback

et al., 2024). Empirical evidence indicates that female board representation increases the presence of women in top management teams (Stainback et al., 2024; Kirsch, 2022), improves retention (Calinaud et al., 2021) and development of leadership capabilities (Ciancetta, Roch, 2021), and mitigates exclusionary dynamics that limit board and executive access, particularly in female dominated functions or contexts of skill shortages (Scheibmayr, Reichel, 2024). These effects generate trickle down benefits for organizational equality (Kirsch, 2022), enhance the effectiveness of diversity initiatives throughout the firm (Ali, Konrad, 2017), and provide access to role models and mentors (Calinaud et al., 2021), thereby strengthening long term talent sustainability (Stainback et al., 2024), improving CEO succession outcomes under distress (Klein et al., 2021), and contributing to greater firm survival (Kalnins, Williams, 2021).

An important point to note is that "these benefits do not automatically occur just because women are present on boards" (Kirsch, 2022). The realization of benefits depends on a range of contextual factors (i.e., female directors' gender identity salience, board culture supportive of gender equality, expectations from other board and organizational members, director experience) (Kirsch, 2022).

5.8. Financial performance

Finally, the literature indicates that gender diversity in corporate boards and top management is associated with more stable and reliable financial performance outcomes (Cooper et al., 2021), higher operating efficiency (Opstrup, Villadsen, 2015), and improved profitability, including higher ROA, ROS, EBITDA, and operating results, particularly in project based and human capital intensive contexts (Joo et al., 2023; Opstrup, Villadsen, 2015; Ali, 2016; Li, Tong, 2023; Yanadori et al., 2021; Ali, Konrad, 2017; Ferrary, Déo, 2023; Baker et al., 2019; Isidro, Sobral, 2015; Kroes et al., 2025). Notably, the evidence on financial and market performance effects is explicitly conditional. While some studies report positive financial or market reactions to board gender diversity (i.e., Lyngsie, Foss, 2017; Todorović et al., 2016), such effects arise only under specific conditions. These findings indicate that positive financial effects are frequently indirect and conditional, arising through improved implementation of high performance work systems (Joo et al., 2023), stronger customer orientation (Srivastava et al., 2023), enhanced knowledge protection (Raza-Ullah et al., 2023), better labor practices (Monteiro et al., 2022), and more effective utilization of female leadership talent, especially under conditions of strong human capital and resource access (Devine et al., 2019). Evidence further suggests that gender diversity strengthens long term growth outcomes - such as post IPO earnings resilience, firm survival, and value creation - while performance effects tend to be neutral in non project based or weakly enabling institutional environments (McGuinness, 2018; Baker et al., 2019). Overall, the diversity-performance relationship is best understood as contingent rather than universal, with financial gains materializing when gender diversity is substantively integrated into governance, strategy execution, and organizational systems.

To summarize, the reviewed studies demonstrate that gender diversity in corporate boards delivers robust benefits in the areas of governance quality, risk control, CSR, sustainability, strategic decision-making, strategic orientation, transparency, disclosure quality, legitimacy, reputation, stakeholder trust, leadership pipelines, succession and financial performance. Direct financial performance gains are neither universal nor automatic and materialize only under clearly specified conditions. The most consistent and theoretically grounded benefits lie in governance quality, risk control, improved board processes and stakeholder-oriented outcomes rather than in immediate profit maximization.

6. Future research

With the spread of the concepts of corporate social responsibility (CSR) and sustainable development (SD), the issue of women's presence in prominent management positions on company boards is increasingly occurring in research and public discourse. Numerous publications emphasize that this phenomenon is characterized by a growing trend, even though it remains relatively little dynamic in many organizations and countries. The authors analyze the factors contributing to women's advancement in the corporate hierarchy and assess the potential benefits of this advancement.

The analysis of the articles selected for this systematic literature review allows for identifying directions for further research on this topic. Considering general suggestions, the authors most often propose replicating their own or similar studies:

- considering the long-term horizon (Ali, Konrad, 2017; Fernando, 2020; Halliday et al., 2022; Kirch, 2022; Axelsdóttir et al., 2023; Stainback et al., 2024),
- in other cultural contexts (Ali, Konrad, 2017; Devine et al., 2019; Nair, 2020; Fernando et al., 2020; Attah-Boakye et al., 2020; Ogundana et al., 2021; Tang et al., 2021; Kalnins, Williams, 2021; Valls Martínez et al., 2022; Taser-Erdogan, 2022; Cunningham, Ereddia, 2023; Srivastava et al., 2023),
- in other sectors/industries/fields (Buil-Fabr et al., 2017; Devine et al., 2019; Attah-Boakye et al., 2020; Bonet et al., 2020; Kalnins, Williams, 2021; Halliday et al., 2022),
- in organizations of varied sizes (Tang et al., 2021).

Considering more detailed recommendations for future research trends, several proposals can be indicated. Management mechanisms related to internal factors within an organization are found among most frequently mentioned. Paoloni et al., (2023) suggest that future research should focus on the broadly understood internal mechanisms through which gender diversity influences knowledge sharing. Women in managerial positions play a significant role in these mechanisms. Therefore, Kirch (2022) proposes initiating research on the role of female directors in promoting gender equality in organizations. Halliday et al., (2022) suggest that

future research should assess carefully and on a long-term basis the percentage of men and women in work teams to confirm how male-dominated a given role may be in a given organization. In turn, Hurst et al., (2024) propose that future research directions related to women in management positions should go beyond the analysis of formal organizational structures and be linked to work organization (e.g., remote work), human resource management strategies, the use of the flutter principle (which could alleviate women's underrepresentation), and retention (whether flat hierarchy is more or less likely to retain employees, especially women, than higher ones). Future research on these issues would explain the extent to which lower hierarchies increase or decrease gender diversity in the workplace.

The share of women in senior management positions depends on the pace of promotion to these positions. Therefore, Bonet et al., (2020) and Ali and Konrad (2017) suggest that future research should explore this issue, with special attention to managerial attributes such as personality, leadership traits, and applied leadership practices, which may be correlated with gender.

The same authors, along with López-Cabarcos et al., (2023), propose that future research should analyze the stages of the selection process and examine the impact of individual manager characteristics, considering gender differences in the nomination process. Examining the impact of algorithmic HRM (AI in people management) on professionalization is another challenge. Research questions might concern the fact whether the automation of HR decisions will strengthen the "technocratic" (often associated with masculinity) side of the profession or whether it will create new, more gender-neutral paths to professionalization.

Linking gender with professionalism and managerial skills, which, according to their findings, are most often associated with the male gender is a prominent issue raised by many authors (Buil-Fabr et al., 2017; Fernando, 2020; Scheibmayr, Reichel, 2024). The gender composition in a given profession matters; that is, female-dominated professions typically encounter greater resistance to achieving "professional" status compared to their male counterparts. The authors suggest that future research should consider how gender interacts with other social categories, such as race, age, and ethnicity, and how these cumulative identities influence the benefits of professionalization and the chances of promotion to management.

The analyzed publications address the issue of inequality, not only in terms of assessing the professionalism of women in management positions compared to men, but also in terms of pay. Yanadori et al., (2021) state that the pay gap, often reflecting women's lower status, reduces their ability to contribute to organizational performance, likely by reducing motivation or signaling unequal value. These results, supported by social exchange theory, indicate that pay equality is not merely a social issue but a direct factor influencing organizational productivity. In practice, this means that companies "pay the penalty" of lower productivity for maintaining gender pay gaps in top management teams (TMTs). The authors propose that future research

on pay inequality in management teams should focus on the impact of new legal regulations and deeper psychological and structural mechanisms.

The financial issues of companies led by women are an interesting topic that provides suggestions for future research (Fernando et al., 2020). Li and Tong (2023) as well as Lyngsie and Foss (2017) highlight the relationship between female CEOs and company financial performance. In their publications, they suggest that future studies should assess the impact of women in managerial positions on improving organizational performance and determine the mechanisms behind this phenomenon. Gracia Lara et al., (2017) propose that future research should address the dilemma of whether achieving the required statutory threshold of female management translates into better accounting quality, or it ends with the formal fulfilment of the requirements. Ho et al. (2015) suggest that future research on women's representation on company boards should assess their conservative attitudes regarding financial matters and the risk of the companies they manage. Earnings management and the presentation and interpretation of various financial indicators are important aspects of a company's operations, which are assessed by investors, creditors, analysts, and auditors, among others. The issue of conservative attitudes toward female entrepreneurs also arises in the context of potential creditors and concerns their ability to obtain capital for running and developing their businesses. Many authors (Kalnins, Williams, 2021; Ketchum, 2022; Brush, Elma, 2024) propose further research on the challenges faced by female entrepreneurs when attempting to obtain capital from banks and venture capitalists.

Several authors (Lyngsie, Foss, 2017; Valls Martínez et al., 2022; Kim, McNeil, 2023; Mallidis et al., 2024) link the presence of women on company boards with the implementation of ESG standards. They believe that further research should include an in-depth analysis of the impact of gender diversity on boards on overall ESG performance and on specific areas, such as environmental, social, and governance (ESG). They also emphasize that future studies on women's participation on boards should consider the impact of such factors as the activities of sustainability and digital transformation committees. Opstrup and Villadsen (2015) propose similar research trends, but for public sector organizations. In their opinion, examining diversity in teams is a good starting point for such research. Organizations utilize a rational approach to recruiting managers with diverse characteristics, therefore factors such as administrative structure and strategy, as well as environmental requirements, will be related to the degree of top management team diversity that public organizations strive for. Attah-Boakye et al. (2020) propose continuing the discussion on the impact of gender diversity on corporate boards on environmentally sustainable innovation, while Moreno-Ureba et al. (2022) suggest that future research should focus on assessing the impact of female directors on environmental innovation and more diverse methodologies for measuring the quality and type of such innovation. Additionally, Byron and Post (2016) encourage to start research to determine whether more socially responsible companies are more likely to appoint women to managerial positions and whether nominated women are more likely to join socially responsible companies.

Currently, increasing the participation of women in managerial positions often requires external intervention. Bednar et al. (2022) propose examining the multi-level and multi-faceted factors that drive or hinder increased diversity in organizational management and leadership. This could concern the impact of, for example, social movements, which can evoke feelings of threat and anxiety in people in management positions. In their view, research combining macrosocial forces, such as social movements, and psychological processes (such as intergroup anxiety) is a promising approach to integrating sociological and psychological theories, thus contributing to a better understanding of important phenomena in strategic management.

A factor with a significant impact on the presence of women in prominent managerial positions, and the one worth continuing in the research, includes changing gender norms (Srivastava et al., 2023), legal regulations, and solutions addressing bias (Chow et al., 2023; Brush, Elma, 2024). Ali and Konrad (2017) propose further research on how Equal Employment Opportunity (EEO) affects diversity management. According to Stainback et al., (2024), future analyses should aim to identify specific policies and practices that support women early in their managerial careers, as they are crucial. The role of professional associations as actors shaping gender equality should also be examined. It is interesting to see how certification programs and codes of ethics can actively counteract the "glass ceiling" barriers, rather than unconsciously promote male career patterns.

Todorović et al. (2016) and Nair (2020) promote the study of entrepreneurial ecosystems, i.e., the dynamic systems of social, economic, cultural, and political factors that support the development of women-managed businesses, in future studies. This is particularly justified given the promotion of work-life balance and the implementation of programs that connect these two spheres in women's lives (Ali, Konrad, 2017; Devine et al., 2019; Ogundana et al., 2021). In their publication, Klarsfeld et al., (2024) argue that in egalitarian regimes (Nordic countries), shared norms and institutional support help equalize the division of household responsibilities, reducing the disproportionately large stress faced by working women. However, in inegalitarian regimes, work often increases women's "double burden", leading to higher levels of stress related to the conflict between family and work responsibilities, emotional exhaustion, and organizational isolation. Future research should examine the long-term consequences of working (including teleworking) in various welfare systems and analyze how work culture and gender norms influence inequality.

It could be argued that the proposals presented here are supplemented by the publication by Foss et al., (2022). The authors suggest that future research should also consider the side effects that may arise from the interaction of women's and men's behaviors in management teams. The results of such studies could help companies and policymakers develop strategies for a more gender-balanced boardroom.

It is clear that there is still a lively debate about whether gender diversity reforms in boardrooms should be implemented. This debate is primarily driven by the inconclusive evidence regarding the effectiveness and importance of gender diversity. Therefore, based on

the analysis of the publications included in this systematic literature review, future researchers can expand their research to include the numerous themes presented in this section.

7. Discussion

The present paper contributes to the theory of management and organizational behavior. Unlike earlier reviews, which primarily focused on selected outcomes of board gender diversity such as financial performance or corporate social responsibility (Post, Byron, 2015; Byron, Post, 2016; Kirsch, 2018), the present review provides an integrated perspective by simultaneously examining the antecedents of women's representation, its organizational consequences, and directions for future research. It provides knowledge about antecedents of presence of women on company boards of directors and in the highest company positions.

The findings indicate that women's presence on company boards is shaped by structural, cultural, and organizational factors. These findings are consistent with previous literature emphasizing that barriers to women's advancement are deeply embedded in organizational structures and institutional norms rather than resulting solely from individual career choices (Kirsch, 2018; Ibarra et al., 2013). Despite the positive effects of gender diversity, entrenched gender stereotypes, masculinized organizational norms, and homophilous nomination processes continue to reproduce male-dominated board structures and reinforce informal barriers such as the glass ceiling. Informal networks and selection mechanisms limit women's access to key decision-making channels, while their distinct working styles—often characterized by higher engagement, multidimensional thinking, and greater sensitivity to risk—are sometimes misinterpreted as disruptive rather than value-enhancing. Although normative interventions (e.g., quotas) may increase numerical representation, they risk fostering tokenism, where women's presence is symbolic rather than substantive. As a result, women frequently operate under tension between expectations of assertiveness and pressures to conform, which can lead to marginalization, self-limitation in career progression, and the reproduction of narratives that normalize inequality at the highest levels of corporate governance.

The presented study offers a multidimensional, evidence-based understanding of the organizational consequences of women's presence at the highest levels of corporate governance. While previous review papers have predominantly examined individual organizational outcomes, particularly financial performance and CSR (Post, Byron, 2015; Byron, Post, 2016), the present synthesis demonstrates that the benefits of female board representation extend across multiple dimensions of organizational functioning. According to the reviewed literature, these benefits can be categorized into eight distinct areas: governance quality and risk control, Corporate Social Responsibility (CSR), sustainability and ESG outcomes, board decision-making processes, long-term strategic orientation, transparency and

disclosure quality, legitimacy and stakeholder trust, leadership pipelines and succession, and financial performance.

The literature consistently shows that the presence of women on corporate boards positively influences key aspects of governance and decision-making. Gender-diverse boards demonstrate stronger monitoring, higher governance quality, improved risk control, and greater financial discipline. They are associated with reduced managerial overconfidence, lower likelihood of misconduct, higher-quality financial and sustainability reporting, and enhanced transparency. Women's participation broadens cognitive perspectives in board deliberations, improves the quality of strategic decisions, and supports more balanced long-term strategic orientation. These conclusions reinforce earlier evidence suggesting that the strongest effects of board gender diversity are observed in governance quality and board processes rather than in direct financial outcomes (Kirsch, 2018; Byron, Post, 2016). In particular, gender diversity strengthens CSR and ESG performance, enhances environmental and social responsibility, and increases the credibility of corporate disclosures. Beyond internal governance effects, female representation contributes to greater organizational legitimacy, stronger stakeholder trust, and improved corporate reputation. Gender-diverse boards also support leadership development and succession by expanding talent pipelines and increasing the representation of women in executive positions. Although positive financial effects—including higher profitability, efficiency, and long-term resilience—are documented, the present review confirms previous meta-analytic evidence that these relationships remain conditional and context-dependent rather than universal (Post & Byron, 2015). Overall, the most robust and consistent benefits of women's representation relate to governance quality, strategic balance, stakeholder alignment, and sustainable long-term value creation rather than immediate financial gains.

The presented analysis also provides important implications for practice. The findings provide guidance for companies, policymakers, and regulators by identifying both the drivers and barriers affecting women's advancement to senior leadership positions. Importantly, the review suggests that increasing female representation should not be viewed solely as a diversity objective but as a governance mechanism capable of improving organizational effectiveness. The synthesized evidence may support the design of more effective diversity initiatives, transparent nomination procedures, and leadership development programs. Furthermore, the findings demonstrate how women's participation in boards and senior management contributes to better governance processes, stronger stakeholder relationships, and more sustainable long-term organizational performance.

The analysis of the literature allowed for the systematization and summary of the directions of future research indicated by the scientists. Future research should explore the long-term and context-dependent effects of women's presence in boards and senior management across different cultural, sectoral, and organizational settings. Key areas include internal governance mechanisms, decision-making processes, promotion and succession dynamics, the role of

leadership traits, pay equality, and the impact of algorithmic HRM. Studies should also examine intersections of gender with other social categories, CSR and ESG outcomes, financial performance, and work–life balance, as well as the influence of legal, institutional, and cultural factors. Overall, future research should adopt multilevel, interdisciplinary approaches to understand when and how gender diversity generates meaningful organizational value.

Similar to most scientific studies, presented literature research has also a few limitations. The publication search procedure presented in this paper uses only the Scopus database. The Scopus database allows for reliable identification of publications that meet the established requirements. In the future, the literature review could be expanded on additional databases. Second, the use of ABS list as criterion could cause that some publications in journals were omitted. Future research can be expanded with other journals.

8. Summary

The present paper represents the results of systematic literature review aimed on organizing and synthetically presenting the current research on the presence of women in higher managerial positions, with particular emphasis on barriers to promotion, organizational conditions and potential positive consequences for the functioning of the organization. In addition, conducted literature review allow to indicate potential directions for further research on women in managerial positions.

The analysis covered publications that were published between January 1, 2015 and the end of March 2025 in peer-reviewed journals in the final stage of publication. The growing trend, especially in 2023 and 2024, indicates the growing interest of scholars in the presence of women on management boards. With use of study eligibility and report eligibility criteria the authors identified 108 research papers for analysis. The vast majority of papers represent research that examines large numbers of data collected from different sources for example career histories of the top executives in the large corporations, information about the companies' CEOs, new director appointments, ownership, firm performance, and accounting information like capital structure, operating efficiency, firm innovation.

The conducted literature analysis indicates the following antecedents of presence of women on company board of directors and higher management positions: gender stereotypes, structure of nomination processes, informal networks, size of company, image of women as manager, normative solutions. According to current literature the benefits of presence of women on company board of directors can be categorized into eight distinct areas aligned with specific organizational objectives, namely: governance quality and risk control, Corporate Social Responsibility (CSR), sustainability and ESG outcomes, board decision processes, strategic

orientation (long-term balance), transparency and disclosure quality, legitimacy, reputation and stakeholder trust, leadership pipelines and succession, and financial performance.

Presented research allow to identified future research directions. It is most frequently recommended to examine the long-term, context-dependent effects of women's representation in boards and senior management, focusing on governance processes, decision-making, leadership dynamics, CSR/ESG outcomes, promotion and succession, and the interaction of gender with institutional, cultural, and organizational factors.

References

1. Akter, S., Hossain, M.A., Lu, Q.S., Shams, S.R. (2021). Big data-driven strategic orientation in international marketing. *International Marketing Review*, *38(5),* 927-947.
2. Ali, M. (2016). Impact of gender-focused human resource management on performance: The mediating effects of gender diversity. *Australian Journal of Management*, *41(2),* 376-397.
3. Ali, M., Konrad, A.M. (2017). Antecedents and consequences of diversity and equality management systems: The importance of gender diversity in the TMT and lower to middle management. *European Management Journal*, *35(4),* 440-453.
4. Attah-Boakye, R., Adams, K., Kimani, D., Ullah, S. (2020). The impact of board gender diversity and national culture on corporate innovation: A multi-country analysis of multinational corporations operating in emerging economies. *Technological Forecasting and Social Change*, *161(C).*
5. Axelsdóttir, L., Einarsdóttir, Þ.J., Rafnsdóttir, G.L. (2023). Justice and utility: Approval of gender quotas to increase gender balance in top-level managements—lessons from Iceland. *Gender, Work and Organization*, *30(4),* 1218-1235.
6. Baker, M., Ali, M., French, E. (2019). The impact of women's representation on performance in project-based and non-project-based organizations. *International Journal of Project Management*, *37(7),* 872-883.
7. Bednar, M.K., Westphal, J.D., McDonald, M.L. (2022). Birds of a feather flock (even more) together: An intergroup relations perspective on how#MeToo- related media coverage affects the evaluation of prospective corporate directors. *Strategic Management Journal*, *43(11),* 2313-2350.
8. Billings, M.B., Klein, A., Shi, Y.C. (2022). Investors' response to the #MeToo movement: Does corporate culture matter? *Review of Accounting Studies, 27(3),* 897-937.
9. Bonesso, S., Cortellazzo, L. (2024). A journey into women's managerial career development through the social cognitive career lens. *European Management Journal*.

10. Bonet, R., Cappelli, P., Hamori, M. (2020). Gender differences in speed of advancement: An empirical examination of top executives in the Fortune 100 firms. *Strategic Management Journal*, *41(4),* 708-737.
11. Brenner, S. (2015). The risk preferences of U.S. executives. *Management Science*, *61(6),* 1344-1361.
12. Brush, C.G., Elam, A.B. (2024). Clearing the hurdles: Revisiting the under-performance hypothesis for women-led VC funded firms. *Journal of Small Business Management*, *Taylor & Francis Journals, 62(5),* 2287-2321.
13. Buil-Fabregà, M., Alonso-Almeida, M.D.M., Bagur-Femenías, L. (2017). Individual dynamic managerial capabilities: influence over environmental and social commitment under a gender perspective. *Journal of Cleaner Production*, *151(10),* 371-379.
14. Byron, K., Post, C. (2016). Women on Boards of Directors and Corporate Social Performance: A Meta-Analysis. *Corporate Governance: An International Review*, *24(4),* 428-442.
15. Calinaud, V., Kokkranikal, J., Gebbels, M. (2021). Career Advancement for Women in the British Hospitality Industry: The Enabling Factors. *Work, Employment and Society*, *35(4),* British Sociological Association, 677-695.
16. Chow, D.Y.L., Petrou, A.P., Procopiou, A. (2023). Gender salience and recategorization of new directors: The role of political ideology. *Journal of Management*, *49(8),* 2695-2726.
17. Ciancetta, L.M., Roch, S.G. (2021). Backlash in performance feedback: Deepening the understanding of the role of gender in performance appraisal. *Human Resource Management*, *60(4),* 641-657.
18. Clark, C.E., Arora, P., Gabaldon, P. (2022). Female Representation on Corporate Boards in Europe: The Interplay of Organizational Social Consciousness and Institutions. *Journal of Business Ethics, 180*, 165-186.
19. Cook, A., Glass, C. (2018). Women on corporate boards: Do they advance corporate social responsibility? *Human relations*, *71(7),* 897-924.
20. Cooper, R., Baird, M., Foley, M., Oxenbridge, S. (2021). Normative collusion in the industry ecosystem: Explaining women's career pathways and outcomes in investment management. *Human Relations*, *74(11),* 1916-1941.
21. Cumming, D., Leung, T.Y. (2021). Board diversity and corporate innovation: Regional demographics and industry context. *Corporate Governance: An International Review*, *29(3),* 277-296.
22. Cunningham, L.M., Ereddia, L.E. (2023). Attracting Female Directors in the United States: The Roles of Boards, Executives, and Other Stakeholders. *Journal of International Accounting Research*, *22(2),* 57-81.
23. Czakon, W. (2011). Metodyka systematycznego przeglądu literatury. *Przegląd Organizacji*, *3,* 57-61.
24. Czakon, W., Klimas, P., Kawa, A. (2019). Krótkowzroczność strategiczna: metodyczne aspekty systematycznego przeglądu literatury. *Studia Oeconomica Posnaniensia, 7(2).*

25. Devine, R.A., Molina-Sieiro, G., Holmes, R.M., Jr., Terjesen, S.A. (2019). Female-Led High-Growth: Examining the Role of Human and Financial Resource Management. *Journal of Small Business Management*, *57(1),* 81-109.
26. Elms, N., Kent, P.F. (2024). Nomination committees in Australia, outcomes for influence of a powerful CEO and diversity. *Journal of Accounting Literature*, *46(4),* 481-509.
27. Fernando, G.D., Jain, S.S., Tripathy, A. (2020). This cloud has a silver lining: Gender diversity, managerial ability, and firm performance. *Journal of Business Research*, *117(C),* 484-496.
28. Ferrary, M., Déo, S. (2023). Gender diversity and firm performance: when diversity at middle management and staff levels matter. *The International Journal of Human Resource Management*, *34(14),* 2797-2831.
29. Fortune 500 (2024). *The share of Fortune 500 companies run by women CEOs stays flat at 10.4% as pace of change stalls*.
30. Foss, N., Lee, P.M., Murtinu, S., Scalera, V.G. (2022). The XX factor: Female managers and innovation in a cross-country setting. *The Leadership Quarterly*, *33(3),* 101537.
31. Gallego-Álvarez, I., PuchetaMartínez, M.C. (2020). Environmental strategy in the global banking industry within the varieties of capitalism approach: The moderating role of gender diversity and board members with specific skills. *Business Strategy and the Environment*, *29(2),* 347-360.
32. García Lara, J.M., García Osma, B., Mora, A., Scapin, M. (2017). The monitoring role of female directors over accounting quality. *Journal of Corporate Finance*, *45(C),* 651-668.
33. GarcíaSánchez, I.-M., Suárez-Fernández, O., Martínez-Ferrero, J. (2019). Female directors and impression management in sustainability reporting. *International Business Review*, *28(2),* 359-374.
34. Gregorič, A., Oxelheim, L., Randøy, T., Thomsen, S. (2017). Resistance to change in the corporate elite: Female directors' appointments onto Nordic boards. *Journal of Business Ethics*, *141(2),* 267-287.
35. Griffin, D., Li, K., Xu, T. (2021). Board gender diversity and corporate innovation: International evidence. *Journal of Financial and Quantitative Analysis*, *56(1),* 123-154.
36. Halliday, C.S., Paustian-Underdahl, S.C., Stride, C., Zhang, H. (2022). Retaining Women in Male-Dominated Occupations across Cultures: The Role of Supervisor Support and Psychological Safety. *Human Performance*, *35(3-4),* 156-177.
37. Heyden, M.L.M., Fourné, S.P.L., Matthews, L., Wilden, R., Tarkovska, V. (2024). Too busy to balance? A longitudinal analysis of board of director busyness and firms' ambidextrous orientation. *Industrial and Corporate Change*, *33(6),* 1532-1561.
38. Hiebl, M.R. (2023). Sample selection in systematic literature reviews of management research. *Organizational research methods*, *26(2),* 229-261.
39. Ho, S.S.M., Li, A.Y., Tam, K., Zhang, F. (2015). CEO Gender, Ethical Leadership, and Accounting Conservatism. *Journal of Business Ethics*, *127(2),* 351-370.

40. Hurst, R., Lee, S., Frake, J. (2024). The effect of flatter hierarchy on applicant pool gender diversity: Evidence from experiments. *Strategic Management Journal*, *45(8),* 1446-1484.
41. Ibarra, H., Ely, R., Kolb, D. (2013). Women rising: The unseen barriers. *Harvard business review*, *91(9),* 60-66.
42. Isidro, H., Sobral, M. (2015). The effects of women on corporate boards on firm value, financial performance, and ethical and social compliance. *Journal of business ethics*, *132(1),* 1-19.
43. Islam, R., French, E., Ali, M. (2022). Evaluating board diversity and its importance in the environmental and social performance of organizations. *Corporate Social Responsibility and Environmental Management*, *29(5),* 1134-1145.
44. Joecks, J., Pull, K., Scharfenkamp, K. (2023). Women directors and firm innovation: The role of women directors' representative function. *Managerial and Decision Economics*, *44(2),* 1203-1214.
45. Joo, M.-K., Lee, J.-Y., Kong, D.T., Jolly, P.M. (2023). Gender diversity advantage at middle management: Implications for high performance work system improvement and organizational performance. *Human Resource Management*, *62(5),* 765-785.
46. Kalnins, A., Williams, M. (2021). The geography of female small business survivorship: Examining the roles of proportional representation and stakeholders. *Strategic Management Journal*, *42(7),* 1247-1274.
47. Ketchum, A.D. (2022). Cooking the books: Feminist restaurant owners' relationships with banks, loans and taxes. *Business History, Taylor & Francis Journals*, *64(1),* 1-27.
48. Kim, I., McNeil, B. (2023). Stock price implications of DEI initiatives when liberties of vulnerable groups are politically undermined—Evidence from veterans and LGBT groups. *Journal of Business Research*, *166*, 1-12.
49. Kirsch, A. (2018). The gender composition of corporate boards: A review and research agenda. *The Leadership Quarterly*, *29(2),* 346-364.
50. Kirsch, A. (2022). Revolution from above? Female directors' equality-related actions in organizations. *Business & Society*, *61(3),* 572-605.
51. Klarsfeld, A., Carillo, K., Cachat-Rosset, G., Saba, T., Marsan, J. (2024). Does the welfare regime impact the telework gender stress gap? *New Technology, Work and Employment*, *38(1),* 168-195.
52. Klein, F.B., Chaigneau, P., Devers, C.E. (2021). CEO gender-based termination concerns: Evidence from initial severance agreements. *Journal of Management*, *47(3),* 567-596.
53. Kroes, J., Land, A., Manikas, A.S., Klein, F. (2025). Gender diversity and injustice among supply chain executives: exploring outcomes that advance social justice. *International Journal of Operations & Production Management*, *45(3),* 677-699.
54. Lara, J.M.G., Osma, B.G., Mora, A., Scapin, M. (2017). The monitoring role of female directors over accounting quality. *Journal of Corporate Finance*, *45*, 651-668.

55. Leonidou, E., Christofi, M., Vrontis, D., Thrassou, A. (2020). An integrative framework of stakeholder engagement for innovation management and entrepreneurship development. *Journal of Business Research*, *119(April),* 245-258.
56. Li, H., Tong, X. (2023). When does a female leadership advantage exist? Evidence from SOEs in China. *Corporate Governance: An International Review, 31(6),* 945-970.
57. López-Cabarcos, M.Á., Vizcaíno-González, M., López-Pérez, M.L. (2023). Gender diversity on boards: Determinants that underlie the proposals for female directors. *Technological Forecasting and Social Change*, *190*, 122417.
58. Lyngsie, J., Foss, N.J. (2017). The more, the merrier? Women in top-management teams and entrepreneurship in established firms. *Strategic Management Journal, 38(3),* 487-505.
59. Mallidis, I., Giannarakis, G., Sariannidis, N. (2024). Impact of board gender diversity on environmental, social, and ESG controversies performance: The moderating role of United Nations Global Compact and ISO. *Journal of Cleaner Production*, *444*, 3.
60. McGuinness, P.B. (2018). IPO firm performance and its link with board officer gender, family‐ties and other demographics. *Journal of Business Ethics*, *152*, 499-521.
61. McGuinness, P.B., Vieito, J.P., Wang, M. (2017). The role of board gender and foreign ownership in the CSR performance of Chinese listed firms. *Journal of Corporate Finance*, *42*, 75-99.
62. Mingers, J., Yang, L. (2017). Evaluating journal quality: A review of journal citation indicators and ranking in business and management. *European journal of operational research, 257(1),* 323-337.
63. Mitrega, M., Klézl, V., Spáčil, V. (2022). Systematic review on customer citizenship behavior: Clarifying the domain and future research agenda. *Journal of Business Research*, *140*, 25-39.
64. Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*, *151(4).*
65. Moreno-Ureba, E., Bravo-Urquiza, F., Reguera-Alvarado, N. (2022). An analysis of the influence of female directors on environmental innovation: When are women greener? *Journal of Cleaner Production*, *374(2),* 133871.
66. Moura, S. (2015). Try it at home: Avon and gender in Brazil, 1958-1975. *Business History*, *57(6),* 800-821.
67. Nair, S.R. (2020). The link between women entrepreneurship, innovation and stakeholder engagement: A review. *Journal of Business Research*, *119(C),* 28-–290.
68. Ogundana, O.M., Simba, A., Dana, L.-P., Liguori, E. (2021). Women entrepreneurship in developing economies: A gender-based growth model. *Journal of Small Business Management, Taylor & Francis Journals*, *59(S1),* 42-72.
69. Opstrup, N., Villadsen, A.R. (2015). The right mix? Gender diversity in top management teams and financial performance. *Public Administration Review*, *75(2),* 291-301.

70. Özbilgin, M., Tatli, A., Ipek, G., Sameer, M. (2015). Four approaches to accounting for diversity in global organisations. *Critical Perspectives on Accounting*, *35*, 1-12.
71. Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., ..., Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *bmj*, 372.
72. Paoloni, P., Lombardi, R., Principale, S. (2023). The impact of gender diversity on corporate social responsibility knowledge: empirical analysis in European context. *Journal of Knowledge Management*, *27(9),* 2484-2498.
73. Pereira, V., Hadjielias, E., Christofi, M., Vrontis, D. (2021). A systematic literature review on the impact of artificial intelligence on workplace outcomes: A multi-process perspective. *Human Resource Management Review*, 100857.
74. Post, C., Byron, K. (2015). Women on boards and firm financial performance: A meta-analysis. *Academy of management Journal*, *58(5),* 1546-1571.
75. Raza-Ullah, T., Stadtler, L., Fernandez, A.-S. (2023). The individual manager in the spotlight: Protecting sensitive knowledge in inter‐firm coopetition relationships. *Industrial Marketing Management*, *110*, 85-95.
76. Rixom, J.M., Jackson, M., Rixom, B.A. (2023). Mandating diversity on the board of directors: do investors feel that gender quotas result in tokenism or added value for firms? *Journal of Business Ethics*, *182(3),* 679-697.
77. Ruiz-Jiménez, J.M., Fuentes-Fuentes, M.D.M., Ruiz-Arroyo, M. (2016). Knowledge combination capability and innovation: The effects of gender diversity on top management teams in technology-based firms. *Journal of business ethics*, *135(3),* 503-515.
78. Saeed, A., Baloch, M.S., Riaz, H. (2022). Global insights on TMT gender diversity in controversial industries: A legitimacy perspective. *Journal of Business Ethics*, *179*, 711-731.
79. Scheibmayr, I., Reichel, A. (2024). Who benefits from (Human Resource Management) professionalization? The moderating role of gender on professionalization effects in organisations. *Human Resource Management Journal*, *34(3),* 668-693.
80. Segovia-Pérez, M., Figueroa-Domecq, C., Fuentes-Moraleda, L., Muñoz-Mazón, A. (2019). Incorporating a gender approach in the hospitality industry: Female executives' perceptions. *International Journal of Hospitality Management*, *76*, 184-193.
81. Shan, L., Fu, S., Zheng, L. (2017). Corporate sexual equality and firm performance. *Strategic Management Journal, 38(9),* 1812-1826.
82. Simon, S.J. (2019). Hollywood power brokers: Gender and racial inequality in talent agencies. *Gender, Work & Organization*, *26(9),* 1340-1356.
83. Srivastava, C., Kashmiri, S., Mahajan, V. (2023). Customer orientation and financial performance: women in top management teams matter! *Journal of Marketing*, *87(2),* 190-209.

84. Stainback, K., Roberts, H., Biswas, P.K. (2024). Women's representation in managerial hierarchies: An examination of trickle-down and pipeline effects. *Human Resource Management*, *63(4),* 619-637.
85. Tang, S., Nadkarni, S., Wei, L., Zhang, S.X. (2021). Balancing the Yin and Yang: TMT gender diversity, psychological safety, and firm ambidextrous strategic orientation in Chinese high-tech SMEs. *Academy of Management Journal*, *64(5),* 1578-1604.
86. Taser-Erdogan, D. (2022). Careers advancement of women: Applying a multi-level relational perspective in the context of Turkish banking organisations. *Human Relations, 75(6),* 1053-1083.
87. Todorović, I., Komazec, S., Jevtić, M., Obradović, V., Marić, M. (2016). Strategic management in development of youth and women entrepreneurship - Case of Serbia. *Organizacija, 49(4),* 197-207.
88. Torres-Carrión, P.V., González-González, C.S., Aciar, S., Rodríguez-Morales, G. (2018, April). *Methodology for systematic literature review applied to engineering and education*. 2018 IEEE Global Engineering Education Conference (EDUCON). IEEE, pp. 1364-1373.
89. Tranfield, D., Denyer, D., Smart, P. (2003). Towards a methodology for developing evidence- informed management knowledge by means of systematic review. *British Journal of Management*, *14(3),* 207-222.
90. Vafaei, A., Henry, D., Ahmed, K., Alipour, M. (2021). Board diversity: female director participation and corporate innovation. *International Journal of Accounting & Information Management*, *29(2),* 247-279.
91. Valls Martínez, M.D.C., Santos-Jaén, J.M., Soriano Román, R., Martín-Cervantes, P.A. (2022). Are gender and cultural diversities on board related to corporate CO2 emissions? *Journal of Cleaner Production*, *363*, id.132638.
92. Voorberg, W.H., Bekkers, V.J., Tummers, L.G. (2015). A systematic review of co-creation and co-production: Embarking on the social innovation journey. *Public Management Review*, *17(9),* 1333-1357.
93. Wahid, A.S. (2019). The effects and the mechanisms of board gender diversity: Evidence from financial manipulation. *Journal of Business Ethics*, *159*, 705-725.
94. Wang, Y., Nadeem, M., Malik, I., Xiong, L. (2024). Board gender reforms and voluntary disclosure: International evidence from management earnings forecasts. *Corporate Governance: An International Review*, *Vol. 32, No. 5*, pp. 890-914.
95. Xiao, Y., Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, *39(1),* 93-112.
96. Yanadori, Y., Kulik, C.T., Gould, J.A (2021). Who pays the penalty? Implications of gender pay disparities within top management teams for firm performance. *Human Resource Management*, *60(4),* 681-699.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

RESILIENCE OF INTERNATIONAL COAL ENTERPRISES TO ECONOMIC CRISES FROM A FINANCIAL PERSPECTIVE

Izabela JONEK-KOWALSKA[1], Tomasz L. NAWROCKI[2*]

[1] Silesian University of Technology; izabela.jonek-kowalska@polsl.pl, ORCID: 0000-0002-4006-4362
[2] Silesian University of Technology; tomasz.nawrocki@polsl.pl, ORCID: 0000-0002-2120-3494
* Correspondence author

Purpose: With the widespread globalization and internationalization of human activities, changes – both beneficial and destructive – are shifting and escalating very rapidly. As a result, the exposure of economies, industries, and the companies operating within them to the risks and effects of the changes that have occurred is increasing. Thus, the purpose of the article is to assess the resilience of international coal enterprises to economic crises (the Covid-19 pandemic and Russia's invasion of Ukraine) from a financial perspective.
Design/methodology/approach: The analysis conducted in the article covers the years from 2010 to 2023. It includes 15 international coal companies, which, due to the scale of internationalization, and thus exposure to economic risk, were further divided into three groups. The research methodology is based on financial analysis indicators and econometric modelling of bankruptcy risk.
Findings: The results show an increase in exposure to crisis risks in companies with a higher share of exports in sales. The consequences of cyclical changes are also more severe for all coal companies with generally weak financial conditions. The economic crisis is also more intensely experienced by mining companies in the immediate vicinity of its outbreak.
Research limitations/implications: This analysis is financial in nature and does not focus on other aspects of the business, which may pose a certain research limitation. Furthermore, the relationships and reactions described are not statistically confirmed and, aside from crises, the impact of other factors on the financial condition of the companies studied is not analysed.
Practical implications: Despite similar problems, the adaptability and resilience of mining companies in different regions can differ significantly. Thus, there is a real opportunity to strengthen the resilience of coal companies by among others: planning production considering national and international economic conditions, as well as opportunities for both product and geographic diversification and optimizing the share of exports in sales.
Social implications: The role of the state in mitigating economic shocks should become apparent long before economic changes occur, as the energy market is insensitive to ad hoc and short-term decisions.
Originality/value: The contribution of the research to industrial economics is to determine the financial consequences of the impact of economic crises on the operation of coal companies and to answer the question of the extent of their crisis resilience.
Keywords: resilience; economic crisis; mining company; financial dimension of resilience.
Category of the paper: Research paper.

1. Introduction

The last fifteen years have been a period fraught with many rapid and profound changes of varying nature and origin (Gaigaliene and Jurakovaite, 2024; Vukovic et al., 2017; Kozub-Idźkowska, Proniewski, 2011). Some were positive, stimulating socio-economic develop-ment, such as the development of Industry 4.0 (Valaskova et al., 2024; Eger, Žižka, 2024), or the wider use of artificial intelligence in business and society (Yu et al., 2021; Shoufu et al., 2021; Doloreux, Turkina, 2021). Others, on the other hand, had a devastating im-pact on the environment and the economy, such as natural and climatic disasters, the Covid-19 pandemic (Ayinde et al., 2024; Zheng et al., 2023), the subprime mortgage crisis (Kao et al., 2018; Seabrooke, 2010), or armed conflicts (Merli, 2024; Kulyk, 2023).

With the widespread globalization and internationalization of human activities, changes – both beneficial and destructive – are shifting and escalating very rapidly (Armah, Amewu, 2022; Filipava, 2024). As a result, the exposure of economies, industries, and the companies operating within them to the risks and effects of the changes that have occurred is increasing. This exposure is particularly acute for the mining industry, due to its traditional nature, low level of adaptation to change, and detrimental impact on the environment and local communities (Kramarz, 2021; Andrews, Oppong, 2022).

Under such circumstances, resilience, understood as an organization's invulnerability or insensitivity to crisis factors, is a particularly desirable characteristic (Elliott, 2014). In practice, it means the avoidance of problems and difficulties and the ability to resist the negative impact of the socio-economic environment (Zabłocka-Kluczka, 2014; Tarapata, Woźniak, 2022). It allows to cope with threats and can be a driver of entrepreneurship, even during recessions (Sienkiewicz-Małyjurek, 2020). Thus, having resilience conditions the interruption of an enterprise during an economic crisis.

Given these circumstances, the purpose of the article is to assess the resilience of international coal enterprises to economic crises (the Covid-19 pandemic and Russia's invasion of Ukraine) from a financial perspective. Analyses in such a context are very rarely conducted. This is because the literature is dominated by economy-wide considerations using mainly statistical and/or econometric research tools. These are of a macroeconomic, environmental or social nature, with the result that the area of microeconomic and financial consequences of economic crises is overlooked and neglected. Meanwhile, building resilience at the meso and macro levels is not possible without developing individual resilience strategies for individual companies.

The analysis conducted in the article covers the years 2010-2023. It includes 15 international coal companies, which, due to the scale of internationalization, and thus exposure to economic risk, were further divided into three groups. The research methodology is based on financial analysis indicators, to identify the effects of the economic crisis

on individual companies and assess their resilience in financial terms. These indicators identify profitability, liquidity, quality of working capital management and debt. In addition, an econometric bankruptcy prediction model was used in the process of aggregating the obtained results.

The contribution of the research conducted to the economics of mining companies is due, according to the above argumentation, to the following circumstances:

- Considering the financial micro-perspective of the resilience of mining companies to crisis situations, which is neglected in contemporary research.
- Carrying out a diagnosis of resilience in a group of 15 mining companies, considering the scale of internationalization of their operations.
- Using financial analysis tools and an econometric bankruptcy pre-diction model to assess the economic dimension of resilience in mining companies.
- Identifying characteristics, that promote the resilience of mining companies to economic crises.
- Formulating management conclusions towards strengthening the resilience of mining companies.

In the following part of the article, literature studies are presented that provide the background for the research problem undertaken. They concern risk resilience in the mining industry and the response of mining companies to the Covid-19 pandemic and Russia's invasion of Ukraine. Based on these, a substantive and methodological research gap was identified. Then, the research approach was described, and the results of the analysis were presented. The entire discussion is closed with recommendations and a summary of the research results, that also includes research limitations and directions for further research.

2. Literature review

2.1. Risk resilience in companies and the mining industry

Considerations of corporate and extractive industry resilience are currently focused on several key issues. An overview of these is provided later in this subsection.

In contemporary research on the resilience and risk of extractive companies, a lot of attention is paid to the security of supply, which can be threatened by sudden random events and unexpected economic crises. Thus, Radebe and Chipangamate (2024) distinguish four groups of risk factors, that must be considered in the planning process of the minerals and metals supply chain. These are conditions relating to: machinery and technical systems, human resources, the environment, and general logistical circumstances. The authors also emphasize that creating effective resilience strategies requires a high level of competence in hazard

assessment and risk management. This observation demonstrates the importance of adequately preparing mining companies for economic crises, that are difficult to predict and violent.

Similar conclusions are made by Lim-Camacho et al. (2021) based on a study of Australian mining companies exposed to risks associated with sudden climatic events (e.g., cyclone). The authors believe that strengthening the resilience of the entire mineral supply chain requires a systemic approach for identifying levers, that managers and policy makers can use to facilitate discussion and decision making toward the goal of responsive, resilient and rewarding mining value chains.

Maoela et al. (2024) look at supply chain resilience from the perspective of workers in mining companies in South Africa affected by the Covid-19 pandemic. Their surveys show that the impact of the crisis has affected different occupational groups in different ways. Nevertheless, the pandemic in all cases analysed reduced the income and general well-being of workers. In strengthening industry's resilience to future crises, it is, therefore, necessary to take a proactive stance and develop a plan of countermeasures to prevent long-term negative impacts on human resources.

Given the climate risks, the issue of resilience of mining companies is also being analysed in an environmental context. Studies by Gustafsson et al. (2022), conducted in a group of multinational private mining corporations, show, that most of the surveyed companies have implemented a system for assessing the impact of climate on business operations and have integrated environmental risk management. Nevertheless, this attitude and actions are primarily the result of investor pressure. Local community opinion and legal legislation are far less important in this case, illustrating the power and importance of private capital in transforming the mining industry and shaping its resilience to changes in the socio-economic environment.

The low resilience of mining companies to environmental changes is also described by Xiao et al. (2021) using Chinese coal mines as an example. The authors note, that the main manifestation of the mining industry's ecological adaptation is the natural link between the intensity of mining and the scale of the harmful impact of mining on the environment. It is, therefore, imperative to strengthen the process of conscious and long-term planning for sustainable development of mining areas.

Many studies also expose the low resilience of the mining industry to economic shocks in very different contexts. One of these is the local and regional approach. In this thread, da Silva et al. (2021) analyse the situation of Brazilian municipalities associated with iron ore mining after the sharp drop in iron ore prices in 2013. Their findings show, that the vast majority of local communities lack economic resilience and are unable to cope with the financial and fiscal consequences of reduced demand. This illustrates the low awareness of the consequences of economic changes and the poor preparedness of local authorities to manage risks.

Low community resilience to changes related to mine operations is also described by Wasylycia-Leis et al. (2014). According to the authors, it can be strengthened mainly by effective governance, which, in practice, means cooperation between mining companies and local authorities, the development of sustainable mining development plans and ongoing communication of all stakeholders involved in the development of the mining industry.

The importance of cooperation between mining company stakeholders increases in the case of mine closures, which most often represent an economic and social shock to the local community. Preparing a region for the impact of mine closures, according to Syahrir et al. (2021), should, therefore, begin as early as the start of mining operations. In addition, it is critical to take a responsible approach to planning alternative paths for regional development, using best practices and involving both local government and the mining industry.

According to Maconachie and Conteh (2025), the mining industry is also characterized by low resilience to changes and transformations induced by the socio-economic environment, especially in less developed regions. This is most often due to financial shortcomings, as well as the habits and customs of mining communities (Jonek-Kowalska, 2024). Adaptation to change is also complicated by environmental challenges, forcing a rapid and effective energy transition (Li et al., 2024). However, as Hu and Hassik (2017) describe, despite similar issues, the adaptive capacity and resilience of mining companies in different regions can differ significantly, which accentuates the importance of proper governance in mitigating socioeconomic risks.

2.2. Mining industry responses to the Covid-19 pandemic and the Russia-Ukraine armed conflict

Given the hypersensitivity of the mining industry to change, one can conclude, that sudden and deep crises caused by unpredictable circumstances are a particular threat to mining companies. In the past five years, such crises can certainly include the Covid-19 pandemic and the Russia-Ukraine armed conflict.

In this vein, research on a group of 333 gold mining companies is conducted, among others, by Klayme et al. (2023). Their conclusions show, that the Covid-19 pandemic has exacerbated the risk aversion of capitalists and inhibited industry investment. This attitude is holding back the development of the mining sector for many years, due to the time and capital intensity of investment in mining companies.

It is interesting, however, that the mining industry's response to deep economic crises is not uniform. Studies by Zhang et al. (2023) show, in fact, that in the case of coal mining, the Covid-19 pandemic contributed to increased production and demand for thermal coal, thus reviving the sector's operation and halting decarbonization. This is primarily due to the volatility of energy prices and the uncertainty of alternative energy supplies, and the desire of countries to maintain energy security at the expense of other energy policy priorities.

Similar observations are presented by Liu et al. (2022) in the case of China's coal sector. The authors note, that the Covid-19 pandemic caused a significant increase in demand for hard coal and a marked expansion of domestic coal production. Nevertheless, as a result of the crisis, China's raw material exports declined and, as a result, mining companies focused on internationalization of mining operations suffered the most.

The changes in the international hard coal market caused by the Covid-19 pandemic are also confirmed by a study by Parra et al. (2021). Furthermore, the authors also note the increase in the use of hard coal as an energy feedstock, which poses a threat to the implementation of zero-carbon climate policy and negatively impacts the environment.

In their analysis of the energy raw materials market response to the Covid-19 pandemic, Wang et al. (2022), in turn, point to the risk transmission mechanism between the oil and thermal coal sectors. They also emphasize the role of state interventionism in mitigating raw materials market crises, although they also note its waning effectiveness over time. Their observations suggest that, in the future, volatility and risk in the energy raw materials market under the influence of economic fluctuations may increase significantly.

A factor, that has certainly increased uncertainty in the energy raw materials market, is the Russia-Ukraine armed conflict, which has resulted, among other things, in an embargo on coal and gas supplies from Russia to Europe. Under these conditions, as in the case of the Covid-19 pandemic, some regions (e.g., Poland) have begun to reconsider increasing thermal coal production and postponing the liquidation of hard coal mining (Bijańska, Wodarski, 2024; Overland, Loginova, 2023; Ślusarczyk et al., 2023).

As a result, coal is still the main energy resource in the Polish economy. Following the invasion, only the directions of its inflow to Poland changed (Jonek-Kowalska, Grebski, 2024; Carmona, Dąbkowska, 2024). Thus, the adopted policy adversely affects the energy transition and the implementation of EU environmental policy in the country.

There is also no shortage of hypotheses in the literature about the beneficial effect of reducing the supply of Russian coal and oil on the greening of the energy industry. Such a view is represented by Clegg (2024), who states, that shortages in the supply of traditional energy resources can become an impetus for accelerating the green transition and making European countries independent of non-renewable energy sources. This calls into question the sense of the Russian invasion of Ukraine and the importance of Russia's energy resources in creating economic development.

The above views are also shared by Černoch et al. (2024), who believe, that limiting the supply of Russian coal to Europe will accelerate the decommissioning of mining and force the adoption of alternative energy development paths in many other European countries.

However, the question of the feasibility of choosing pro-environmental energy policies remains open, especially in emerging and developing countries, that are clearly struggling with energy transition. After all, it is one thing to set development directions, that are otherwise clear and lucid, and quite another to implement them, which requires determination, investment,

time, and a lasting change in attitudes and views. This is clearly confirmed by the recent course in the energy policy of Germany, which was at the forefront of Europe's green transition, and is now reopening mines and investing in coal-fired power plants (Kinkartz, 2022).

The wishful thinking of rapid and effective change in energy policies seems to be confirmed by Xin and Zhang's (2024) research. Indeed, their analysis shows, that the highest energy instability, manifested, among other things, by large fluctuations in energy prices, is for countries that impose sanctions on Russia. Countries, that do not restrict trade with Russia, are characterized by higher resilience to the crisis, as is Russia itself. Further escalation of sanctions and armed conflict, according to the authors, could contribute to destabilizing the energy market in most European countries.

Meanwhile, the increase in prices in the mining and quarrying sector as a result of Russia's invasion of Ukraine was noticeable around the world and, according to estimates by Yagi and Managi (2024), brought a global loss to the world economy of a 2.85% decline in annual GDP. This illustrates the magnitude of the military crisis, not only in relation to the mining sector, but more importantly in relation to overall economic development.

The identifiable impact of the increase in demand and prices for coal and oil caused by the Russia-Ukraine military conflict also affected the quotations of mining companies. A study by Nerlinger and Utz (2022) shows, that it contributed to an increase in the stock prices of mining companies. At the same time, the increase was more intense for North American companies than for European and Asian companies. Thus, those competing with Russian suppliers of fossil fuels were more effective, having gained the opportunity to capture new (mainly European) markets.

It is worth adding, however, that, according to Izzeldin et al. (2023), the crisis triggered by Russia's invasion of Ukraine has less impact on the global economy than the Covid-19 pandemic of 2020 or the subprime mortgage crisis of 2008. Its effects are mainly translated into raw materials markets. The stock and commodity markets are also reacting quickly to it.

2.3. Identification of research gap

From the analyses presented in the previous subsections, it is clear, that considerations of mining industry resilience are concentrated within three main threads, namely: (1) logistical resilience relating to the supply chain; (2) environmental resilience related to the adaptation of mining companies to increasing climate demands; and (3) community resilience to mining operations. The authors of most of these studies use statistical analyses, surveys or case studies. Furthermore, these analyses are conducted at the national or regional level, and less often focus on the mining companies themselves.

In contrast, the threads describing the impact of the Covid-19 pandemic and Russia's invasion of Ukraine on the coal sector largely refer to macroeconomic relations along the demand-supply price line. They are mainly conducted at the economywide level using econometric analysis.

In the context of the above observations, it can be said, that the literature lacks microeconomic analyses, concerning individual companies or groups of companies. The financial consequences of the impact of economic crises on the operation of mining companies are also not determined. Therefore, it is difficult to answer the question of the extent of the resilience of these enterprises to rapid socio-economic changes and to identify the determinants of this resilience.

Given the above research gap, the purpose of this article is to assess the resilience of international coal enterprises to economic crises (the Covid-19 pandemic and Russia's invasion of Ukraine) from a financial perspective. The results of this analysis will provide conclusions on the financial consequences of the aforementioned developments and allow us to assess the extent and distinguishing features of the resilience of the mining companies under study.

3. Research methodology

3.1. Sample and research design characteristics

As already mentioned, the study included 15 coal mining companies operating in the international raw materials market. The selection of the sample for the study was guided by the following considerations:

- the possibility of making direct comparisons, expressed by concentrating the operations of the studied companies primarily on thermal coal mining,
- maximization of the size of the research sample to identify as many responses to economic crises in coal companies as possible,
- financial data availability, which is guaranteed when coal companies are publicly traded on stock exchanges.

The features of coal companies that meet the above requirements are shown in Table 1.

Given the varied size of the share of exports in sales, the companies studied were further divided into three groups. The first included companies with a share of 0% or close to 0%. The second consisted of coal companies with an average share of exports in sales of up to 50%. The third group included companies with the highest share of exports in sales – above 50%. In this way, it was possible to conduct identification of the financial impact of economic crises in connection with the individual risk exposure of the companies studied to the international raw materials market (Arbelo et al., 2024; Domínguez Romero et al., 2024; Shen et al., 2023).

Table 1.
Characteristics of the coal companies in the research sample

Company	Stock Exchange	Coal type	Mining volume [kt]*	Mining site	Directions of sale	Share of exports in sales
China Coal Energy	HKSE*, China	thermal coal	119170	China	China	0.00%
China Shenhua Energy	HKSE, China	thermal coal	324500	China	China	0.00%
Coal India	BSE*, India	thermal coal	703000	India, Africa (Mozambique)	India	0.00%
Bumech	WSE*, Poland	thermal coal	1380	Poland	Poland	0.00%
LW Bogdanka	WSE, Poland	thermal coal	7100	Poland	Poland	0.00%
Hallador Energy	Nasdaq Capital Market, USA	thermal coal	6600	USA	USA	0.00%
NACCO INDUSTRIES	NYSE*, USA	thermal coal	22900	USA	USA	0.00%
PT Bukit Asam	IDX*, Indonesia	thermal coal	37140	Indonesia	Indonesia, India, South Korea, China, Thailand, Italy, Japan, Cambodia, Others	42.11%
Exxaro Resources Limited	JSE*, South Africa	thermal coal	42500	South Africa	South Africa, Switzerland, UK, Japan, Singapore	28.63%
Bisichi Mining	LSE*, UK	thermal coal	807	South Africa	South Africa, UK	22.48%
Alliance Res.	Nasdaq Global Select Market, USA	thermal and coking coal	34900	USA	Europe, Africa, Asia, North America, and South America	15.70%
New Hope	ASX*, Australia	thermal coal, oil	7217	Australia	Japan, China, Taiwan, Chile, Australia	91.53%
Whitehaven Coal	ASX, Australia	thermal and coking coal	15740	Australia	Japan, Korea, Taiwan, Malaysia, New Caledonia, Vietnam, Indonesia, Europe	99.10%
PT Adaro Energy	IDX, Indonesia	thermal coal	65880	Indonesia, Australia	Indonesia, China, Malaysia, India, Japan, Korea, Philippines, Hong Kong, Taiwan, Thailand	88.80%
Banpu Public Company	SET*, Thailand	thermal coal	29900	Thailand, Indonesia, Australia, Mongolia, China	Thailand, Indonesia, Australia, China, Japan, India, Bangladesh, Philippines, Malaysia	97.09%

* HKSE – Hong Kong Stock Exchange, BSE – Bombay Stock Exchange, WSE – Warsaw Stock Exchange, NYSE – New York Stock Exchange, IDX – Indonesia Stock Exchange, JSE – Johannesburg Stock Exchange, LSE – London Stock Exchange, ASX – Australian Securities Exchange, SET – Stock Exchange of Thailand

– share of exports close to 0%; – share of exports up to 50%; – share of exports above 50%; * – status at the end of 2023.

Source: Own compilation based on data from the annual reports of the companies studied.

The source data was obtained from the annual financial statements of the companies studied. The analysis period covers 2010-2023. Two economic crises were considered during the research. The first is the Covid-19 pandemic, which affected all global economies (Ayaaba et al., 2024). The other is the Russia-Ukraine armed conflict, which primarily hit the energy industry (Pata et al., 2023; Ragab, Sultan, 2024). However, its repercussions are also being felt by other branches of the world's economies.

3.2. Description of research methods

As already emphasized in the introduction, the methodology of the analyses conducted in this article is based on the tools used in corporate finance. It is adapted to the subsequent research stages involving the evaluation of the following:

- The profitability of the enterprise as an efficiency dimension of the response to the economic crisis,
- Liquidity and the level of net working capital as a reflection of the actual and potential ability to settle current obligations in the pre- and post-crisis periods,
- The regularity of the capital structure as a dimension of securing the balance between own and foreign sources of financing,
- The risk of bankruptcy as a resultant assessment of the response to the crisis aggregating the assessment of profitability, liquidity and regularity of the capital structure.

The indicators used in the framework of the above research stages are shown in Table 2.

The measures used in the first three stages are among the classic indicators of financial analysis. In the article, they were used to assess their overall volatility over time and their volatility during crisis periods, that is, during the Covid-19 pandemic and after Russia's invasion of Ukraine.

In the final stage of the research, a bankruptcy prediction model was used to collectively assess the changes in profitability, liquidity and capital structure, that occurred during the aforementioned crises. This is because the changes in many indicators are most often multivariate and multidirectional, which provides important analytical conclusions, but makes them difficult to synthesize.

The best-known bankruptcy prediction model is the Altman model. This article uses the Poznań model, developed in Poland in 2004 by M. Hamrol, B. Czajka and M. Piechocki (Hamrol, 2008). According to the literature, despite the passage of time, it is rated as one of the most effective (Wojnar, 2014; Godlewska, 2010) and is based on the main commonly used financial indicators.

Table 2.
List of indicators and research methods used in each research phase

Stage	Index	Formula	Interpretation
Profitability assessment	ROA Return on Assets	$\frac{net\ profit}{total\ assets}$	Efficiency of asset exploitation
	ROE Return on Equity	$\frac{net\ profit}{equity}$	Rate of return for equity donors
	EBIT Margin on Sales	$\frac{EBIT}{sales\ revenues}$	Operating profitability of sales
Evaluation of financial liquidity and net working capital	Current Ratio	$\frac{current\ assets}{current\ liabilities}$	Ability to settle current liabilities from current assets (1.5-2.0 standard)
	Quick Ratio	$\frac{current\ assets - inventories}{current\ liabilities}$	Ability to settle current liabilities from current assets after adjusting for inventories (1.0 standard)
	Net Working Capital Level	$\frac{net\ working\ capital}{total\ assets}$	Portion of fixed capital (equity plus long-term liabilities) involved in financing current assets in relation to total assets
Assessment of the regularity of the capital structure	Total Debt Ratio	$\frac{total\ liabilities}{total\ assets}$	The degree to which a company has used debt to finance its assets (max. 67%)
	Financial Debt to Equity	$\frac{financial\ liabilities}{equity}$	Assessment of the degree, to which financial (interest-bearing) liabilities are secured in equity
	Net Debt to EBIT	$\frac{net\ debt}{EBIT}$	Assessment of the ability to repay net debt (liabilities less cash and cash equivalents) from operating profit
Bankruptcy risk assessment	Econometric bankruptcy prediction model: the Poznań variant	$Z(P) = 3.562\ X_1 + 1.58\ X_2 + 4.288\ X_3 + 6.719\ X_4 + 2.368$ X_1 – Return on Assets X_2 – Quick Liquidity X_3 – Fixed Capital to Total Assets X_4 – Gross Margin on Sales	Bankruptcy risk assessment: $Z(P) \leq 0$ high probability of bankruptcy $Z(P)>0$ no threat of bankruptcy (Hamrol et al., 2004; Kisielińska, Waszkowski, 2010)

Source: Own work based on Wędzki (2009) and Hamrol (2008).

4. Results

4.1. Assessing profitability from the perspective of exposure to international risks and economic crises

The first stage of the analyses assessed the profitability of the coal companies under study. The results of this assessment are included in Figures 1-3 and Tables 3-5.

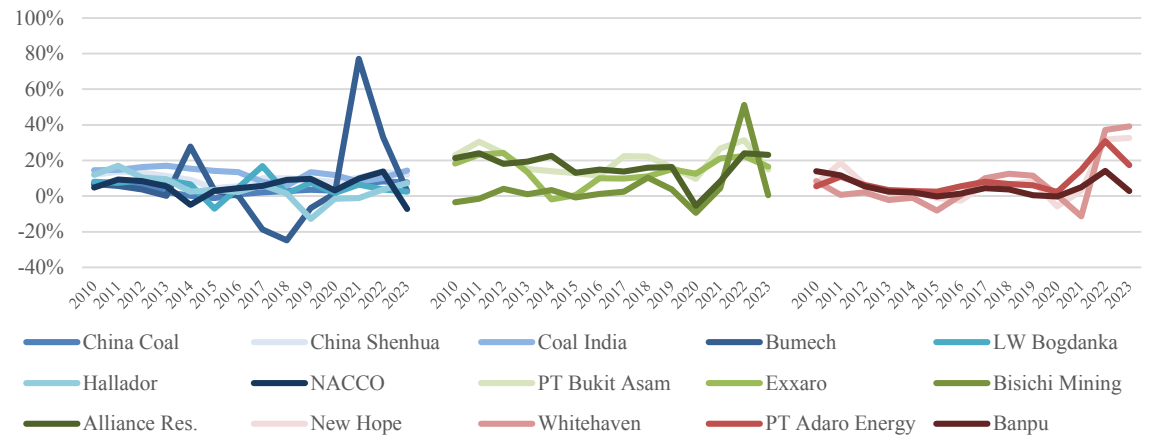


Figure 1. Return on Assets (ROA) of the coal companies studied in 2010-2023 [in %].

Source: own calculations.

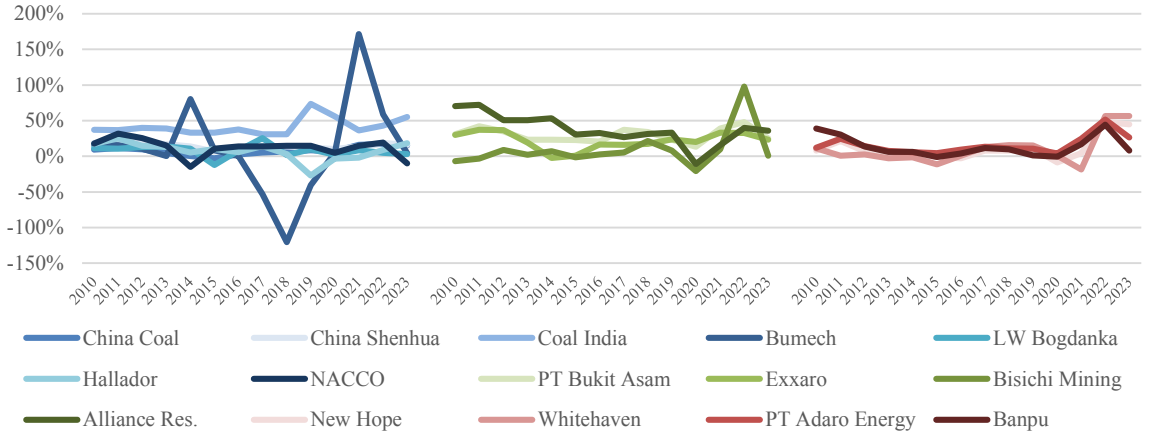


Figure 2. Return on Equity (ROE) of the coal companies studied in 2010-2023 [in %].

Source: own calculations.

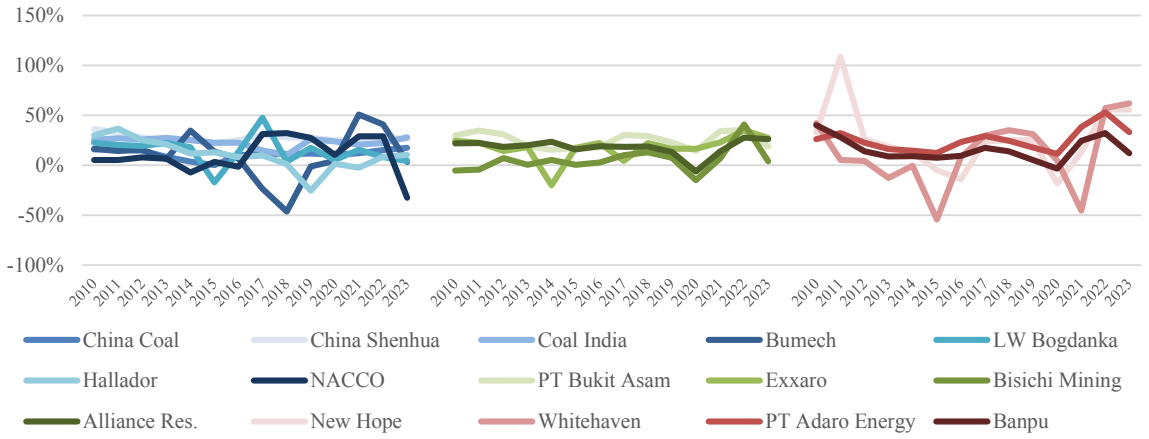


Figure 3. EBIT Margin on Sales of the coal companies studied in 2010-2023 [in %].

Source: own calculations.

Table 3.
ROA volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	9.31%	4.05%	3.04%	0.7495
China Shenhua Energy	9.32%	10.19%	2.80%	0.2752
Coal India	11.34%	12.66%	3.40%	0.2682
Bumech	101.78%	7.98%	24.86%	3.1160
LW Bogdanka	23.77%	5.56%	5.33%	0.9582
Hallador Energy	29.81%	4.34%	7.16%	1.6518
NACCO INDUSTRIES	20.94%	5.36%	5.68%	1.0601
PT Bukit Asam	21.77%	19.59%	7.07%	0.3611
Exxaro Resources Limited	26.14%	14.06%	7.93%	0.5639
Bisichi Mining	60.70%	4.82%	14.10%	2.9234
Alliance Res.	29.52%	16.40%	7.84%	0.4780
New Hope	38.47%	8.36%	11.60%	1.3880
Whitehaven Coal	50.46%	7.16%	14.82%	2.0703
PT Adaro Energy	28.49%	8.79%	7.78%	0.8850
Banpu Public Company	14.44%	4.81%	4.93%	1.0249

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 4.
ROE volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	20.39%	7.99%	5.89%	0.7368
China Shenhua Energy	14.09%	14.70%	4.25%	0.2892
Coal India	42.68%	41.71%	12.05%	0.2889
Bumech	291.91%	11.30%	66.37%	5.8719
LW Bogdanka	37.76%	8.05%	8.38%	1.0414
Hallador Energy	51.71%	7.49%	12.65%	1.6882
NACCO INDUSTRIES	46.59%	12.29%	12.21%	0.9934
PT Bukit Asam	34.45%	29.87%	9.73%	0.3257
Exxaro Resources Limited	39.83%	21.83%	12.15%	0.5566
Bisichi Mining	118.43%	9.38%	27.18%	2.8968
Alliance Res.	83.17%	37.99%	21.40%	0.5633
New Hope	56.90%	11.07%	16.62%	1.5017
Whitehaven Coal	74.70%	9.97%	21.86%	2.1915
PT Adaro Energy	47.55%	15.73%	12.69%	0.8069
Banpu Public Company	45.24%	13.61%	14.40%	1.0580

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 5.
EBIT margin on Sales volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	17.29%	11.28%	4.81%	0.4262
China Shenhua Energy	14.68%	27.46%	3.80%	0.1382
Coal India	17.51%	23.04%	4.95%	0.2150
Bumech	97.20%	9.68%	24.59%	2.5403
LW Bogdanka	64.89%	14.31%	14.31%	0.9999

Cont. table 5.

Hallador Energy	62.29%	10.61%	15.29%	1.4417
NACCO INDUSTRIES	64.88%	10.43%	18.25%	1.7486
PT Bukit Asam	20.96%	25.12%	7.70%	0.3067
Exxaro Resources Limited	55.05%	17.41%	12.87%	0.7391
Bisichi Mining	56.05%	5.26%	12.53%	2.3841
Alliance Res.	33.82%	18.06%	8.14%	0.4508
New Hope	126.93%	25.77%	32.28%	1.2528
Whitehaven Coal	116.35%	11.92%	34.32%	2.8790
PT Adaro Energy	41.93%	25.35%	11.42%	0.4504
Banpu Public Company	43.76%	15.71%	11.78%	0.7500

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Thus, the average return on total assets of companies with the lowest share of exports ranges from 4% to almost 13% (Table 3), and Figure 1 additionally shows, that the amplitude of its fluctuations over time in the analyzed group is the smallest. The standard deviations of ROA (with the exception of Bumech and Hallador Energy) are the lowest among the surveyed companies and do not exceed 6%. Nevertheless, only China Shenhua Energy and Coal India (high ROA, low coefficient of variation) can be considered outstanding in terms of the level and volatility of return on assets. US and Polish companies show lower return on assets and significantly higher risk associated with its realization, despite a very low share of exports and exposure to international risk.

In the group of companies with a higher share of exports (up to 50%), the profitability of total assets is higher. In 3 of the 4 companies, its average value exceeds 14%. Standard deviations are also higher. Nevertheless, given the rather moderate levels of the coefficient of variation, it is difficult to say unequivocally, that the risk exposure of this group of companies is higher. Undoubtedly, South Africa's Bisichi Mining, with its low average profitability and high volatility over time, is the worst performer on the list.

Among companies with the highest share of exports (above 50%), ROA ranges from 4% to almost 9%, and the standard deviation from almost 5% to over 11%. Average profitability with high volatility negatively affects the final level of risk expressed by the coefficient of variation – in all companies in the group its value exceeds 0.80.

Referring to the impact of the Covid-19 pandemic, it can be noted, that the decline in ROA in 2019 and 2020 primarily affected companies in groups 2 and 3. Thus, it more severely affected the companies with greater exposure to the international coal market than those serving the domestic market.

On the other hand, Russia's invasion of Ukraine resulted in a significant increase in ROA for companies in group 2 and 3, meaning, that they benefited from the imbalance in the energy raw materials market and became – in terms of profits – a beneficiary of this economic crisis. In group 1, Bumech also benefited from this economic turnaround. It’s worth adding, however, that the described growth was incidental in most companies, as ROA dropped significantly in 2023, reaching levels close to precrisis ones. Still, this was not the case for 2 Australian

companies (New Hope and Whitehaven Coal) and 1 US company (Alliance Resource Partners), which is most likely due to their raw material diversification (in addition to thermal coal, they also offer coking coal or oil).

As the share of exports increases, the ROE increases in group 2, with moderate volatility, and thus risk (Figure 2 and Table 4). The exception, as in the ROA assessment, is the Indian company Bisichi Mining, with the lowest group profitability and the highest tendency for it to change over time.

ROE, on the other hand, is declining in the last analysed group, characterized by the highest share of exports. The volatility of this indicator is also increasing, and thus its unpredictability and associated risks. This suggests an optimal volume of exports, not exceeding 50% of sales, which makes it possible to maximize profitability, while minimizing its volatility over time. It applies to the Indonesian, South African and American companies. The first two mine only hard coal, while the third also produces coking coal.

Given the high correlation of the above-described profitability, the Covid-19 pandemic also caused a significant reduction in ROE in the companies in groups 2 and 3. On the other hand, the Russia-Ukraine armed conflict contributed to a periodic increase in ROE in these companies in 2022.

Looking at the profitability of the surveyed companies only from the perspective of operating profit before taxes (EBIT) – Table 5, Figure 3, it can be seen, that in all groups the leading companies are Chinese, Indian, Indonesian or Australian, which are characterized by a high EBIT Margin on Sales and its lowest volatility. Polish and US companies do not perform as well in any of the assessed dimensions. This suggests greater resilience of the Asian market to general economic changes.

Nevertheless, susceptibility to deeper economic crises is already affecting all of the companies surveyed, which, as in the case of the profitability indicators surveyed earlier, is expressed in the reduction of the EBIT Margin on Sales during the Covid-19 pandemic and its marked increase after the outbreak of the Russian – Ukrainian war. Notably, severe economic fluctuations expose the weakness of the weakest. Indeed, the biggest fluctuations in EBIT Margin on Sales concern Bumech, Bisichi Mining and Whitehaven Coal – companies with the worst average performance in their groups.

4.2. Assessing liquidity and working capital from the perspective of exposure to international risks and economic crises

In the second stage of the diagnosis, the effects of economic crises on liquidity and working capital in the surveyed coal companies were assessed. The data used in this analysis are included in Figures 4-6 and Tables 6-8.

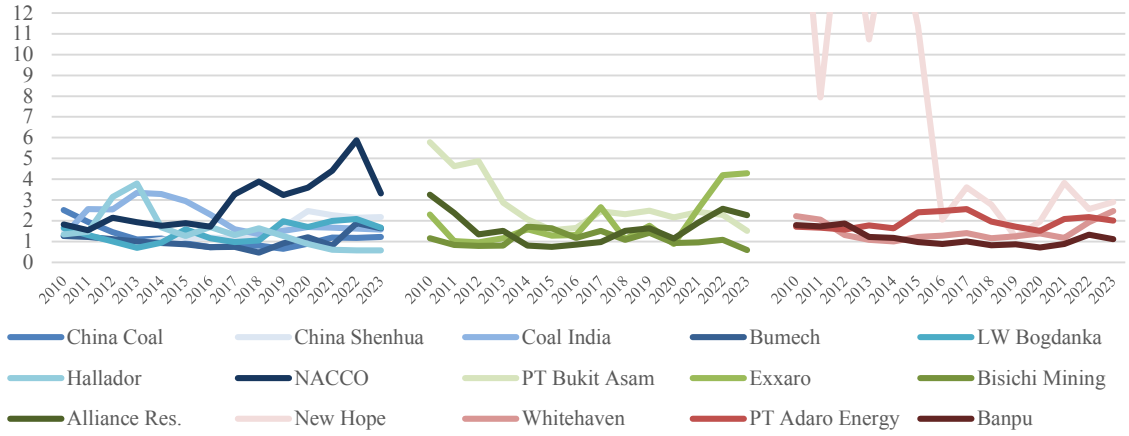


Figure 4. Current Ratio of the coal companies studied in 2010-2023.

Source: own calculations.

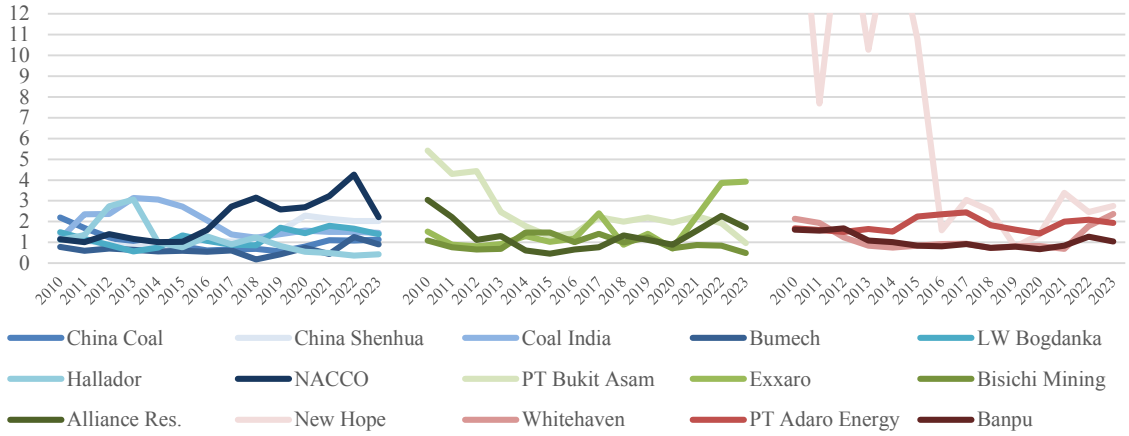


Figure 5. Quick Ratio of the coal companies studied in 2010-2023.

Source: own calculations.

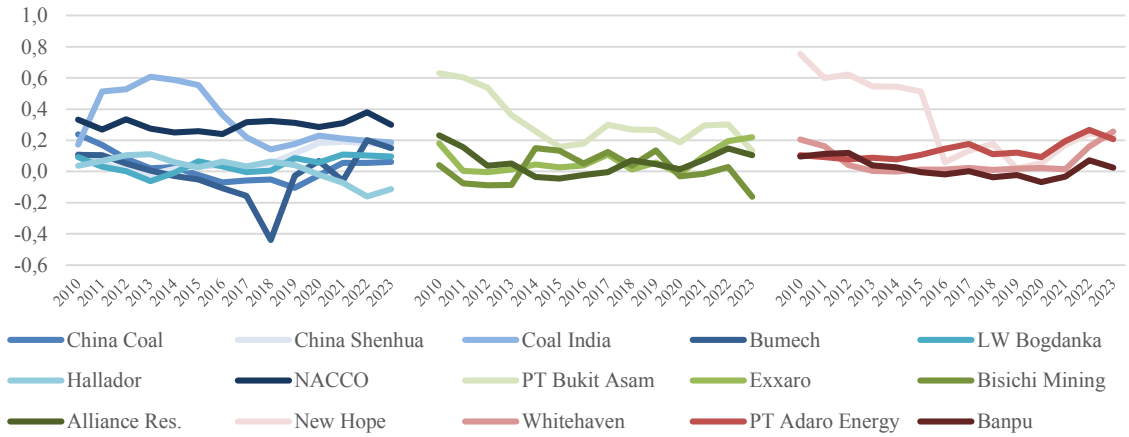


Figure 6. Net Working Capital Level of the coal companies studied in 2010-2023.

Source: own calculations.

Table 6.
Current Ratio volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	1.85	1.18	0.51	0.4322
China Shenhua Energy	1.56	1.52	0.53	0.3463
Coal India	2.08	2.09	0.72	0.3458
Bumech	1.42	1.06	0.37	0.3518
LW Bogdanka	1.38	1.42	0.45	0.3166
Hallador Energy	3.22	1.52	0.93	0.6082
NACCO INDUSTRIES	4.34	2.89	1.28	0.4431
PT Bukit Asam	4.27	2.79	1.33	0.4753
Exxaro Resources Limited	3.41	1.94	1.14	0.5870
Bisichi Mining	1.12	1.12	0.34	0.3033
Alliance Res.	2.51	1.64	0.76	0.4617
New Hope	19.85	7.68	6.89	0.8963
Whitehaven Coal	1.45	1.50	0.47	0.3113
PT Adaro Energy	1.05	1.95	0.35	0.1785
Banpu Public Company	1.15	1.17	0.38	0.3232

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 7.
Quick Ratio volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	1.63	1.03	0.45	0.4350
China Shenhua Energy	1.51	1.39	0.52	0.3723
Coal India	1.97	1.92	0.69	0.3575
Bumech	1.08	0.64	0.25	0.3851
LW Bogdanka	1.23	1.22	0.39	0.3183
Hallador Energy	2.70	1.15	0.81	0.7026
NACCO INDUSTRIES	3.26	2.09	1.04	0.4994
PT Bukit Asam	4.45	2.47	1.30	0.5263
Exxaro Resources Limited	3.22	1.65	1.08	0.6534
Bisichi Mining	0.98	0.98	0.32	0.3256
Alliance Res.	2.59	1.36	0.74	0.5441
New Hope	19.84	7.24	6.79	0.9382
Whitehaven Coal	1.67	1.20	0.59	0.4900
PT Adaro Energy	1.03	1.85	0.34	0.1821
Banpu Public Company	1.01	1.06	0.34	0.3201

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 8.
Net Working Capital Level volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	0.34	0.03	0.09	3.4812
China Shenhua Energy	0.21	0.08	0.07	0.8788
Coal India	0.47	0.33	0.18	0.5398
Bumech	0.64	-0.01	0.16	-11.9779
LW Bogdanka	0.17	0.04	0.05	1.1976

Cont. table 8.

Hallador Energy	0.27	0.02	0.08	4.6355
NACCO INDUSTRIES	0.14	0.30	0.04	0.1292
PT Bukit Asam	0.50	0.32	0.16	0.5014
Exxaro Resources Limited	0.24	0.07	0.08	1.1239
Bisichi Mining	0.31	0.02	0.10	5.6507
Alliance Res.	0.28	0.06	0.08	1.3477
New Hope	0.74	0.33	0.25	0.7532
Whitehaven Coal	0.26	0.07	0.09	1.2994
PT Adaro Energy	0.19	0.13	0.06	0.4319
Banpu Public Company	0.19	0.02	0.06	2.6789

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Thus, if values from 1.5 to 2.0 are taken as the optimal level of current liquidity, it can be seen, that in group 1 only 2 companies (American NACCO INDUSTRIES and Indian Coal India) maintain current liquidity throughout the analysis period. In contrast, Bumech, China Coal Energy and LW Bogdanka have the highest number of periods of lack of current liquidity (Figure 4). This is reflected in the averaged ratio, which is below the required standard for the aforementioned companies.

It should be added, however, that the quick liquidity ratio (for which the norm is around 1.00) in all the studied companies of group 1 performs better and allows confirmation of the ability to settle current liabilities in most of the analysed periods. The infamous exception in this regard is only Bumech, for which the averaged value of the quick liquidity ratio remains below the norm (the company meets the requirements only in 2022).

The volatility of the current and quick liquidity ratios does not exceed 0.45, which allows it to be described as moderate. Nevertheless, it should be borne in mind, that periodic or long-term inability to settle current liabilities (occurring in 5 out of 7 companies in this group) nevertheless indicates an increased liquidity risk (Table 6).

Referring to the impact of the Covid-19 pandemic on liquidity, it can be said that in group 1 it was minor. In 2019, current liquidity declined, and there was an aggravation of the inability to pay current obligations only at China Coal Energy. In the case of quick liquidity, this occurred at China Coal Energy and Hallador Energy.

The Russia-Ukraine conflict also did not affect significantly the changes in current and quick liquidity at group 1 companies. Only Bumech lost quick liquidity (while maintaining current liquidity). Furthermore, the previous inability to service current debt was maintained by Hallador Energy, so the low values of quick and current liquidity ratios can hardly be attributed to the described economic crisis in this case.

In group 2, with a greater extent of internationalization, current and quick ratios are characterized by higher variability over time (Table 7). In the companies studied, there are periods, when it is below the accepted norms (Figure 5). There are also periods of excess liquidity. The only company, that maintains the correct ability to settle current liabilities is PT Bukit Asam. On the other hand, the largest number of periods of lack of liquidity occur

at South Africa's Bisichi Mining, which ultimately translates into low, nonnormative averaged values of liquidity ratios.

In the second group, the companies' more intense liquidity responses to the Covid-19 pandemic can also be observed. In all the companies, the current and quick liquidity then noticeably decrease, including a loss of liquidity in 3 out of 4. Thus, it can be concluded, that stronger exposure to international risks exacerbates crisis risks.

For the Russia-Ukraine conflict, the reactions of the surveyed companies are no longer so clearcut. South Africa's Exxaro Resources Limited and the US-based Alliance Resource Partners maintain both current and quick liquidity, with a tendency toward over-liquidity. On the other hand, Indonesia's PT Bukit Asam and South Africa's Bisichi Mining are losing their ability to settle current liabilities for both indicators analyzed. Thus, the observed correlations may be the result of the production strategies and management goals chosen, rather than the market changes that have occurred.

In group 3, the majority (3 out of 4) of the analysed coal companies have the ability to regulate short-term liabilities throughout the period under study. They very often have excess liquidity, hence the high values of the averaged liquidity ratios. The Asian Banpu Public Company has the worst liquidity problems in this group.

During the Covid-19 pandemic, current and quick liquidity in 3 out of the 4 companies studied declined sharply, compared to previous periods, which indicates the severity of this economic crisis. The only exception in this regard is US-based New Hope, where liquidity improved in 2020 compared to 2019. Finally, 2 of the 4 companies surveyed in the Covid-19 pandemic did not retain the ability to pay current obligations.

The Russia-Ukraine conflict, as in the group 2 companies, did not significantly affect the level of liquidity of companies with a share of exports in sales above 50%. All the companies studied retained the ability to settle current liabilities. Two of them displayed an increase in liquidity ratios.

At this research stage, reference was also made to the level of net working capital of the coal companies studied (Table 8 and Figure 6). It represents that part of fixed capital, that finances current assets, and is a reserve, that can be used to meet the demand for funds necessary for current liquidity. Its amount (in the article analysed in relation to the size of total assets) is decided by the managers of the company. Nevertheless, the value of this capital should not be negative and should enable the liquidity objective indicated above to be met.

In group 1, only 2 (NACCO INDUSTRIES and Coal India) of the 7 coal companies studied have positive net working capital throughout the period under review (Figure 6). It also assumes the highest level in these companies, which positively affects its averaged values (Table 8). The worst management of net working capital is in the Polish company Bumech, Chinese company China Coal Energy and US company Hallador Energy, which is also consistent with the low evaluation of liquidity in these companies.

During both the Covid-19 pandemic and the Russia-Ukraine military crisis, no uniform trends can be identified in terms of changes in net working capital, which may indicate the insensitivity of this parameter to the described economic changes. Interestingly, however, in 4 of the 7 companies surveyed, net working capital has a low level, and its value in relation to total assets does not exceed 5%. This implies a weak liquidity buffer and a rather high exposure to the associated risks.

In this context, it is also important to note the very high volatility of the analysed indicator, indicating an inconsistent approach to net working capital management and, most likely, the realization of its random values (Table 8). The exceptions in this regard are NACCO INDUSTRIES and Coal India, which also systematically maintain the highest and positive level of net working capital in relation to total assets.

In group 2 of the studied companies, only Indonesian company PT Bukit Asam maintains a positive level of net working capital throughout the research period. In the remaining 3 companies, the fixed capital involved in financing current assets periodically tends to be negative, and its average value is very low and strongly fluctuates over time.

Unlike in group 1, in all companies with higher export involvement, net working capital decreases, and in 2 of them it changes its value from positive to negative. Similarly, this parameter reacts to the Russia-Ukraine armed conflict (it deteriorates in 3 of the 4 companies analysed). Thus, companies with increased international activity are characterized by greater sensitivity of net working capital to economic crises.

The above conclusion is also supported, in part, by the observations of group 3 of the studied companies. In 3 of the 4, both during the Covid-19 pandemic and after Russia's invasion of Ukraine, the value of net working capital decreases.

Interestingly, among the companies with the highest share of exports in sales, only 1 coal company periodically has negative net working capital (Banpu Public Company). At Whitehaven Coal, it takes on very low values but remains positive. In the other two companies, its value is quite stable over time and at a medium to high level in relation to total assets.

4.3. Debt from the perspective of exposure to international risks and economic crises

In the final stage of the analysis, reference was made to capital changes caused by the economic crises under study. The underlying data are compacted in Tables 9-11 and Figures 7-9.

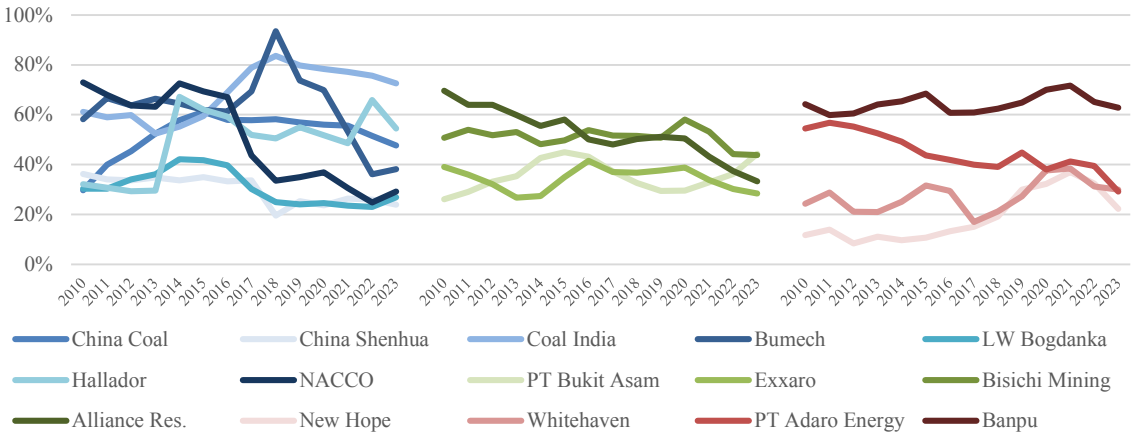


Figure 7. Total Debt Ratio of the coal companies studied in 2010-2023.

Source: own calculations.

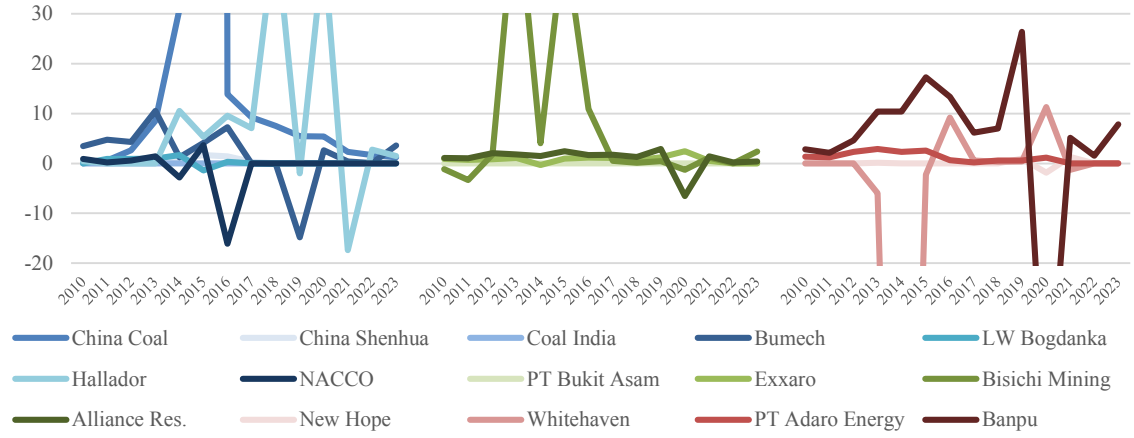


Figure 8. Net Debt to EBIT of the coal companies studied in 2010-2023.

Source: own calculations.

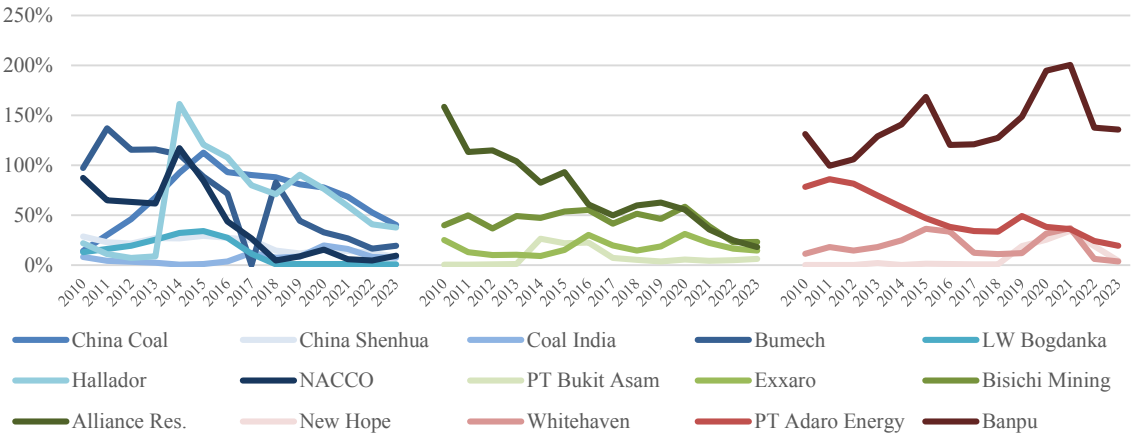


Figure 9. Financial Debt to Equity of the coal companies studied in 2010-2023.

Source: own calculations.

Table 9.
Total Debt Ratio volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	31.37%	52.02%	8.68%	0.1669
China Shenhua Energy	16.64%	29.95%	5.47%	0.1828
Coal India	31.27%	68.72%	10.53%	0.1532
Bumech	57.38%	62.64%	14.19%	0.2266
LW Bogdanka	19.12%	30.85%	6.87%	0.2226
Hallador Energy	37.92%	49.17%	13.47%	0.2740
NACCO INDUSTRIES	48.13%	50.74%	18.68%	0.3681
PT Bukit Asam	18.87%	35.50%	6.23%	0.1755
Exxaro Resources Limited	14.72%	34.34%	4.67%	0.1359
Bisichi Mining	14.31%	51.06%	3.77%	0.7390
Alliance Res.	36.29%	52.51%	10.26%	0.1955
New Hope	28.68%	19.08%	9.88%	0.5178
Whitehaven Coal	21.40%	27.44%	6.29%	0.2291
PT Adaro Energy	27.59%	44.71%	7.95%	0.1778
Banpu Public Company	11.77%	64.37%	3.61%	0.5610

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 10.
Net Debt to EBIT volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	2356.10	174.67	627.91	3,5947
China Shenhua Energy	1.66	0.39	0.57	1,4864
Coal India	0.00	0.00	0.00	-
Bumech	25.35	1.96	5.70	2,9075
LW Bogdanka	3.12	0.24	0.72	2,9532
Hallador Energy	64.09	7.69	17.12	2,2254
NACCO INDUSTRIES	19.80	-0.87	4.59	-5,3075
PT Bukit Asam	0.00	0.00	0.00	-
Exxaro Resources Limited	2.78	0.82	0.68	0,8290
Bisichi Mining	57.39	8.22	17.95	2,1824
Alliance Res.	9.42	0.93	2.26	2,4184
New Hope	3.11	0.04	0.67	18,2390
Whitehaven Coal	175.45	-10.85	44.34	-4,0866
PT Adaro Energy	2.88	1.14	1.03	0,9042
Banpu Public Company	82.86	4.19	18.70	4,4589

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Table 11.
Financial Debt to Equity volatility measures of the coal companies studied in 2010-2023

Company	Range	Arithmetic mean	Standard deviation	Coefficient of variation
China Coal Energy	98.65%	68.18%	28.03%	0.4111
China Shenhua Energy	21.22%	20.28%	7.39%	0.3643
Coal India	19.34%	7.24%	5.61%	0.7752
Bumech	137.16%	68.49%	44.60%	0.6511
LW Bogdanka	33.40%	13.07%	12.72%	0.9732

Cont. table 11.

Hallador Energy	154.30%	63.81%	46.36%	0.7265
NACCO INDUSTRIES	112.83%	42.66%	37.33%	0.8753
PT Bukit Asam	26.25%	7.77%	8.89%	1.1443
Exxaro Resources Limited	22.10%	17.79%	7.13%	0.4006
Bisichi Mining	35.87%	43.81%	10.95%	0.2498
Alliance Res.	140.37%	73.79%	39.39%	0.5337
New Hope	34.23%	7.66%	11.55%	1.5075
Whitehaven Coal	33.28%	19.20%	11.32%	0.5896
PT Adaro Energy	66.79%	49.51%	21.80%	0.4404
Banpu Public Company	100.97%	140.06%	29.70%	0.2120

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Taking the value of 67% of total assets as the upper limit of Total Debt Ratio, it can be concluded, that in the analysed group 1 only Coal India (in the last 8 years), Bumech (in four periods) and NACCO (in four periods) exceed this safe level (Figure 7). The remaining coal companies did not have excessive debt throughout the analysed period.

During the Covid-19 pandemic and the Russia-Ukraine conflict, Total Debt Ratio is within the normal range and does not really change. Thus, the described crises do not cause changes in the capital structure of the studied companies. The coefficient of variation for the studied indicator is at a moderate level, which also means, that the sensitivity and resilience of total debt to economic changes is quite low (Table 9).

The Total Debt Ratio meets the required standards and is stable over time in 2 of the analysed groups with a share of exports in total production up to 50%. This is reflected in the low average value of this ratio and the low coefficient of variation that describes it.

The share of total liabilities in financing the assets of coal companies increases slightly during the Covid-19 pandemic. During the Russia-Ukraine conflict, the observed changes are also small, but multidirectional. Therefore, similar to group 1, the described economic crises do not significantly affect the capital structures of coal companies with an average share of exports in sales.

In the 3rd group under study, the total debt ratio meets the required standards throughout the analysed period in 3 of the 4 companies. Periodically, Total Debt Ratio in Banpu Public Company is excessive. The variability of the capital structure over time is low and moderate, which indicates its stability.

As in group 2, in the Covid-19 pandemic, Total Debt Ratio increases slightly in most of the entities studied. In the second of the described crises, fluctuations in the capital structure are multidirectional and small. Therefore, it can be concluded, that the level of Total Debt Ratio is resilient to economic changes

On the other hand, significant instability and variation over time are shown in the values of the indicator illustrating the ratio of Net Debt to EBIT (Figure 8 and Table 10), which is a consequence of the high variability of the financial performance of the surveyed companies.

In group 1, the lowest ability to regulate net debt from operating profit is found in China Coal Energy, Hallador Energy and Bumech. It is also characterized by high volatility over time, as expressed by the standard deviation, the spread and the coefficient of variation.

Neither during the Covid-19 pandemic, nor the Russia-Ukraine armed crisis, is it possible to establish uniform trends in the changes of the analysed indicator in group 1 of companies. These changes vary in values and are multidirectional, which, as already mentioned, is mainly due to the instability of EBIT.

In group 2 of coal companies studied, both the value and the volatility of the ratio of Net Debt to EBIT are on a much better level. The only exception in this case is Bisichi Mining, where the average net debt exceeds the average operating profit by more than eight times.

In 3 of the 4 companies analysed in this group, the value of the analysed ratio also does not change noticeably under the influence of the analysed economic crises. Only in Bisichi Mining does the Net Debt to EBIT increase during the period of Russia's invasion of Ukraine. This confirms the low resilience to crises in coal companies with a generally weak financial condition.

The volatility of EBIT, in turn, significantly affects the ability to settle net debt on companies classified in group 3 with the highest share of exports in sales. The volatility of this indicator is high in all analysed companies. The worst parameters in this regard are shown by Banpu Public Company, which is also a company with a rather weak overall condition.

It is also the only company, in which the ratio of Net Debt to EBIT deteriorated during the Russia-Ukraine conflict. In the other analysed entities, there was no clear relationship between the crises and the described indicator.

The last of the financial variables examined is the financial indebtedness of equity expressed by the ratio of financial (interest-bearing) liabilities to equity, which should not exceed 1 (Figure 9 and Table 11).

Thus, in group 1, long-term financial security was at risk in 3 coal companies exceeding the above standard during the period under consideration, namely: China Coal Energy, Bumech and Hallador Energy. At the end of 2023, the situation in all entities of group 1 in this regard was already normal. The variability of the examined parameter is at a moderate and low level.

It is also not affected by the Covid-19 pandemic, which means, that this economic crisis capital structure in group 1 of companies remained insensitive. For the Russia-Ukraine armed conflict, the security of financial liabilities in equity in 6 of the 7 studied companies improved, which means its favourable impact on the ability to settle these liabilities.

In group 2 of companies, Financial Debt to Equity in the period under consideration can be considered excessive only at Alliance Res, and only in the early years. In the other companies it is low or moderate.

This ratio changes and is slightly different under the influence of the Covid-19 pandemic. In 3 of the 4 coal companies, its slight increase can be observed, which means a reduction in the security of financial liabilities in equity and less resilience of these entities to the effects of the analysed economic change. The Russia-Ukraine crisis, on the other hand, is associated with an improvement of the described indicator in 3 of 4 companies, which is consistent with the observations made in group 1 of coal companies.

In group 3 of companies, the Financial Debt to Equity is abnormally elevated in Banpu Public Company. It is also characterized by high volatility over time expressed by the high value of the bifurcation and standard deviation.

This group also shows the strongest response of its capital structure to the economic crises analysed in the article. During the Covid-19 pandemic, there is a marked deterioration in the value of the analysed indicator in 3 of the 4 coal companies. In turn, the armed crisis between Russia and Ukraine reduces the ratio of financial liabilities to equity in all the described entities.

4.4. Assessing the threat of bankruptcy in crisis situations

Due to the multiplicity of the considered indicators, as well as their differential nature, in the last research stage, the econometric bankruptcy prediction model, described in the methodology section, was used to aggregate the results, which uses 2 parameters for assessing profitability and 1 parameter each for assessing liquidity and capital structure. This is consistent with the areas described in the previous subsections. The modelling results are shown in Table 12.

Table 12.
The value of the bankruptcy risk function in the Poznań model in the Covid-19 pandemic and during the Russia-Ukraine armed conflict

Company	Years/direction of change					
	2019	2020	Direction	2022	2023	Direction
China Coal Energy	4.39	4.51	↑	4.01	3.49	↓
China Shenhua Energy	3.14	4.35	↑	4.14	3.64	↓
Coal India	2.49	3.16	↑	2.30	2.73	↑
Bumech	0.40	0.96	↑	4.70	0.72	↓
LW Bogdanka	1.84	0.41	↓	0.98	0.28	↓
Hallador Energy	2.43	3.38	↑	1.25	1.62	↑
NACCO INDUSTRIES	4.52	3.78	↓	7.16	-0.63	↓
PT Bukit Asam	3.47	2.44	↓	4.51	1.36	↓
Exxaro Resources Limited	2.82	2.46	↓	8.07	7.33	↓
Bisichi Mining	3.20	0.98	↓	5.05	0.24	↓
Alliance Res.	4.86	1.97	↓	5.65	4.21	↓
New Hope	2.24	0.22	↓	7.75	7.18	↓
Whitehaven Coal	2.30	1.47	↓	6.06	7.20	↑
PT Adaro Energy	4.87	3.37	↓	7.27	4.95	↓
Banpu Public Company	7.87	9.30	↑	10.29	8.18	↓

– share of exports close to 0% – share of exports up to 50% – share of exports above 50%

Source: own calculations.

Thus, in group 1, the value of the function describing the risk of bankruptcy during the Covid-19 pandemic worsens in 2 of the 7 coal companies studied. However, the function does not take a negative value in any of the companies, which means, that there is no immediate and significant threat of bankruptcy.

For Russia's invasion of Ukraine, the value of the bankruptcy function did not decrease in only 2 of the 7 entities studied, indicating a more intense combined impact of this crisis on the results in terms of profitability, liquidity and capital structure. In addition, in the case of US-based NACCO Industries, there was a high risk of bankruptcy (negative function value).

Notably, in group 1, there are 2 companies, whose situation does not deteriorate in any of the analysed crises. Therefore, they can be considered the most resilient to changes in the economic situation. These are Asian Coal India and US-based Hallador Energy, which mine thermal coal for the needs of local economies. With the former being the largest coal producer in the studied group, and the latter one of the smallest, this may mean that low sensitivity to crises is not directly related to company size.

In group 2, all coal companies in both the Covid-19 pandemic and Russia's invasion of Ukraine experience a reduction in the value of the bankruptcy function. At the same time, in the case of the latter crisis, it is deeper due to a stronger reaction of the function value. This is due to the focus of the described model on indicators relating to current profitability and liquidity, i.e., the parameters that were most strongly affected by the analysed crises, and which are also the most important for the survival of the company.

In group 3, both described economic crises cause an increased risk of bankruptcy in 3 of the 4 analysed coal companies. However, in this group, as in the previous one, there are no companies immune to economic changes. Companies with a higher share of exports in sales, therefore, find it more difficult to maintain financial equilibrium during economic turmoil.

5. Discussion

5.1. Analytical results vs. conclusions of previous studies and considerations

The study found that both the Covid-19 pandemic and Russia's invasion of Ukraine affected the operations of the surveyed coal companies and their financial performance. Nevertheless, the impact was not homogeneous, which clearly signals the variation of crisis resilience in the mining industry. It is determined by such factors, as the share of exports in total sales, geographic location, diversification of production and proximity to the crisis focus, as well as initial financial condition. The above insights complement and expand the knowledge of the economics of mining companies and their financial responses in crisis situations.

The effects of the Covid-19 pandemic had the strongest impact on the profitability of the studied coal companies. However, declines in ROA and ROE were less severe for companies with a lower share of exports in sales, including primarily Asian entities. This is consistent with the conclusions of Zhang et al. (2023) and Parra et al. (2021), indicating a pandemic increase in domestic coal production and a revival of the mining sector dictated by the need to maintain energy security. This also confirms the observations of Liu et al. (2022) on the more severe impact of the Covid-19 pandemic on hard coal exporting companies.

It's worth adding, however, that the above observations do not apply to all coal companies oriented toward supplying domestic markets. Indeed, the paper's research shows that Polish mining companies (Bumech and LW Bogdanka) have not been as resilient to the financial effects of crises as Asian companies. This could be a result of EU pressure for decarbonization, preventing the development of the mining sector in Poland. It could also be the result of unstable and inconsistent energy policies in the country.

Based on the conducted analysis, the conclusions reached by Wang et al. (2022) regarding the direct transmission of risk between the coal and oil sectors, previously observed at the macroeconomic level, cannot be fully confirmed. Indeed, from a micro perspective, it appears that coal companies with a more diversified production structure (thermal coal, coking coal, oil) had a somewhat easier time meeting the challenges of the Covid-19 pandemic.

The second of the crises described in the article, concerning Russia's invasion of Ukraine, most strongly affected Polish coal companies located in the immediate vicinity of the focus of this crisis. Unfortunately, as a result of the cessation of coal supplies from Russia, the greening of the Polish power sector could not be accelerated, as Clegg (2024) and Černoch et al. raised in their studies. (2024). Although the mining companies studied did not significantly increase internal production, Poland continued to import thermal coal, only changing the direction of its inflow, as described by Jonek-Kowalska and Grebski (2024), as well as Carmona and Dąbkowska (2024), among others. Currently, a slowdown in the pace of mining industry liquidation is also being reconsidered (Bijańska and Wodarski, 2024; Overland and Loginova, 2023; Ślusarczyk et al., 2023).

The above conundrums, as well as an analysis of the reactions and positive changes in the financial indicators of a large part of the mining companies studied during the Russia-Ukraine crisis (Yagi and Managi, 2024), entitle us to conclude, that economic crises intensify the fear concerning the possibility of losing energy security. This fear, due to the capital-intensive and time-consuming nature of energy transitions, cannot be quickly eliminated, hence the drive to increase domestic production and seek new directions for coal supply (often replacing Russian gas as well). In the face of these developments, it is difficult to support the thesis that economic crises have a positive impact on decarbonization, especially in emerging and developing economies, as Xin and Zhang (2024) also point out.

The above statement also confirms the low environmental resilience of mining companies described, among others, by Gustafsson et al. (2022) and Xiao et al. (2021), resulting primarily from the prioritization of economic objectives and the dominance of these priorities in crisis or conflict situations (Syahrir et al., 2021; Wasylycia-Leis et al., 2014). Thus, economic crises cannot be expected to accelerate the shift away from coal. It seems that energy transition is more conducive to periods of economic stability, which allows more rational planning of raw material production and energy demand.

5.2. Recommendations and policy implications

One of the more optimistic conclusions from this research, however, is that the studied companies respond very differently to crisis situations. So, as Hu and Hassik (2017) write, despite similar problems, the adaptability and resilience of mining companies in different regions can differ significantly. Thus, there is a real opportunity to strengthen the resilience of coal companies. In this regard, the following steps are recommended:

- Planning production considering national and international economic conditions, as well as opportunities for both product and geographic diversification.
- Optimizing the share of exports in sales, allowing to maximize financial results, while minimizing exposure to risk in the international raw material market.
- Securing markets through resilient logistical supply chains (Radebe, Chipangamate, 2024; Lim-Camacho et al., 2021; Maoela et al., 2024) and long-term trade contracts.
- Monitoring financial ratios and maintaining their proper levels.
- Carefully planning for net working capital requirements, which can effectively safeguard liquidity in crisis situations.
- Considering environmental and social priorities in crisis planning as well, preventing the escalation of the effects of economic changes (da Silva et al., 2021), not only for local and regional communities, but also for coal companies themselves (thinking about the continuation and development of operations in the post-crisis phase).

In conclusion of the recommendations, it is also worth noting that energy resource extraction companies are closely linked to the state and its key role in ensuring energy security. In crisis situations, therefore, the importance of and requirements for state interventionism grows, as also highlighted by Wang et al. (2022). With that said, the role of the state in mitigating economic shocks should become apparent long before economic changes occur, as the energy market is insensitive to ad hoc and short-term decisions. Therefore, key issues in this regard are the following:

- A consistent, long-term energy policy, that also considers environmental and social goals.
- Contingency plans relating to energy resource supply in the event of the loss of major import markets.

- The use of the potential of renewable energy sources in effectively enhancing energy security.
- Monitoring of the strategy, operations and financial condition of domestic energy resource extraction companies.

6. Conclusions

6.1. Diagnosis of crisis resilience of coal companies

The main conclusions of the analysis can be divided into two groups. The first concerns the financial responses to the economic crises described in the article. In this respect, the following were found:

- A decline in the profitability of coal companies during the Covid-19 pandemic and a marked, but short-lived, increase in profitability after the outbreak of the Russia-Ukraine armed conflict.
- Very good levels of profitability in Chinese and Indian companies with low volatility over time.
- A decline in liquidity during the Covid-19 pandemic in companies with a higher share of exports in sales; also, no clear impact of the Russia-Ukraine conflict on the ability to settle current obligations in mining companies of all the groups analysed.
- The association of a weak level of profitability with low (or no) liquidity, indicating a coupling of parameters assessing the financial performance of operations and ineffective financial management.
- High volatility and low levels of net working capital in most of the coal companies studied, indicating a lack of consistent management of this capital and significant exposure to liquidity risk.
- A decrease in net working capital as a reserve for liquidity in both analysed economic crises in companies with a higher share of exports in sales.
- The very low sensitivity of Total Debt Ratio to economic changes and the fulfilment by this indicator of the postulated norm in most of the coal companies studied.
- The high volatility of the ratio of Net Debt to EBIT, especially in companies with the lowest and highest shares of exports in sales, mainly due to the high volatility of operating results.

The second group of observations relates to the resilience of the surveyed coal companies to economic changes. In this regard, the following were found:

- Higher vulnerability to the financial consequences of economic crises for Polish, American and South African coal companies than for Asian and Australian companies.
- More rapid response to economic crises in companies with the weakest financial performance.
- The best crisis resilience (expressed as a weak response of financial parameters to economic changes) in coal companies with the lowest share of exports in sales.
- The possibility of developing high resilience to economic crises in coal companies operating primarily in domestic markets (no deterioration of the bankruptcy rate in the case of both crises in Indian Coal India and US Hallador Energy).
- Better average and interim financial performance (profitability, liquidity, net working capital levels, debt) at companies with the average and highest share of exports in sales, suggesting that crisis resilience is compensated for as exposure to international risk increases by the ability to realize higher financial returns.
- The relative balance between crisis resilience and financial performance in coal companies with a medium share of exports in sales (indicators that meet the norm, with moderate volatility).

6.2. Research limitations and directions for further research

This analysis is financial in nature and does not focus on other aspects of the business, which may pose a certain research limitation. Nevertheless, by doing so, it fills a research gap relating to the microeconomic view of the impact of economic changes on the operation of coal companies.

Furthermore, the relationships and reactions described are not statistically confirmed and, aside from crises, the impact of other factors on the financial condition of the companies studied is not analysed. This may impair the quality of inference, but it is in line with the ceteris paribus assumption, that allows for rational economic analyses.

Further research in the area of the resilience of companies to economic crises could be more individualized and refer to case studies of companies considered most and least resilient. This would allow for identifying the determinants of crisis resilience more broadly.

Moreover, the present study could be expanded to include macroeconomic themes relating to changes in demand, supply and, consequently, coal prices over the business cycle and their impact on the financial situation of the companies studied. This would allow a more precise link between the observed reactions and their market causes.

Acknowledgements

This research was funded by Silesian University of Technology, Poland, grant number BK-270/ROZ1/2026 (13/010/BK_26/0093).

References

1. Andrews, N., Oppong, N. (2022). How global norms matter: norm diffusion and the tangled web of localization in Ghana's extractive industry. *Globalizations*, *20(3),* 482-498. https://doi.org/10.1080/14747731.2022.2069916
2. Arbelo, A., Arbelo-Pérez, M., Pérez-Gómez, P. (2024). Internationalization and individual firm performance: a resource-based view. *Eurasian Business Review*, *14*, 881-915. https://doi.org/10.1007/s40821-024-00276-5
3. Armah, M., Amewu, G. (2022). Time-frequency dynamics of financial market stress and global economic uncertainties: evidence from the COVID-19 pandemic. *Applied Economics Letters*, *31(10),* 934-939. https://doi.org/10.1080/13504851.2022.2156465
4. Ayaaba, E., Adusei-Asante, K., Fannam Nunfam, V., Rumchev, K., Amponsah, S.K. (2024). Mining through pandemic crisis: a systematic review of the impacts of COVID-19 management strategies on mining industries in West Africa and Western Australia. *Critical Public Health*, *34(1),* 1-23. https://doi.org/10.1080/09581596.2024.2438654
5. Ayinde, T.O., Fatai, B.O., Adeyemi, F.A. (2024). Macroeconomic determinants of foreign direct investment in emerging economies in turbulent times – A case of COVID'19 pandemic. *Transnational Corporations Review*, *16(4),* 200079. https://doi.org/10.1016/j.tncr.2024.200079
6. Bijańska, J., Wodarski, K. (2023). Hard coal production in Poland in the aspect of climate and energy policy of the European Union and the war in Ukraine. Investment case study. *Resources Policy*, *88*, 104390. https://doi.org/10.1016/j.resourpol.2023.104390
7. Carmona, S., Dąbkowska, M. (2024). Uncertain transitions: Affects in the coal supply chain from Colombia to Poland. *Energy Research & Social Science*, *118*, 103740. https://doi.org/10.1016/j.erss.2024.103740
8. Černoch, F., Lehotský, L., Konvalinová, A. (2024). Navigating Russia's war and energy transition: Poland's coal challenge. *Energy Research & Social Science*, *113*, 103548. https://doi.org/10.1016/j.erss.2024.103548
9. Clegg, S. (2024). Russia, Ukraine and the climate crisis: Transforming circuits of power. *Scandinavian Journal of Management*, *40(3),* 101354. https://doi.org/10.1016/j.scaman.2024.101354

10. da Silva, J.D., Silva, F.F., Leal, A.M.M., de Oliveira, H.C. (2021). Regional economic resilience and mining in the State of Minas Gerais/Brazil: The barriers of productive specialization to formal employment and tax management. *Resources Policy*, *70*, 101937. https://doi.org/10.1016/j.resourpol.2020.101937
11. Doloreux, D., Turkina, E. (2021). New path creation in the artificial intelligence industry: regional preconditions, new actors and their collective actions, and policies. *Regional Studies*, *55(10-11),* 1751-1763. https://doi.org/10.1080/00343404.2021.1919610
12. Domínguez Romero, E., Durst, S., Navarro Garcia, A. (2024). Rethinking internationalization processes: toward a circular framework. *Review of Managerial Science*, *18*, 3363-3394. https://doi.org/10.1007/s11846-023-00719-9
13. Eger, L., Žižka, M. (2024). Industry 4.0, digital transformation and human resource management: Emerging themes and research trends in the context of the Visegrad countries. *Oeconomia Copernicana*, *15(3),* 1021-1065. https://doi.org/10.24136/oc.3034
14. Elliott, D. (2014). Disaster and Crisis Management. In: Gill, M. (eds.), *The Handbook of Security*. London: Palgrave Macmillan. https://doi.org/10.1007/978-1-349-67284-4_36
15. Filipava, L. (2024). Does Climate Change Increase Global Economic Gap? Empirical Evidence. *Journal of Poverty*, 1-22. https://doi.org/10.1080/10875549.2024.2443741
16. Gaigaliene, A., Jurakovaite, O. (2024). Post global financial crisis multiplex financial network structure longevity: Does it predict re-globalization? Empirical investigation for 234 countries. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *19(1),* 23-57. https://doi.org/10.24136/eq.3023
17. Godlewska, S. (2010). Skuteczność polskich modeli dyskryminacyjnych w ocenie zagrożenia upadłością spółek giełdowych. *Annales Universitatis Mariae Curie-Sklodowska, Sectio H*, *XLIV, 2*, pp. 701-714.
18. Gustafsson, M.-T., Rodriguez-Morales, J.E., Dellmuth, L.M. (2021). Private adaptation to climate risks: Evidence from the world's largest mining companies. *Climate Risk Management*, *35*, 100386. https://doi.org/10.1016/j.crm.2021.100386
19. Hamrol, M., Czajka, B., Piechocki, M. (2004). Upadłość przedsiębiorstwa-model analizy dyskryminacyjnej. *Przegląd Organizacji, 6*, 35-39. DOI: 10.33141/po.2004.06.09
20. Hamrol, M., Chodakowski, J. (2008). Prognozowanie zagrożenia finansowego przedsiębiorstwa. Wartość predykcyjna polskich modeli analizy dyskryminacyjnej. *Badania Operacyjne i Decyzje*, *3,* 17-32.
21. Hu, X., Hassink, R. (2017). Exploring adaptation and adaptability in uneven economic resilience: a tale of two Chinese mining regions. *Cambridge Journal of Regions, Economy and Society*, *10(3),* 527-541. https://doi.org/10.1093/cjres/rsx012
22. Izzeldin, M., Muradoğlu, Y.G., Pappas, V., Petropoulou, A., Sivaprasad, S. (2023). The impact of the Russian-Ukrainian war on global financial markets. *International Review of Financial Analysis*, *87*, 102598. https://doi.org/10.1016/j.irfa.2023.102598

23. Jonek-Kowalska, I. (2024). Demonstrating the need for a just transition: Socioeconomic diagnosis of polish cities living on hard coal mining. *Resources Policy*, *89*, 104576. https://doi.org/10.1016/j.resourpol.2023.104576
24. Jonek-Kowalska, I., Grebski, W. (2024). Comparative Analysis of Domestic Production and Import of Hard Coal in Poland: Conclusions for Energy Policy and Competitiveness. *Energies*, *17*, 5157. https://doi.org/10.3390/en17205157
25. Kao, W.S., Kao, T.C., Changchien, C.C., Wang, L.H., Yeh, K.T. (2018). Contagion in International Stock Markets After the Subprime Mortgage Crisis. *The Chinese Economy*, *51(2),* 130-153. https://doi.org/10.1080/10971475.2018.1447822
26. Kinkartz, S. (2022). *Germany's energy U-turn: Coal instead of gas*. Retrieved from: https://www.dw.com/en/germanys-energy-u-turn-coal-instead-of-gas/a-62709160, 27.01.2025.
27. Kisielińska, J., Waszkowski, A. (2010). Polskie modele do prognozowania bankructwa przedsiębiorstw i ich weryfikacja. *Zeszyty Naukowe SGGW*, *82*, 17-31. https://doi.org/10.22630/EIOGZ.2010.82.14
28. Klayme, T., Gokmenoglu, K.K., Rustamov, B. (2023). Economic policy uncertainty, COVID-19 and corporate investment: Evidence from the gold mining industry. *Resources Policy*, *85*, 103787. https://doi.org/10.1016/j.resourpol.2023.103787
29. Kozub-Idźkowska, M., Proniewski, M. (2011). Financial Crisis in Central and Eastern Europe? Development Differentiation in the Regions. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *6(1),* 85-107. https://doi.org/10.12775/EQUIL2011.005
30. Kramarz, T. (2021). Extractive industry disasters and community responses: a typology of vulnerable subjects. *Environmental Politics*, *31(1),* 89-109. https://doi.org/10.1080/09644016.2021.1978198
31. Kulyk, V.V. (2023). Modeling the Inter-Industry Economy as a Critical Infrastructure: Generating Scenarios for the Development of the Economy of Ukraine under the Conditions of War and the Post-War Recovery. *Cybernetics and Systems Analysis*, *59*, 967-985. https://doi.org/10.1007/s10559-023-00633-8
32. Li, Y., Wang, L., Cao, Q., Gu, X., Lu, Y., Luo, Y. (2024). Exploring an adaptive management model for "status-optimization-regulation" of mining city in transition: A case study of Huangshi, China. *Applied Geography*, *172*, 103438. https://doi.org/10.1016/j.apgeog.2024.103438
33. Lim-Camacho, L., Jeanneret, T., Hodgkinson, J.H. (2021). Towards resilient, responsive and rewarding mining: An adaptive value chains approach. *Resources Policy*, *74*, 101465. https://doi.org/10.1016/j.resourpol.2019.101465
34. Liu, K., Chen, Y., Zheng, W. (2022). Impact of COVID-19 on China's coal imports: effects and solutions. *Transnational Corporations Review*, *14(1),* 31-45. https://doi.org/10.1080/19186444.2022.2025728

35. Maconachie, R., Conteh, F.M. (2025). Stuck in transition? Artisanal mining, livelihood diversification and rural change in Sierra Leone. *The Extractive Industries and Society*, *22*, 101604. https://doi.org/10.1016/j.exis.2024.101604
36. Maoela, M.B., Chapungu, L., Nhamo, G. (2024). The socio-economic impacts of COVID-19 on selected mining companies in Limpopo Province, South Africa. *The Extractive Industries and Society*, *18*, 101462. https://doi.org/10.1016/j.exis.2024.101462
37. Merli, A. (2024). The Global Economy Between the Pandemic and the War. In: Kotler, P., Pfoertsch, W., Ancarani, F., Ureta, I. (eds.), *Humanism in Marketing*. Humanism in Business Series. Cham: Palgrave Macmillan. https://doi.org/10.1007/978-3-031-67155-5_4
38. Nerlinger, M., Utz, S. (2022). The impact of the Russia-Ukraine conflict on energy firms: A capital market perspective. *Finance Research Letters*, *50*, 103243. https://doi.org/10.1016/j.frl.2022.103243
39. Overland, I., Loginova, J. (2023). The Russian coal industry in an uncertain world: Finally pivoting to Asia? *Energy Research & Social Science*, *102*, 103150. https://doi.org/10.1016/j.erss.2023.103150
40. Parra, P.Y., Hauenstein, Ch., Oei, P.-Y. (2021). The death valley of coal – Modelling COVID-19 recovery scenarios for steam coal markets. *Applied Energy*, *288*, 116564. https://doi.org/10.1016/j.apenergy.2021.116564
41. Pata, U.K., Cevik, E.I., Destek, M.A., Dibooglu, S., Bugan, M.F. (2023). The impact of geopolitical risks on clean energy mineral prices: Does the Russia-Ukrainian war matter? *International Journal of Green Energy*, *21(9),* 2102-2116. https://doi.org/10.1080/15435075.2023.2295867
42. Radebe, N., Chipangamate, N. (2024). Mining industry risks, and future critical minerals and metals supply chain resilience in emerging markets. *Resources Policy*, *91*, 104887. https://doi.org/10.1016/j.resourpol.2024.104887
43. Ragab, E., Sultan, N. (2024). National security outweighs norms and principles: Egypt's foreign policy towards the Russia-Ukraine war. *Contemporary Security Policy*, *45(4),* 684-697. https://doi.org/10.1080/13523260.2024.2406163
44. Seabrooke, L. (2010). What Do I Get? The Everyday Politics of Expectations and the Subprime Crisis. *New Political Economy*, *15(1),* 51-70. https://doi.org/10.1080/13563460903553608
45. Shen, S., Venaik, S., Zhu, Y.A. (2024). Dynamic Model of Internationalization and Innovation in Emerging Market Enterprises: Knowledge Exploration, Transformation, and Exploitation. *Management International Review*, *63*, 561-601. https://doi.org/10.1007/s11575-023-00509-1
46. Shoufu, Y., Dan, M., Zuiyi, S., Lin, W., Li, D. (2022). The impact of artificial intelligence industry agglomeration on economic complexity. *Economic Research [Ekonomska Istraživanja], 36(1),* 1420-1448. https://doi.org/10.1080/1331677X.2022.2089194

47. Sienkiewicz-Małyjurek, K. (2020). Odporność i przedsiębiorczość w zarządzaniu kryzysowym. In: M. Ćwiklicki, K. Sienkiewicz-Małyjurek, (Eds.), *Ekonomia Społeczna. Przedsiębiorczość społeczna w czasie kryzysu* (pp. 22-36). Kraków: Uniwersytet Ekonomiczny w Krakowie. https://doi.org/10.15678/ES.2020.2.03

48. Ślusarczyk, B., Chłąd, M., Michałek, J., Dacko-Pikiewicz, Z., Androniceanu, A. (2023). Strategies for supplying enterprises with energy in the context of changing coal prices on the Polish market - The effect of the war in Ukraine. *Resources Policy*, *85*, 104028. https://doi.org/10.1016/j.resourpol.2023.104028

49. Swoczyna, B., Karaczun, Z. (2021). A mainstay of budget? Coal mining as a source of revenue for Polish local governments. *Energy Policy*, *180*, 113658. https://doi.org/10.1016/j.enpol.2023.113658

50. Syahrir, R., Wall, F., Diallo, P. (2021). Coping with sudden mine closure: The importance of resilient communities and good governance. *The Extractive Industries and Society*, *8(4),* 101009. https://doi.org/10.1016/j.exis.2021.101009

51. Tarapata, J., Woźniak, J. (2022). *Odporność organizacji*. Difin: Warszawa, 10-12.

52. Valaskova, K., Nagy, M., Grecu, G. (2024). Digital twin simulation modeling, artificial intelligence-based Internet of Manufacturing Things systems, and virtual machine and cognitive computing algorithms in the Industry 4.0-based Slovak labor market. *Oeconomia Copernicana*, *15(1),* 95-143. https://doi.org/10.24136/oc.2814

53. Vukovic, D.B., Hanic, E., Hanic, H. (2017). Financial integration in the European Union - the impact of the crisis on the bond market. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *12(2),* 195-210. https://doi.org/10.24136/eq.v12i2.10

54. Wang, Q., Yang, X., Li, R. (2022). The impact of the COVID-19 pandemic on the energy market – A comparative relationship between oil and coal. *Energy Strategy Reviews*, *39*, 100761. https://doi.org/10.1016/j.esr.2021.100761

55. Wasylycia-Leis, J., Fitzpatrick, P., Fonseca, A. (2014). Mining Communities from a Resilience Perspective: Managing Disturbance and Vulnerability in Itabira, Brazil. *Environmental Management, 53*, 481-495. https://doi.org/10.1007/s00267-014-0230-1

56. Wędzki, D. (2009). *Analiza wskaźnikowa sprawozdania finansowego*. *Tom* 2 *– wskaźniki finansowe.* Kraków: Wolters Kluwer.

57. Wojnar, J. (2014). Ocena skuteczności modeli analizy dyskryminacyjnej do prognozowania zagrożenia finansowego spółek giełdowych. *Zeszyty Naukowe Małopolskiej Wyższej Szkoły Ekonomicznej w Tarnowie*, *1(24),* 219-231.

58. Xiao, W., Chen, W., Deng, X. (2021). Coupling and coordination of coal mining intensity and social-ecological resilience in China. *Ecological Indicators*, *131*, 108167. https://doi.org/10.1016/j.ecolind.2021.108167

59. Xin, B., Zhang, M. (2024). Evolutionary game on international energy trade under the Russia-Ukraine conflict. *Energy Economics*, *125*, 106827. https://doi.org/10.1016/j.eneco. 2023.106827

60. Yagi, M., Managi, S. (2024). The spillover effects of rising energy prices following 2022 Russian invasion of Ukraine. *Economic Analysis and Policy*, *77*, 680-695. https://doi.org/10.1016/j.eap.2022.12.025
61. Yu, Z., Liang, Z., Xue, L. (2021). A data-driven global innovation system approach and the rise of China's artificial intelligence industry. *Regional Studies*, *56(4),* 619-629. https://doi.org/10.1080/00343404.2021.1954610
62. Zabłocka-Kluczka, A. (2014). Odporność swoista organizacji. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, *299*, 318-328. https://doi.org/10.15611/pn.2014.359.30
63. Zhang, F., Lu, J., Chen, L. (2023). When green recovery fails to consider coal pushback: Exploring global coal rebounds, production, and policy retrenchment post Covid-19. *Energy Research & Social Science*, *101*, 103142. https://doi.org/10.1016/j.erss.2023.103142
64. Zheng, S.Y., Li, X., Li, J., Li, B., Hafeez, M. (2023). Assessing the COVID-19 impact on economy, health and natural resource prices: An evidence from selected Asian economies. *Resources Policy*, *87*, 104289. https://doi.org/10.1016/j.resourpol.2023.104289

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE USE OF SELECTED METHODS IN THE ANALYSIS OF THE EFFICIENCY OF THE MACHINE AND DEVICE – CASE STUDY

Edyta KARDAS[1*], Zbigniew SKUZA[2]

[1] Faculty of Production Engineering and Materials Technology, Czestochowa University of Technology; edyta.kardas@pcz.pl, ORCID: 0000-0001-7699-2622
[2] Faculty of Production Engineering and Materials Technology, Czestochowa University of Technology; zbigniew.skuza@pcz.pl, ORCID: 0000-0002-4528-9456
* Correspondence author

Purpose: The main purpose of the paper was the assessment of efficiency of selected machine and identification of causes of low efficiency.
Design/methodology/approach: During the analysis three main methods were used: OEE, PAMCO and Ishikawa chart. The analysis covers one calendar year. The analysis was conducted for Bole EKH 90 injection molding machine.
Findings: The analysis showed that low utilization of available time of machine was the main problem. It was caused by many factors, three of them are important: employee factor, machine condition and management.
Research limitations/implications: It should be noted that such an analysis should be further explored, using additional assessment methods and tools, which would allow for even more detailed identification of problems in the future.
Originality/value: The paper presents the example that shows that the low efficiency leads to operational losses. However, the proper use of selected methods give possibility to identify factors decreasing the productivity and to make improvements.
Keywords: efficiency, machine and device, OEE, PAMCO, Ishikawa chart.
Category of the paper: research paper, case study.

1. Introduction

One of the most important elements in assessing the performance of any enterprise is the assessing the effectiveness of its operations as a whole and of its individual components. Efficient use of its resources, including machinery and equipment, yields tangible results in the form of reduced production costs and increased profits. Therefore, the concept of efficiency should be defined.

The diversity of existing organizational and management theories means that efficiency is considered from the perspectives of, among others, general knowledge, praxeology, production management, quality management, value-added management, and business informatics (Głodziński, 2015).

The concept of efficiency has evolved over many years, gaining new meanings. It has become so broad that it combines various categories, such as efficiency, effectiveness, competence, functionality, communication skills, morality, and ecology (Tyrańska, 2009).

According to the PWN Dictionary of the Polish Language (PWN, 2026), efficient means "producing good results, effective", while according to the Management Encyclopedia (EZ, 2026): "Efficiency is the result of undertaken actions, described by the ratio of obtained effects to incurred inputs. It means the best results in production, distribution, sales, or promotion, obtained at the lowest cost".

Generally, efficiency is defined by the degree to which a system utilizes its resources. It can be measured using the following relationship (Głodziński, 2015):

$$Efficiency = \frac{\text{Output}}{\text{Input}} \tag{1}$$

In economics and management sciences, efficiency in general can be treated as a positive characteristic of the result of any action (Pszczołowski, 1978). These actions are usually considered from two perspectives: economic or organizational. The economic aspect refers to the allocation of inputs and technical factors, such as pure technical efficiency and scale efficiency. In turn, the organizational aspect encompasses concepts such as effectiveness, expediency, economy, efficiency, functionality, expandability, profitability, rationality, efficiency, motivation, as well as communicativeness, flexibility, interchangeability, competence, common sense, normativity, professionalism, honesty and acceptability (Becla et al., 2024).

The literature offers many approaches to classifying efficiency. The most common classification is based on the aspect being assessed (Kozuń-Cieślak, 2013):

1. Economic efficiency means achieving specific results with the lowest possible inputs or obtaining the highest possible output from given resources.
2. Organizational efficiency is associated with the efficient functioning of an organization, proper coordination of activities, rational division of tasks, and skillful use of resources.
3. Technical efficiency means the ability to achieve maximum production with a given set of inputs or achieve a desired effect with minimal resource consumption.
4. Labor efficiency is the relationship between the results obtained and the inputs incurred to achieve them, in particular working time, effort, and resources used.
5. Social efficiency refers to the social outcomes of activities, such as improved quality of life, increased availability of services or reduced exclusion.
6. Energy efficiency is the ratio of obtained results, services, goods, or energy to the energy input.

Various assessment tools are used to measure efficiency. In the case of technical efficiency, these include productivity indicators, indicators of economic resource utilization, production quality indicators, and productivity audits and benchmarking (Jaki, 2011).

Technical efficiency is assessed by assessing the performance of machines, equipment, and technical systems, human activity, the functioning of the organization and its individual components (e.g., workstations, departments, projects), the state of individual sectors, the overall economy, and socioeconomic systems (Głodziński, 2015).

One important element of assessing a company's technical efficiency is analyzing the efficiency of machinery and equipment used in production processes. This allows for the improvement of these devices' performance and, consequently, the optimization of production costs.

Machinery and equipment efficiency refers to the degree to which machines, devices, and installations are used efficiently, reliably and economically (Productivity Press Development Team, 1999). This is demonstrated by achieving high productivity, minimizing downtime, reducing failure rates, and maximizing the technical capabilities of the equipment (Muchiri, Pintelon, 2008). Machinery and equipment efficiency is also demonstrated by their ability to operate with the lowest possible consumption of energy, consumables and maintenance time (Hedman et al., 2016). In practice, high machine and equipment efficiency increases production, reduces operating costs, and improves the quality of processes [Productivity Press Development Team, 1999; Muchiri, Pintelon, 2008). Machinery efficiency assessment methods include various indicators and analytical tools that allow for the determination of equipment utilization and operational efficiency (Muchiri, Pintelon, 2008). The most commonly used include the OEE (Overall Equipment Effectiveness) indicator, the PAMCO (Plant & Machine Control) machine operating time utilization method, failure rate analysis, production efficiency measurement, product quality assessment, and operating cost analysis (Hedman et al., 2016; Gupta, Garg, 2012). Thanks to these methods, it is possible to detect downtime, losses and irregularities in the operation of machines and then take actions to improve their efficiency and reliability (Muchiri, Pintelon, 2008; Hedman et al., 2016).

The main goal of this paper is the assessment of the utilization of operating time of a selected device operating in a Polish company and to identify opportunities for improving its performance by increasing operating time utilization and efficiency. The article utilizes two methods for assessing machine efficiency: OEE and PAMCO. Additionally, an Ishikawa diagram was used to identify the key factors negatively impacting efficiency. The analysis was based on results collected during one calendar year of operation of the tested device.

2. Characteristics of research object

This paper analyzes the operation of a selected machine operating in an existing manufacturing facility. This machine, the Bole EKH 90 injection molding machine, is a servo-hydraulic injection molding machine with a clamping force of 90 tons. It is designed for injection molds in industries such as automotive, household appliances, electronics, and many others. It features a central toggle system that ensures full utilization of the clamping force, resulting in higher production precision (bole-europe.com, 2026).

Main parameters of the machine (bole-europe.com, 2026):

- clamping force: 90 tonnes,
- drive system: servo-hydraulic,
- power consumption: 3 kWh,
- injection weight: 80 g,
- screw diameter: 32 mm.

Figure 1 presents general view of the Bole EKH 90 injection molding machine.



Figure 1. Bole EKH 90 injection molding machine.
Source: bole-europe.com, 2026.

3. Methodology

The analysis of efficiency of the tested machine was based on the results from existed company. It covers one calendar year. Data collected to the analysis are divided into four quarters. The whole analysis was divided into three parts:

1. OEE (Overall Equipment Effectiveness) analysis.
2. PAMCO (Plant and Machine Control) analysis.
3. Ishikawa chart for the main reason decreasing the efficiency of machine.

The analysis was conducted in one of Polish companies. Due to trade secrets, the name of company is omitted. However, the company operates in the plastics industry, producing household appliances.

3.1. OEE analysis

During the first part of the analysis OEE indicators were calculated. The OEE (Overall Equipment Effectiveness) analysis is a measure of operational efficiency of machines and devices. It is also an indicator-based method that evaluates its basic indicators (Borkowski, Ulewicz, 2008):

- Availability – the machine's operating time.
- Utilization – the percentage of utilization at its maximum capacity.
- Quality – the quality level of the products it produces.

Based on the above-mentioned parameters the OEE indicator is determined, which can be used to assess the total operational efficiency of the machine. Detailed descriptions of the indicators used in the analysis can be found in numerous research papers related to production management and the analysis of machine and equipment performance (Borkowski, Ulewicz, 2008; Kurnia et al., 2022; AlMashaqbeh, Munive-Hernandez, 2024).

3.2. PAMCO analysis

During the second part of analysis PAMCO method was used. It helps to analyze the efficiency of time of work of machine more detailed. The PAMCO (Plant and Machine Control) method, also known as the machine resource utilization assessment method, involves a ratio analysis of machine operating time, dividing these times into types related to its active operation and interruptions resulting from various groups of factors. The analysis includes eight main indicators expressing the ratio of the duration of various types of activities to total time (related to the length of the analyzed period), available time (reduced by interruptions resulting from the machine's work schedule), or production time (reduced by interruptions related to unused or non-operational time) (Borkowski, Ulewicz, 2008):

- Production Efficiency indicator (PE).
- Operational Efficiency indicator (OE).
- Available Utilization indicator (AU).
- Asset Availability indicator (AA).
- Asset Utilization indicator (Aut).
- Operational Utilization indicator (OU).
- Production Utilization indicator (PU).
- Effective Utilization indicator (EU).

Detailed descriptions of the indicators used in the analysis can be found in numerous research papers related to production management and the analysis of machine and equipment performance indicators (Borkowski, Ulewicz, 2008; Borkowski et al., 2014, Ingaldi, 2015).

3.3. Ishikawa chart

The cause analysis was made for the most significant reason of decreasing efficiency of the machine. Ishikawa chart was used in the paper. The Ishikawa diagram is a graphical analysis of the influence of various factors and their interrelationships that cause a specific quality problem and an analysis of the results (effects) caused by the operation of these interrelationships. All causes identified in the work were grouped according to the traditional classification, the so-called 5M: Manpower (Man), Methods, Machinery (Machine), Materials, Management (Wong et al., 2016; Botezatu et al., 2019).

4. Results

The analysis of efficiency of selected machine was made. It was divided into two part: OEE (Overall Equipment Effectiveness) and PAMCO (Plant and Machine Control). According to the results of this analysis the main reason of decreasing efficiency of the machine was identified. The, the cause analysis was made for this reason using Ishikawa chart.

It must be underline that the during the study period the following values of production parameters were recorded:

- Average working time fund – approx. 130 000 min.
- Average planned working time found – approx. 110 000 min.
- Average time of downtime (planned and unplanned) – approx. 45 000 min.
- Average quarterly production – approx. 17 000 pieces.
- Average quality level percentage of defects– approx. 2%.

4.1. OEE (Overall Equipment Effectiveness) analysis

First step of the analysis was using OEE method to the estimation of efficiency of the tested machine. The main indicators were calculated. The results are presented in Table 1.

Table 1.
Results of OEE analysis of efficiency of the tested machine.

	Availability, %	**Utilization, %**	**Quality, %**	**OEE, %**
Quarter 1	82.8%	78.6%	98.3%	64.0%
Quarter 2	85.0%	82.1%	97.4%	68.0%
Quarter 3	84.2%	80.7%	97.9%	66.5%
Quarter 4	80.2%	75.2%	98.2%	59.2%
World class value (Borkowski, Ulewicz, 2008; Kurnia et al., 2022; AlMashaqbeh, Munive-Hernandez, 2024)	**90%**	**95%**	**99.9%**	**85%**

Source: Own study.

According to results of the analysis presented in Table 1, it can be said that:

- The availability indicator was in the range from 80.2 to 85% and it was lower than the preferred value of 90%. The highest value was noticed in the second quarter while the lowest – in the fourth.
- The utilization indicator was in the range from 75.2 to 82.1% and it was lower than the preferred value of 95%. The highest and the lowest value was noticed in the same quarters as previous indicator.
- The quality indicator was in the range from 97.4 to 98.3% and it was a bit lower than the preferred value of 99.9%. Diversity of values was very small, the lowest values were noticed in the middle of analyzed time.
- The OEE indicator was in the range from 59.2 to 68% and it was much lower than the preferred value of 85%. The highest and the lowest value was noticed in the same quarters as availability and performance indicators.
- It should be underline that problems with utilization of the machine was the biggest cause of low efficiency of the machine.

4.2. PAMCO (Plant and Machine Control) analysis

The PAPMCO analysis was made in the next step. The purpose of this method is to analyze use of machine operating time. Main indicators were calculated. The results are presented in Table 2.

Table 2.
Results of PAMCO analysis of efficiency of the tested machine.

	PE, %	**OE, %**	**AU, %**	**AA, %**	**AUt, %**	**OU, %**	**PU, %**	**EU, %**
Quarter 1	98.92%	77.71%	95.98%	67.96%	65.74%	65.23%	51.25%	50.69%
Quarter 2	99.32%	78.88%	96.99%	69.96%	68.45%	67.86%	53.89%	53.53%
Quarter 3	98.45%	74.41%	96.82%	59.78%	58.65%	57.88%	43.75%	43.07%
Quarter 4	99.29%	74.37%	91.07%	65.40%	59.96%	59.56%	44.61%	44.29%
Optimal value (Borkowski, Ulewicz, 2008; Borkowski et al., 2014, Ingaldi, 2015)	**95%**	**92.5%**	**90%**	**97%**	**65%**	**62%**	**60%**	**50%**

Source: Own study.

According to results of the analysis presented in Table 2, it can be said that:

- Production Efficiency indicator (PE) - the optimal value should be greater than 95%, while results are in the range of 98.45–99.32%. Values are only a bit higher than optimum.
- Operational Efficiency indicator (OE) - the optimal value of approximately 92.5%, results are lower than optimum and in the range of 74.37-78.88%.
- Available Utilization indicator (AU) indicator, with a recommended value of approximately 90%, has values in the range of 91.46-98.93%.

- Asset Availability indicator (AA) indicator, for which recommended value is approximately 97%, has much lower values in the range of 59.78-69.96%.
- Asset Utilization indicator (AUt) - the optimal value is 65%, while results are in the range of 58.65-68.45%.
- Operational Utilization indicator (OU), recommended at approximately 62%, has values in the range of 57.88- 67.86%.
- Production Utilization indicator (PU) – the optimal value above 65%, while results are the range of 43.75-53.89%, below the recommended value.
- Effective Utilization indicator (EU) – the optimal value is approximately 50%, ranging from 43.07-53.53%

Based on the analysis of the results, it can be seen two indicators (PE, AU) were higher than recommended values, while three of them (OE, AA, PU) – lower. In case of three indicators (AUT, OU, EU) values the values fluctuated around the optimal values.

4.3. Ishikawa chart of causes of low utilization of available time of machine

According to the previous analysis the main problem causes low values of efficiency of analyzed machine was problem with low utilization of available time of machine during production process. The analysis of causes of such problem was made. During the analysis Ishikawa chart was used. The results are presented in Figure 2.

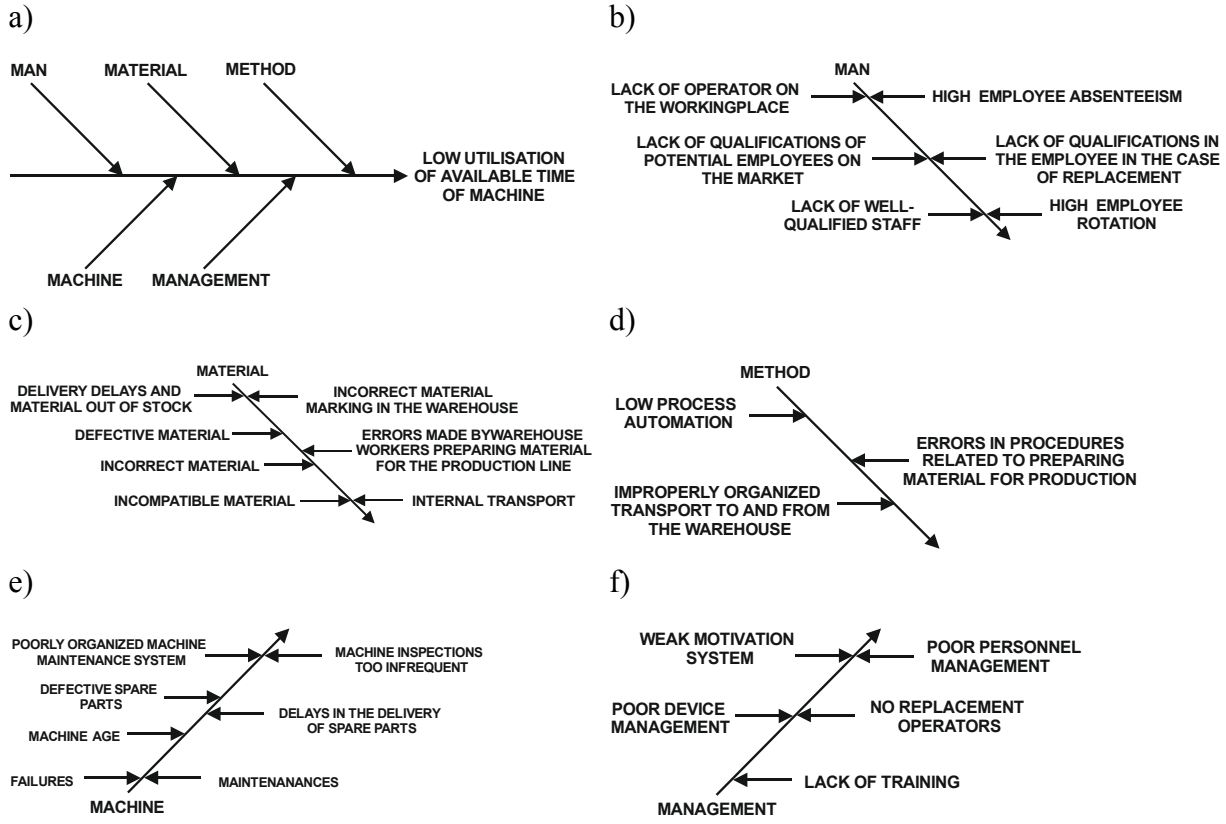


Figure 2. Ishikawa chart for the cause of low values of efficiency of analyzed machine.

Source: Own study.

According to the analysis of Ishikawa chart (Figure 2) it can be said that there are many causes of the problem in the analyzed process. All of them were divided in six groups and it can be observed that some causes in separate group are connected.

5. Discussion of results

It must be said that low efficiency of tested machine is observed. It is caused by many different reasons. Each analysis shows the problem from different point of view.

Based on the result of OEE analysis it can be said that values of the main OEE indicator is on the average level of 64.4% so it is much lower than optimal word class value of 85%. So, it should be concluded that efficiency of analyzed machine is low. The value of the OEE indicator depends on the values of the auxiliary indicators:

- Availability – average value of this indicator for the entire research period was on the level of 83%, while recommended value is 90%. It means that planned stops accounted for 17% of the machine's time fund. It was mainly connected with planned repairs and maintenance.
- Utilization – average value of this indicator for the entire research period was on the level of 79%, while recommended value is 95%. So, it should be concluded that value of this parameter caused the biggest problem in the low value of OEE,
- Quality – average value of this indicator for the entire research period was on the level of 98%, while recommended value is 99.9%.

Based on the result of PAMCO analysis it can be said that main indicator, effective utilization indicator (EU) is, on the average, on the optimal level. Its average value is nearly 48%, while the optimum 50%. However, the analysis of other indicators shows that three of them that:

- Production utilization indicator (PU) - production time accounts for only about 45% of the total time (optimal value 60%). This means that the remaining time includes various breaks when the machine could be used.
- Asset availability indicator (AA) - This indicator is indirectly related to the PU indicator. The average for this indicator is very low, at only 66% (the optimal value is 97%). This is due to only partial utilization of the total machine time. The company operates on a single-shift system, so the device is used only 8 hours a day, the rest of the time is unused.
- Operational efficiency indicator (OE) – the average value of this indicator is on the level of 76% while optimum should be 92.5%. In case of this indicator low operational efficiency results from various types of interruptions during machine operation. These include planned and routine interruptions (maintenance or routine changes to the device).

- The differences between the PU and AA indicators show that the examined enterprise records a very long period of complete machine unusability due to free time, planned and unplanned breaks are a much less significant factor reducing the efficiency of the device.

The Ishikawa helped to analyze the main problem causes low values of efficiency of analyzed machine was problem with low utilization of available time of machine during production process. It shows that main problems are:

1. Man – human resources and manpower:
   - The shortage of machine operators poses a significant challenge in ensuring the machine's continuous operation. A lack of operators leads to production delays and reduces machine efficiency.
   - Frequent employee absences, such as sick leave and vacations, and difficulties in finding replacements.
   - Poorly qualified employees who replace others in their absence can cause numerous errors and downtime during the production process.
   - High demand for specialists in the labor market leads to significant employee turnover, which necessitates hiring people with insufficient qualifications. Difficulties in hiring employees with the appropriate qualifications for a given position, often due to lack of experience.
2. Machine – maintenance of equipment:
   - Poorly organized machine maintenance system.
   - The significant age of the device and its significant wear and tear cause frequent breakdowns and machine downtime.
   - Insufficient machine inspection frequency can lead to more frequent breakdowns, which leads to machine downtime and may also require temporary shutdowns.
   - Lack of regular maintenance action leads to breakdowns and downtime. Insufficient attention to technical condition results in unplanned downtime.
   - Too frequent breakdowns are the result of a lack of proper maintenance and improper equipment management, which directly impacts their availability.
   - Shortages in the supply of spare parts.
   - Defective spare parts.
3. Material – proper parameters, quantity and quality of material in right time:
   - Problems with the supply of materials and spare parts lead to downtime.
   - Inadequate quality of materials used in production also contributes to delays and the need for downtime.
   - Errors when delivering incorrect material to the workstation cause additional downtime: material with incorrect parameters, errors in material deliveries to the production line.

- Failure to follow procedures and employee inattention often result in incorrect preparation of material transferred to the production line.
- Problems with internal transport result in problems with delivering material to the production line and delays in product transport, which can cause unnecessary downtime.

4. Management – personnel management:
   - Poor personnel management, both production staff and warehouse employees, reduces their work efficiency and negatively impacts the production process itself.
   - Inadequate organization of staff work, including the lack of a replacement system in the event of operator absences, contributes to limited availability.
   - Low qualifications of operators, resulting from a lack of appropriate training, contribute to inefficient utilization and an increased risk of failure.
   - Incorrect planning of inspections and incorrect planning of the use of a given device can significantly reduce its efficiency.
5. Method – organization of work:
   - Incorrectly organized transport to and from warehouse.
   - Errors in procedures related to preparing material for production.

According to the analysis presented in this paper it must be said that the relationship between the OEE, PAMCO, and Ishikawa results is consistent. OEE identifies the general problem of low effectiveness, PAMCO shows that the main losses are connected with insufficient use of available time and low asset availability, while the Ishikawa diagram indicates the probable root causes of these losses. This confirms that the problem should not be treated only as a technical failure of the machine. It is also connected with production planning, maintenance organization, staff management, material flow, and work procedures. For this reason, improvement actions should be systemic and should involve both technical and organizational measures.

The first recommended direction of improvement is the development of a more effective maintenance system. Preventive maintenance should be planned on the basis of machine condition, failure history, and production load. Regular inspections, faster access to spare parts, and better documentation of failures could reduce unplanned downtime and improve availability. The second important direction is better organization of labor resources. The company should introduce a replacement system for absent operators, improve training for new and substitute workers, and standardize operating procedures. These actions could reduce interruptions caused by operator shortages and insufficient qualifications.

Another possible improvement is better planning of production time. Since the low AA and PU indicators are strongly connected with the single-shift system, the company should analyze whether extending machine operation to an additional shift would be economically justified. Even partial extension of working time could increase the use of the machine without the need

for new investment in equipment. At the same time, the flow of materials and spare parts should be improved by introducing clearer procedures for material preparation, internal transport, and delivery control. This would reduce the risk of waiting time caused by incorrect or delayed materials.

In summary, the obtained results show that the analyzed injection molding machine has significant potential for efficiency improvement. The production process produces parts of relatively good quality, but the machine is not used intensively enough and is affected by organizational and maintenance-related interruptions. The most important improvement opportunities are connected with increasing utilization, reducing downtime, improving maintenance planning, strengthening operator availability and competence, and ensuring better material flow. Implementation of these actions should lead to higher availability and utilization values and, as a result, to a gradual increase in the OEE indicator.

6. Conclusion

Efficient resource utilization is a key factor influencing a company's success. Low efficiency leads to operational losses and, consequently, reduced profits. This article analyzes the efficiency of a selected machine in a manufacturing company. The analysis revealed that the primary factor reducing the efficiency of the analyzed machine is the inappropriate use of available operating time. Causes that significantly impacted this situation included: employee factor (absenteeism and low qualifications of replacement line workers or new employees), machine condition (age, improper maintenance activities, breakdowns), and poor management. This factor is largely linked to the previous two. Improving employee work organization and machine maintenance will significantly improve its efficiency. However, it should be noted that such an analysis should be further explored, using additional assessment methods and tools, which would allow for even more detailed identification of problems in the future.

References

1. AlMashaqbeh, S., Munive-Hernandez, E. (2024). Evaluation and improvement of a plastic production system using integrated OEE methodology: A case study. *Management Systems in Production Engineering, 32(3),* 450-463. https://doi.org/10.2478/mspe-2024-0042
2. Becla, A., Czaja, S., Tutaj, J. (2024). *Spory wokół pojęcia efektywności gospodarowania i pojęć pochodnych we współczesnej literaturze i praktyce gospodarczej*. Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu.
3. Borkowski, S., Ulewicz, R. (2008). *Zarządzania produkcją, systemy produkcyjne*. Humanitas.
4. Borkowski, S., Knop, K., Mielczarek, K. (2014). A comparative analysis of effectiveness for work time utilization of air bags sewing machines based on PAMCO times and coefficients. In: S. Borkowski, M. Krynke (Eds.), *Machines operating conditions* (pp. 48-59). Oficyna Wydawnicza Stowarzyszenia Menedżerów Jakości i Produkcji.
5. Botezatu, C., Condrea, I., Oroian, B., Hriţuc, A., Eţcu, M., Slătineanu, L. (2019). Use of the Ishikawa diagram in the investigation of some industrial processes. *IOP Conference Series: Materials Science and Engineering, 682(1),* 012012. https://doi.org/10.1088/1757-899X/682/1/012012
6. Encyklopedia Zarządzania (n.d.). *Efektywność.* mfiles.pl, 27.05.2026.
7. Głodziński, E. (2015). Efektywność w naukach o zarządzaniu. Przyczyny wieloznaczności i rekomendacje dotyczące ich ograniczenia. *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie, 83,* 165-176.
8. Gupta, A.K., Garg, R.K. (2012). OEE improvement by TPM implementation: A case study. *International Journal of IT, Engineering and Applied Sciences Research (IJIEASR), 1(1),* 115-124.
9. Hedman, R., Subramaniyan, M., Almström, P. (2016). Analysis of critical factors for automatic measurement of OEE. *Procedia CIRP, 57*, 128-133. https://doi.org/10.1016/j.procir.2016.11.023
10. https://bole-europe.com/, mfiles.pl, 27.05.2026.
11. Ingaldi, M. (2015). Use of the PAMCO method for assessing the effectiveness of the rolling mill. *Hutnik-Wiadomości Hutnicze, 83(11),* 517-519.
12. Jaki, A. (2011). Paradygmat efektywności w zarządzaniu. *Przegląd Organizacji, 4,* 3-7. https://doi.org/10.33141/po.2011.04.01
13. Kozuń-Cieślak, G. (2013). Efektywność – rozważania nad istotą i typologią. *Kwartalnik Kolegium Ekonomiczno-Społecznego. Studia i Prace, 4,* 13-42. https://doi.org/10.33119/KKESSiP.2013.4.1

14. Kurnia, H., Jaqin, C., Purba, H.H. (2022). The PDCA approach with OEE methods for increasing productivity in the garment industry. *Jurnal Ilmiah Teknik Industri, 10(1),* 57-68.
15. Muchiri, P., Pintelon, L. (2008). Performance measurement using overall equipment effectiveness (OEE): Literature review and practical application discussion. *International Journal of Production Research, 46(13),* 3517-3535. https://doi.org/10.1080/00207540601142645
16. Productivity Press Development Team (1999). *OEE for operators: Overall equipment effectiveness.* Productivity Press. https://doi.org/10.4324/9780367807528
17. Pszczołowski, T. (1978). *Mała encyklopedia prakseologii i teorii organizacji*. Zakład Narodowy im. Ossolińskich.
18. Tyrańska, M. (2009). Jakość kapitału ludzkiego a efektywność przedsiębiorstwa. *Problemy Jakości, 5*, 9-16.
19. Wong, K.C., Woo, K.Z., Woo, K.H. (2016). Ishikawa diagram. In: W. O'Donohue, A. Maragakis (Eds.), *Quality improvement in behavioral health*. Springer. https://doi.org/10.1007/978-3-319-26209-3_9.
20. Wydawnictwo Naukowe PWN (n.d.). *Słownik języka polskiego PWN*. https://sjp.pwn.pl/, mfiles.pl, 27.05.2026.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

CUSTOMER-FACING EMPLOYEES' KNOWLEDGE USE BY SUPERVISORS IN MARKET-IMMATURE SMES

Marcin KOMAŃDA[1*], Wiktor ZYGOSZ[2], Masoud HAJIZADE[3], Honorata KSIĄŻEK[4]

[1] Opole University of Technology; m.komanda@po.edu.pl, ORCID: 0000-0003-1695-2949
[2] Opole University of Technology; w.zygosz@po.edu.pl, ORCID: 0009-0009-4608-0337
[3] Opole University of Technology; masoud.hajizade@student.po.edu.pl, ORCID: 0009-0006-8214-5538
[4] Opole University of Technology; h.ksiazek@po.edu.pl, ORCID: 0009-0008-9598-5741
* Correspondence author

Purpose: The Knowledge Management (KM) literature draws on multiple perspectives to describe this issue. Articles published on the research problem are located at the intersection of market activity, enterprise size, and knowledge sources. Among the topics related to knowledge sources, both internal and external ones are highlighted. However, their inherent characteristics can influence the difficulty and cost of acquiring/creating them. Therefore, it becomes crucial to identify knowledge resources that are critical to the enterprise and within its reach. The article title asks whether, in small- and medium-sized enterprises with limited market experience, employees can be a source of useful knowledge in selected areas (in the perception of managers).
Design/methodology/approach: The research project was conducted through a survey of the opinions of individuals in managerial positions responsible for achieving goals and managing employee teams. For this purpose, a survey was conducted among 139 managers from different SMEs operating in Poland. SMEs were market-immature entities (running for up to 5 years). Respondents provided answers on a seven-point scale. The questions concerned the frequency of using knowledge from employees who interact with customers in seven specific areas identified in previous studies. The obtained data were statistically processed using factor analysis.
Findings: The obtained results suggest that there are two main areas of customer-facing employees' knowledge utilization in emerging SMEs. These are: collaboration with external partners and within the company to reduce operating costs (1), and reporting and planning to increase revenue (2). Therefore, these areas can be identified as both operational and strategic. There is an inverse relationship between the variables and the observed strategic factor.
Research limitations/implications: The purposive selection of respondents was used. The research results can be extended only to the surveyed group of respondents.
Originality/value: This article proposes a cognitive perspective grounded in a research gap: the lack of findings on how small and medium-sized, market-immature companies can effectively approach knowledge management.
Keywords: knowledge management; SMEs; employees.
Category of the paper: research paper.

1. Introduction

Theoretical inspiration for discussing knowledge management (KM) draws from several key concepts underlying this domain of scientific knowledge. The primary descriptive perspective on this topic in management and quality sciences is the strategic perspective, which recognizes knowledge as a key organizational resource. Effective knowledge management is considered essential to achieving sustainable competitive advantage, emphasizing the need to integrate knowledge with organizational strategies (Michna, 2023). Polanyi's distinction between tacit and explicit knowledge (Ujwary-Gil, 2011), applied to the organizational context, often underlies discussions in this field regarding the nature of the environment and development opportunities. Tacit knowledge resides within individuals and is often difficult to express, whereas explicit knowledge can be systematically shared. This distinction allows for the formulation of knowledge-sharing strategies within organizations and for the identification of distinct knowledge assets within organizations (Ujwary-Gil, 2011; Xuan, 2020; Tokarz, Rosiński, 2024).

Understanding KM processes is therefore crucial for enterprise management. Dalkir's integrated management cycle, for example, can be distinguished within the so-called process-based perspective. This model encompasses the following basic stages: knowledge capture and creation, knowledge distribution and sharing, and knowledge retrieval and utilization (Dalkir, 2005; Xuan, 2020). This approach emphasizes how KM practices can impact organizational productivity and efficiency, while also offering opportunities to improve ongoing business activities (Olan et al., 2016). The discourse on knowledge management can also take a different direction, drawing on Andriessen's (2008) metaphorical analysis. It explains how metaphors shape the conceptualization of KM theory and the practice of knowledge management itself. This approach to shaping a cognitive perspective enriches understanding of KM strategies and supports creative approaches to knowledge dynamics (Michna, 2023).

Another critical aspect of research is knowledge transfer between organizational members, including an intergenerational perspective that emphasizes the importance of mentoring and mutual trust for the effective sharing of personal knowledge. This relates to the issue of human resources within the enterprise, their experience, and competence levels. This transfer is crucial for optimizing KM within organizations, especially in relation to organizational social networks (Tokarz Rosiński, 2024; Okere, 2017). However, implementing and executing KM is not without challenges. Barriers to knowledge sharing, such as cultural resistance, individual attitudes, and structural obstacles, pose significant obstacles to effective knowledge management (Egwunatum Oboreh, 2022). Creating a culture that supports knowledge sharing and fosters collaboration is essential to overcoming these barriers (Whelton et al., 2002).

The role of knowledge management has evolved today, particularly under the influence of digital transformation. Organizations are challenged to adapt their knowledge processes to leverage new technologies across acquisition, transfer, and utilization. This interaction between knowledge management practices and technological competencies is crucial in today's organizational value creation (Michna, 2023; Kianto et al., 2014).

Discussions about knowledge management also extend to specific organizational contexts, such as small and medium-sized enterprises (SMEs). SMEs, crucial to the economic growth of many national economies, face unique knowledge management challenges due to limited resources and the lack of formal knowledge management systems. Promoting a culture of knowledge sharing and leadership practices that nurture organizational commitment are key strategies for strengthening KM in SMEs (Durst et al., 2024; Hariputra et al., 2023). A cognitive framework distinguishing internal KM (focusing on employee collaboration and processes) from external KM (involving external partnerships) offers valuable insights for adapting practices in this regard (Durst et al., 2024). Furthermore, the impact of digital transformation on SMEs highlights the need for innovative approaches to navigating technological complexities in KM (Michna, 2023; Zwierzchowski, 2023).

The aim of this article is to determine whether, in the case of small and medium-sized enterprises with limited market experience (this means that they are grappling with a range of organizational and market-related constraints and challenges), it can be concluded that it is possible to group the main areas of utilization of employees' knowledge derived from customers. This aim will be achieved based on a survey of the opinions of individuals in managerial positions responsible for achieving goals and managing employee teams.

2. Knowledge management from the SME perspective

Effective knowledge management (KM) practices are crucial to the success of small and medium-sized enterprises (SMEs). These practices emphasize collaboration and knowledge sharing, both internally and externally. Internally, fostering collaboration between employees, managers, and stakeholders through various tools, such as Web 2.0 technologies, is essential to enhancing KM capabilities (Narayanan, 2023). Employee expertise is therefore crucial for creating new knowledge and fostering innovation (Bolisani, Scarso, 2016; Martinez-Costa et al., 2019). Externally, SMEs benefit from knowledge acquisition through strategic alliances, partnerships, and relationship networks, which increase their absorptive capacity and enable them to effectively utilize this knowledge (Durst, 2024). Customer knowledge and market insights are invaluable for developing products and services tailored to market requirements (Georgiana Balau et al., 2020; Baena-Luna et al., 2021). Collaboration with suppliers, competitors, and academic institutions further enriches SMEs' knowledge base (Durst et al.,

2024; Narayanan et al., 2023). Communities of practice provide additional platforms for knowledge exchange, enhancing innovation and operational efficiency (Pattinson, Preece, 2014; Zhou et al., 2021).

The understanding outlined above provides a strategic perspective on knowledge management. This approach encompasses addressing issues such as integrating knowledge management with organizational strategy, communicating its benefits, and fostering an appropriate organizational culture. Alignment of knowledge management initiatives with business goals is crucial to their success (Riege, 2005; Dale, 2011). Clear communication by management about the benefits of knowledge management promotes employee adoption and utilization. Lack of trust and knowledge hoarding behaviors can undermine knowledge sharing, highlighting the need for a culture that encourages collaboration (Egwunatum, Oboreh, 2022).

A key aspect of KM, therefore, is overcoming barriers such as technological, cultural, and communication challenges. Creating a supportive organizational culture and investing in technology and training are essential to overcoming these barriers (Egwunatum, Oboreh, 2022). Furthermore, SMEs should focus on customer and market knowledge to tailor their offerings to customer preferences. Co-creation with customers drives innovation and increases the effectiveness of achieving business goals, especially when tailored to the situational context of specific industries (Abrokwah-Larbi, 2023; Yoon et al., 2023). Continuous learning and adaptation are crucial for SMEs to remain competitive in a dynamic environment. Promoting a culture of adaptive learning ensures that knowledge remains relevant and accessible, enabling organizations to effectively respond to social, environmental, and technological changes (Durst, 2024). Organizational leadership plays a key role in shaping a knowledge-based culture. Top management must prioritize KM initiatives and ensure they are strategically aligned with the organization's goals—and therefore demonstrate commitment to this (Egwunatum, Oboreh, 2022).

The crucial role of knowledge assets makes their protection increasingly important, especially in their digitized form. This is often the case because modern KM solutions rely heavily on IT. SMEs must develop measures to protect knowledge from threats such as cyberattacks while maintaining effective processes for generating, transmitting, and protecting knowledge within IT systems (Durst, 2024). Technology itself, therefore, plays a significant role in KM, enabling the capture, storage, and sharing of knowledge as an asset. Knowledge management systems ultimately contribute to improved operational efficiency and innovation (Centobelli et al., 2018). Experience-based knowledge from previous projects and customer interactions also significantly enriches an SME's knowledge base, even if it is digitalized (Sandberg, 2014).

Resource allocation remains a constant challenge for SMEs, and limited availability of personnel, time, and technology often hinders knowledge management practices. Investing in training and a robust ICT infrastructure is essential to overcome these barriers (Oliva, Kotabe, 2019). Furthermore, measuring knowledge management effectiveness requires clear metrics to

assess the impact of knowledge management initiatives on overall business performance (Davenport et al., 1998).

However, research findings suggest differences in KM implementation between young and established SMEs. Mature SMEs with a long history and established market position may be more likely to demonstrate a well-developed KM culture, infrastructure, and extensive networks that support effective knowledge sharing. Young SMEs, while agile and flexible, may struggle with resource constraints and limited experience. These distinctions highlight the need to develop tailored knowledge management strategies that account for specific needs and opportunities (Magni et al., 2021).

In summary, SMEs should adopt a holistic approach to knowledge management that encompasses collaboration, strategic alignment, continuous learning, and technology. By leveraging diverse sources of relevant knowledge (including internal and external sources generated at the intersection of the organization and the external environment) and addressing strategic challenges, SMEs can increase their competitiveness and drive sustainable growth (Esfandyarpour et al., 2024). It is important to remember that large enterprises possess the resources and competencies to implement knowledge management solutions in a conscious and broad manner (Hörisch et al., 2015). This context of scale prompts the need to address the research challenge of leveraging employee knowledge in emerging SMEs. This knowledge originates both within the enterprise and in relationships with its stakeholders, and at the same time, it often reflects the individual perspective of the employee and their interactions with representatives of other departments, customers, and contractors. In the context of SME operations, it can therefore serve as an equivalent to knowledge and data derived from specialized management systems, enabling them to overcome resource-related barriers. Its utilization also requires an active role for managers within the enterprise, which relates to shaping organizational conditions conducive to KM. However, it must not be forgotten that contemporary discussions on these issues are often framed within the context of the digitalization of management processes, overlooking an alternative approach based on the personalization of knowledge (Scheepers et al., 2004; Liu et al., 2013).

The current multifaceted cognitive and practical contexts of knowledge management in enterprises allow us to address a research problem at the intersection of selected issues. This research gap stems from a lack of explanation regarding whether supervisors utilize employees' knowledge derived from customers - specifically within the context of limited development opportunities. The issue mentioned above is presented from a novel perspective, combining enterprise size and market experience as sources of business development limitations. Both factors can contribute to the barrier of insufficient resources for implementing technological solutions, including those related to knowledge management. This may necessitate a greater focus on solutions that rely more heavily on human resources and personalized knowledge. From this perspective, customer-originating knowledge is a key aspect, though it is also absorbed by the company's employees who maintain contact with

customers. This entails the challenge of building a reputation among customers, which is considered crucial for the commercial growth of young companies (De Jong et al., 2021).

3. Methodology

The survey covered small and medium-sized service-oriented enterprises (from various industries) operating in Poland. The service-oriented profile of the enterprises makes it possible to address the conditions under which business activities are carried out through direct customer contact, thereby highlighting the issues under investigation. Employment was used to determine whether a company was classified as a small or medium-sized enterprise. Small enterprises employed between 10 and 49 employees, while medium-sized enterprises employed between 50 and 249. The target group of respondents consisted of owners or managers who directly supervised employees performing duties for clients as part of the services offered. Respondent selection was purposive, with availability as a criterion. Each respondent represented a different enterprise. A total of 139 respondents were recruited for the study. Most of them came from the Masovian Voivodeship (n = 90; 64.75%), a voivodeship with the highest level of entrepreneurship in Poland (Nieć, 2025). In the case of small enterprises, 88 respondents were from single-unit companies, and 15 were from branch offices (for a total of 103 respondents from small enterprises). Among medium-sized enterprises, 12 were single-unit companies, 23 were branch offices, and 1 was the company's headquarters (a total of 36 respondents from medium-sized enterprises). Respondents from enterprises operating for no more than two years accounted for 27,33% (n = 38). The remaining 101 (72.67%) represented enterprises operating for a period of two to five years.

The research project also considered the characteristics of the enterprises, expressed in their market immaturity. This means that the respondents represented enterprises that had been operating in the market for no longer than 5 years. This time period stems from research on SMEs in Poland over the last decade, which shows that both the first year of operation and the second or third year (depending on the period studied) can be considered crisis periods. At the same time, fewer than 50% of them survive to their fifth birthday (Przeżylność firmy w Polsce…., 2016; Zakrzewski et al., 2025). These data are consistent with examples from other countries. As D. Nicolo points out, the results of his research on the survival of young enterprises show that in the United States and Canada, the five-year survival rate for enterprises is slightly over 50%. Of course, as indicated, this survival rate may depend on the country, industry, and even the year in which they were founded (Nicolo, 2015). However, the literature emphasizes that these enterprises (young ones) are primarily characterized by limited resources (Murray, 2007) and experiment to identify customers and their needs (De Jong et al., 2021). This also leads to a number of managerial challenges (Parhankangas, 2007).

The adoption of a five-year survival rate is therefore justified and can serve as a temporary censorship for identifying market-immature enterprises. In turn, as the literature indicates, their qualitative characteristics are related to the research problem and the identified cognitive gap.

The survey was designed to verify the following research hypothesis:

H: It is possible to group the areas in which managers use the knowledge of employees who have direct contact with customers.

To verify this hypothesis, a survey questionnaire was designed. Questions asked of managers concerned the frequency of utilization of employee knowledge in specific domains, determined based on previous research results (Komańda, Sowa, 2014). These include: ongoing reporting and analysis, predictive analysis, intra-company collaboration, collaboration with contractors, collaboration with customers, cost reduction, and revenue growth. Respondents provided answers on a seven-point scale. Factor analysis was used to verify the hypothesis.

4. Results

The Cronbach's alpha coefficient for respondent responses across variables was 0.869. This is therefore a satisfactory value (for social sciences, a minimum value of 0.7 is assumed). Therefore, there was no need to exclude any variables for analysis.

The next step was to determine the number of factors using principal component analysis. The Cattell and Kaiser method was used. The Kaiser method retains factors with eigenvalues >1, while the Cattell method, known as a scree plot, visually identifies the breakpoint in the eigenvalue graph. The results of this analysis are presented below (Table 1 and Figure 1). The results in the table show that, according to the Kaiser criterion, it is necessary to distinguish two factors that together explain 71.289% of the variance in the output variables.

As can be seen in the scree plot, the graph is steep towards the second component. The reference line cuts off those factors for which eigenvalues are greater than 1 (component 2 still has a value >1). Therefore, both Catell and Kaiser criteria yield the same solution.

To obtain a good fit of the factors to the data, rotation was applied in the next step of the data analysis. In this case, the Direct Oblimin oblique rotation method together with Kaiser normalization was used. This method allows identification of correlations among factors and does not assume zero factor correlations. Factor loadings were obtained from the Pattern Matrix (Table 2), which represents the unique variance explained by each factor. The threshold factor value (so-called strong factor saturation) was assumed to be 0.5.

Table 1.
Total Variance Explanation

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3,937	56,242	56,242	3,937	56,242	56,242	3,274
2	1,053	15,047	71,289	1,053	15,047	71,289	2,996
3	0,773	11,037	82,326				
4	0,502	7,176	89,502				
5	0,361	5,151	94,653				
6	0,208	2,965	97,618				
7	0,167	2,382	100,000				

Source: own work.

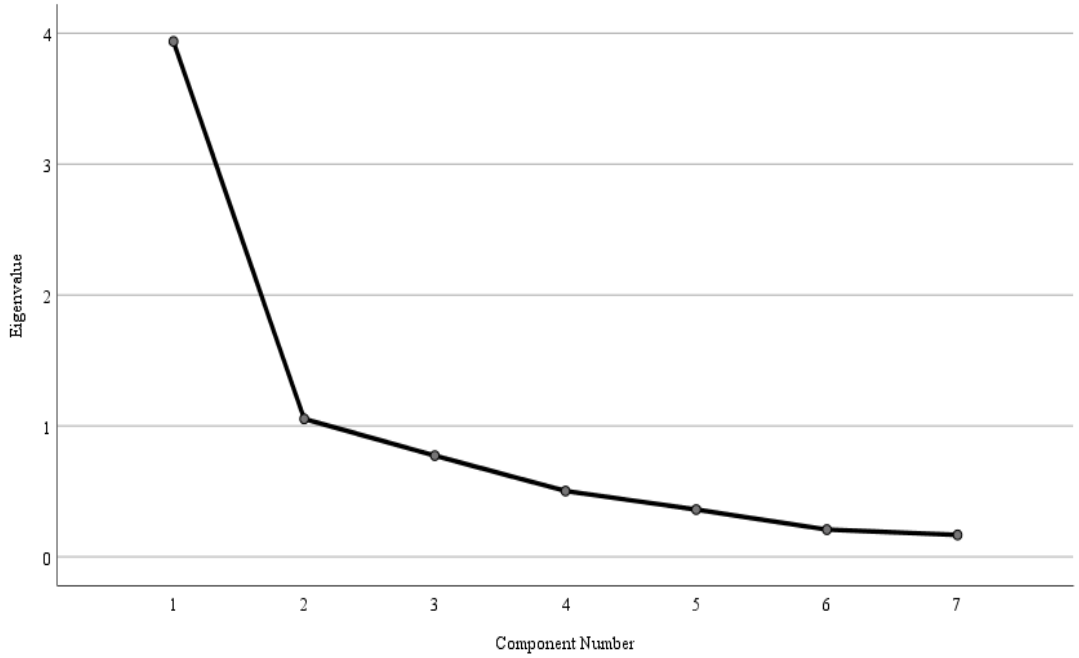


Figure 1. Complex Scree plot.

Source: own work.

The rotation method resulted in a clear separation of two factors. The factor correlation matrix (as the next step in the analysis) also shows that they are negatively correlated (correlation value: -0.446). Therefore, the correct rotation method (Oblimin) was used.

Table 2.
Total Variance Explanation

Variables	Component	
	1	2
Ongoing reporting and analysis		-,935
Predictive analysis		-,906
Intra-company collaboration	,645	
Collaboration with contractors	,796	
Collaboration with customers	,925	
Cost reduction	,607	
Revenue growth		-,506

Source: own work.

The Kaiser-Meyer-Olkin (KMO) test and Barlett's test of sphericity were also conducted. The K-M-O test value was 0.793, and the Barlett test value was 999.796 ($p < 0.001$). These values are significant. The K-M-O test assesses the adequacy of variable selection in factor analysis (i.e., whether dimensionality reduction is justified; the desired value is above 0.5). The higher the value of this test, the more likely it is that there are relationships between variables, which means that the data are better suited for factor analysis.

The obtained results allowed us to assign variables to the two extracted factors. The hypothesis was thus positively verified. For the first factor, these are: cooperation within the enterprise, cooperation with contractors, cooperation with customers, and cost reduction. For the second factor, these are: ongoing reporting, predicting phenomena, and increasing revenue.

The first factor can be linked to reducing the costs of ongoing operations and facilitating them (linked to the operational dimension), and the second to reporting and planning (linked to the strategic dimension). It should also be noted that, in the case of a strategic factor, the factor loadings are negative. This means that they have an inverse relationship between the observed variable and the factor.

5. Conclusions

The research results indicate that it is possible to group variables related to the areas in which managers utilize knowledge derived from employees possessing customer knowledge. It was indicated that the two factors grouping these areas of knowledge utilization are operational and strategic aspects. It was confirmed that there is variation in managers' utilization of this knowledge (by frequency of use) across individual areas, constituting a cognitive result in the management discipline. This variation is also characterized by an inverse relationship for the strategic factor. This is an extremely interesting fact. Customers are perceived as an important source of knowledge, as they often possess insights into competitors' activities, a comprehensive overview of available market offerings, and firsthand experience working with other entities. Acquiring this knowledge, it seems, should be a normal part of employee-customer interactions, and managers should strive to utilize this knowledge in a broad perspective of managerial decisions, especially in those of a strategic nature.

The study conducted has a key limitation: the purposive selection of respondents. This means that the research results cannot be extended to the entire population of managers of small and medium-sized enterprises in Poland. This can only be done for the surveyed group of respondents.

However, this limitation also presents an opportunity to design and conduct further research. Research can be designed to account for industry diversity. This could reveal possible differences between industries in the scope of the research problem discussed, depending on the intensity and frequency of contacts with customers. It should also be noted that adopting the perspective of small and medium-sized enterprises operating for up to 5 years provides an opportunity to deepen and explain the causes of the inverse relationship between the variables and the factor expressing strategic aspects. The role that managers or owners of these enterprises play in these initial periods, in developing a specific vision of business expansion and how this translates into the use of employees' knowledge in operational and strategic dimensions, may be a field for exploration and explanation. This research project could also include an attempt to determine whether only behavioral issues related to owners and managers would play a decisive role in this perspective, or, as the published research findings indicate, whether this issue would be at least partially related to the company's infrastructure and procedural solutions (and how to possibly expand and improve them).

References

1. Abrokwah-Larbi, K. (2024). The impact of customer-focus on the performance of business organizations: evidence from SMEs in an emerging West African economy. *African Journal of Economic and Management Studies*, *Vol. 15, Iss. 1,* 31-59. https://doi.org/10.1108/AJEMS-04-2022-0167
2. Andriessen, D.G. (2008). Stuff or love? How metaphors direct our efforts to manage knowledge in organisations. *Knowledge Management Research & Practice*, *Vol. 6, Iss. 1,* 5-12. https://doi.org/10.1057/palgrave.kmrp.8500169
3. Baena-Luna, P., Martínez-Román, J.A., Liñán, F. (2022). Corporate Entrepreneurship Strategy and Internationalization: A Literature Review. In: Faghih, N., Forouharfar, A. (Eds.), *Strategic Entrepreneurship. Contributions to Management Science*. Cham: Springer, 143-160. https://doi.org/10.1007/978-3-030-86032-5_7
4. Balau, G., Van der Bij, H., Faems, D. (2020). Should SMEs get out of the building? Examining the role of customer co- creation on radical organizational creativity. *R&D Management*, *Vol. 50, Iss. 4*, 535-547. https://doi.org/10.1111/radm.12403
5. Bolisani, E., Scarso, E. (2016). Factors affecting the use of wiki to manage knowledge in a small company. *Journal of Knowledge Management*, *Vol. 20, Iss. 3*, 423-443. https://doi.org/10.1108/JKM-05-2015-0205
6. Centobelli, P., Cerchione, R., Esposito, E. (2018). How to deal with knowledge management misalignment: A taxonomy based on a 3D fuzzy methodology. *Journal of*

Knowledge Management, *Vol. 22, Iss. 3,* 538-566. https://doi.org/10.1108/JKM-10-2016-0456

7. Dalkir, K. (2005). *Knowledge management in theory and practice*. Oxford: Routledge. https://doi.org/10.4324/9780080547367
8. Davenport, T.H., De Long, D.W., Beers, M.C. (1998). Successful knowledge management projects. *MIT Sloan Management Review, Vol. 39, Iss. 2*, 43-57.
9. De Jong, A., Zacharias, N.A., Nijssen, E.J. (2021). How young companies can effectively manage their slack resources over time to ensure sales growth: the contingent role of value-based selling. *Journal of the Academy of Marketing Science*, *Vol. 49, Iss. 2*, 304-326. https://doi.org/10.1007/s11747-020-00746-y
10. Dong, J., Lai, X., Zhao, D. (2022). How incentive affects knowledge transfer performance in corporate user community: The mediating roles of users' transfer willingness and ability. *Managerial and Decision Economics*, *Vol. 43, Iss. 6,* 2249-2260. https://doi.org/10.1002/mde.3522
11. Dous, M., Salomann, H., Kolbe, L., Brenner, W. (2005). Knowledge management capabilities in CRM: Making knowledge for, from, and about customers work. *AMCIS 2005 Proceedings*, *Vol. 33*, 167-178.
12. Durst, S., Zieba, M. (2020). Knowledge risks inherent in business sustainability. *Journal of Cleaner Production*, *Vol. 251*, 119670. https://doi.org/10.1016/j.jclepro.2019.119670
13. Durst, S., Foli, S., Edvardsson, I.R. (2024). A systematic literature review on knowledge management in SMEs: current trends and future directions. *Management Review Quarterly*, *Vol. 74, Iss. 1*, 263-288. https://doi.org/10.1007/s11301-022-00299-0
14. Egwunatum, S.I., Oboreh, J.C. (2022). Factors Limiting Knowledge Management among Construction Small and Medium Enterprises. *Journal of Engineering, Project, and Production Management*, *Vol. 12, Iss. 1,* 25-38. https://doi.org/10.32738/JEPPM-2022-0003
15. Esfandyarpour, A., Arasti, M.R., Farazi, M.S., Miremadi, I. (2024). From depth and breadth of knowledge to technological capability: a journey inside a firm's intellectual capital. *R&D Management*, *Vol. 54, Iss. 4*, 864-881. https://doi.org/10.1111/radm.12669
16. Hariputra, A., Koestiono, D., Muhaimin, A.W. (2024). Mediation of knowledge sharing and commitment in the relationship of transformational leadership on SMEs' performance. *Journal of System and Management Sciences*, *Vol. 13, Iss. 1*, 511-531. https://doi.org/10.33168/JSMS.2023.0127
17. Hörisch, J., Johnson, M.P., Schaltegger, S. (2015). Implementation of sustainability management and company size: a knowledge- based view. *Business Strategy and the Environment, Vol. 24, Iss. 8,* 765-779. https://doi.org/10.1002/bse.1844
18. Kianto, A., Ritala, P., Spender, J.C., Vanhala, M. (2014). The interaction of intellectual capital assets and knowledge management practices in organizational value creation.

Journal of Intellectual Capital, Vol. 15, Iss. 3, 362-375. https://doi.org/10.1108/JIC-05-2014-0059

19. Komańda, M., Sowa, M. (2016). Zarządzanie wiedzą klientów w przedsiębiorstwie w opinii menedżerów i pracowników. *Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach*, *No. 202*, 78-89.
20. Lettner, N., Wilhelm, S., Güldenberg, S., Güttel, W. (2022). Customers as knowledge partners in a digital business ecosystem: From customer analytics towards knowledge partnerships. *Journal of Digital Economy*, *Vol. 1, Iss. 2,* 130-140. https://doi.org/10.1016/j.jdec.2022.08.001
21. Lis, M., Kotelska, J. (2023). Knowledge-based inter-organizational cooperation of universities and businesses in the chemical sector. *Zeszyty Naukowe. Organizacja i Zarządzanie*, *No. 172.* Politechnika Śląska*,* 417-450. http://dx.doi.org/10.29119/1641-3466.2023.172.26
22. Liu, H., Chai, K.H., Nebus, F.J. (2013). Balancing codification and personalization for knowledge reuse: a Markov decision process approach. *Journal of Knowledge Management*, *Vol. 17, Iss. 5*, 755-772. https://doi.org/10.1108/JKM-04-2013-0127
23. Magni, D., Chierici, R., Fait, M., Lefebvre, K. (2022). A network model approach to enhance knowledge sharing for internationalization readiness of SMEs. *International Marketing Review*, *Vol. 39, Iss. 3,* 626-652. https://doi.org/10.1108/IMR-03-2021-0110
24. Martinez-Conesa, I., Soto-Acosta, P., Carayannis, E.G. (2017). On the path towards open innovation: Assessing the role of knowledge management capability and environmental dynamism in SMEs. *Journal of Knowledge Management*, *Vol. 21, Iss. 3*, 553-570. https://doi.org/10.1108/JKM-09-2016-0403
25. Michna, A. (2023). Organizational knowledge: definitions, taxonomies, and metaphors in a digital transformation environment. *Scientific Papers of Silesian University of Technology. Organization & Management*, *No. 190*, 95-107, http://dx.doi.org/10.29119/1641-3466.2023.190.7
26. Mohammed, F., Ahmad, R.B., Hassan, S.B., Fazea, Y., Alzahrani, A.I. (2024). An empirical evidence on the impact of social customer relationship management on the small and medium enterprises performance. *International Journal of Information Management Data Insights*, *Vol. 4, Iss. 2,* 100248. https://doi.org/10.1016/j.jjimei.2024.100248
27. Murray, G.C. (2007). Venture capital and government policy. In: H.E. Landström (Ed.), *Handbook of Research on Venture Capital* (pp. 113-152). Elgar Publishing, https://doi.org/10.4337/9781847208781.00011
28. Narayanan, S., Nadarajah, D., Sambasivan, M., Ho, J.A. (2023). Antecedents and outcomes of the knowledge management process (KMP) in Malaysian SMEs. *Journal of Small Business & Entrepreneurship*, *Vol. 35, Iss. 5,* 697-723. https://doi.org/10.1080/08276331.2020.1818540

29. Nicolò, D. (2015). Towards a theory on corporate reputation and survival of young firms. *Procedia Economics and Finance, Vol. 22*, 296-303. https://doi.org/10.1016/S2212-5671(15)00289-0
30. Nieć, M. (2025). Ranking małej i średniej przedsiębiorczości w układzie wojewódzkim. Wskaźnik syntetyczny. In: A. Skowrońska, A. Tarnawa (Eds.), *Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce* (pp. 33-39). Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.
31. Okere, G. (2017). Barriers and enablers of effective knowledge management: A case in the construction sector. *Electronic Journal of Knowledge Management*, *Vol. 15, Iss. 2,* 85-97.
32. Olan, F., Liu, S., Neaga, I., Alkhuraiji, A. (2016). How knowledge sharing and business process contribute to organizational performance: Using the fsQCA approach. *Journal of Business Research*, *Vol. 69, Iss. 11*, 5222-5227. https://doi.org/10.1016/j.jbusres.2016.04.116
33. Oliva, F.L., Kotabe, M. (2019). Barriers, practices, methods and knowledge management tools in startups. *Journal of Knowledge Management*, *Vol. 23, Iss. 9,* 1838-1856. https://doi.org/10.1108/JKM-06-2018-0361
34. Parhankangas, A. (2007). An Overview of Research on Early Stage Venture Capital: Current Status and Future Directions. In: H.E. Landström (Ed.), *Handbook of Research on Venture Capital* (pp. 253-280). Elgar Publishing. https://doi.org/10.4337/9781847208781.00018
35. Pattinson, S., Preece, D. (2014). Communities of practice, knowledge acquisition and innovation: a case study of science-based SMEs. *Journal of Knowledge Management*, *Vol. 18, Iss. 1*, 107-120. https://doi.org/10.1108/JKM-05-2013-0168
36. *Przeżywalność firm w Polsce rośnie. Kluczowy jest trzeci rok działalności* (2016). Controlling. Rachunkowość zarządcza i finanse. Retrieved from: https://www.controllingirachunkowosc.pl/aktualnosci/przezywalnosc-firm-w-polsce-rosnie-kluczowy-jest-trzeci-rok-dzialalnosci, 20.02.2026.
37. Riege, A. (2005). Three- dozen knowledge- sharing barriers managers must consider. *Journal of Knowledge Management*, *Vol. 9, Iss. 3,* 18-35. https://doi.org/10.1108/13673270510602746
38. Sandberg, S. (2014). Experiential knowledge antecedents of the SME network node configuration in emerging market business networks. *International Business Review*, *Vol. 23, Iss. 1,* 20-29. https://doi.org/10.1016/j.ibusrev.2013.08.001
39. Scheepers, R., Venkitachalam, K., Gibbs, M.R. (2004). Knowledge strategy in organizations: refining the model of Hansen, Nohria and Tierney. *The Journal of Strategic Information Systems*, *Vol. 13, Iss. 3,* 201-222. https://doi.org/10.1016/j.jsis.2004.08.003
40. Taghizadeh, S.K., Karini, A., Nadarajah, G., Nikbin, D. (2020). Knowledge management capability, environmental dynamism and innovation strategy in Malaysian firms.

Management Decision, *Vol. 59, Iss. 6,* 1386-1405. https://doi.org/10.1108/MD-01-2020-0051

41. Tokarz, M., Rosiński, J. (2024). Transfer of tacit knowledge: exploring effective methods and techniques of tacit knowledge across generations in cultural institutions – a case study. *Scientific Papers of Silesian University of Technology. Organization & Management*, *No. 199,* 619-631, http://dx.doi.org/10.29119/1641-3466.2024.199.46
42. Ujwary-Gil, A. (2011). The analysis of barriers of knowledge management. In: A. Nalepka, A. Ujwary-Gil (Eds.), *Business and non-profit organizations facing increased competition and growing customers' demands* (pp. 84-100). Nowy Sącz: Wyższa Szkoła Biznesu National Louis University.
43. Whelton, M., Ballard, G., Tommelein, I.D. (2003). A knowledge management framework for project definition. *Journal of Information Technology in Construction (ITcon)*, *Vol. 7, Iss. 13*, 197-212.
44. Xuan, V. (2020). Factors affecting knowledge sharing in enterprises: Evidence from small and medium enterprises in Vietnam. *Management Science Letters*, *Vol. 10, Iss. 2*, 469-478. http://dx.doi.org/10.5267/j.msl.2019.8.023
45. Yoon, S., Kim, G., Chung, Y., Son, H. (2023). Is customer involvement always beneficial for R&D efficiency? The difference between high-tech and low-tech industries. *Managerial and Decision Economics*, *Vol. 44, Iss. 3,* 1678-1688. https://doi.org/10.1002/mde.3775
46. Zakrzewski R., Tarnawa A., Orłowska J., Nieć M. (2025). Obraz statystyczny przedsiębiorstw w Polsce. In: A. Skowrońska, A. Tarnawa (Eds.), *Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce* (pp. 11-32). Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.
47. Zhou, H., Uhlaner, L.M., Jungst, M. (2023). Knowledge management practices and innovation: A deliberate innovation management model for SMEs. *Journal of Small Business Management*, *Vol. 61, Iss. 4,* 2126-2159. https://doi.org/10.1080/00472778.2021.1888383
48. Zwierzchowski, D. (2023). The importance of knowledge transfer in the implementation of an integrated ERP system. *Scientific Papers of Silesian University of Technology. Organization & Management*, *No. 186,* 771-779. http://dx.doi.org/10.29119/1641-3466.2023.186.55

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE ROLE OF COMMUNICATION IN ENTERPRISE RISK MANAGEMENT (ERM) – SYSTEMATIC LITERATURE REVIEW

Anna KOROMBEL[1*], Beata ZATWARNICKA-MADURA[2]

[1] Czestochowa University of Technology; anna.korombel@pcz.pl, ORCID: 0000-0003-0546-9708
[2] Rzeszow University of Technology; bezat@prz.edu.pl, ORCID: 0000-0002-7579-8630
* Correspondence author

Purpose: The aim of this study is to identify the current state of research on the role of communication in integrated risk management, to highlight research gaps, and to suggest future research directions.
Design/methodology/approach: To achieve the research objective, the authors conducted a bibliometric review using the VOSviewer software (version 1.6.20). The study included only English-language, peer-reviewed scientific publications indexed in the Scopus database.
Findings: The study identified a research gap concerning the role of communication in enterprise risk management. It highlighted the lack of consideration of communication as an integrating mechanism within Enterprise Risk Management.
Research limitations/implications: The review of the state of knowledge on the role of communication in integrated risk management was limited to the Scopus database. Future research will aim to develop an Enterprise Risk Management model in which communication plays an integrating role within the structure of this process.
Originality/value: The study offers a new perspective, positioning communication as a key integrative mechanism in enterprise risk management.
Keywords: Risk management, enterprise risk management (ERM), risk communication, internal and external communication.
Category of the paper: Literature review.

1. Introduction

The evolution of risk management over recent decades is most evident in the shift away from viewing risk solely within the organisation towards integrating risk management with the organisation's broader strategic objectives. There has been a noticeable shift from siloed risk management to integrated risk management (ERM) (Gordon et al., 2009; Bromiley et al., 2014; Gleißner, Berger, 2024). The responsibility of directors and board members for the quality of risk management, and the growing claims by external stakeholders against them for

mismanagement of assets, have meant that risk assessment and risk communication have become crucial for managerial careers, corporate reputation and the evaluation of management performance (Alatassi, Pillai, 2024; Amiraslani et al., 2025). The role of risk communication in risk management has evolved. Not only have the quality and quantity of information changed, but so too have the parties involved in the communication. Senior management and the board have begun to communicate with shareholders to present and discuss risk management practices, whilst developing a common, organisation-wide language of risk has become a key challenge for organisations (Beretta, Bozzolan, 2004; Jiang et al., 2024; Xu et al., 2025).

Risk communication has proven to be an important tool in effective risk management (Nielson et al., 2005). Many organisations and research findings confirm the positive impact of communication on risk management within a company. COSO identifies 'Information, communication, and reporting' as one of the five components of effective Enterprise Risk Management (COSO framework) – the continuous flow of information and reporting improves risk oversight and decision-making (COSO, 2020). Authors of literature reviews indicate that risk communication supports social risk management as well as decision-making in the private sector (Goerlandt et al., 2020), and that better communication changes risk perceptions and decisions (Marynissen, Ladkin, 2012). The three-line model of risk management organisation proposed to enterprises also emphasises communication (The Institute of Internal Auditors [IIA], 2020; Łusiakowski, 2024). Companies often use digital tools for internal and external communication, which have a positive impact on the effectiveness of this process (Machnik-Słomka, Rzemek, 2025).

The quality of risk communication is also important in the area of preventing casualties resulting from disasters. Effectively communicating information about risks to the public and stakeholders is a fundamental element of disaster risk reduction. Effective risk communication, as part of early warning systems, enables effective disaster preparedness and response, mitigates their impacts, and prevents fatalities (Fakhruddin et al., 2020).

Risk communication is "the process of exchanging views on how best to assess and manage risks among academics, regulatory practitioners, interest groups, and the general public" (Powell, Leiss, 2004, p. 33). The evolution of risk communication over the years has proceeded in three phases. In phase 1, stakeholders focused on risk and its management at a high level of detail, whilst in phase 2 the emphasis was placed on the development of communication. In Phase 3, the final phase, these stakeholders recognised the importance of a responsible approach to both issues simultaneously, identifying the practice of sound risk communication as an element of good business practice (Leiss, 1996).

Powell and Leiss (Powell, Leiss, 2004) identified the existence of a 'risk information vacuum', i.e. a gap in the understanding of risk communication between its senders and its recipients (Powell, Leiss, 2004, p. IX). Effective risk communication can be used to fill this vacuum, translating the often complex language of experts into comprehensible content for an increasingly broad group of recipients – external stakeholders (Nielson et al., 2005).

According to M.N. Ndlela, risk communication will only be effective and credible if the person communicating the risk understands the stakeholders and the way in which they understand risk, whilst the stakeholders engage in communication at every stage of the risk management process, making it a two-way communication (Ndlela, 2018).

The aim of this article is to identify the current state of knowledge regarding the role of communication in integrated risk management, research gaps, and future research directions. The authors posed the following research questions:

- How has the trend in academic publications on the role of communication in risk management developed?
- Which authors, publications and journals have had the greatest influence on the development of research in this area?
- What are the main thematic trends (areas of research) that dominate the literature on communication in risk management?
- How has the role of communication evolved in risk management research?

What research gaps and future research directions can be identified in the area concerning the role of communication in risk management?

2. Methodology

Systematic literature reviews are part of a growing interest in rigorous reviews, which has been observed in many social science disciplines in recent decades (Bem, 1995). A similar trend can be observed in business disciplines, where leading journals encourage the conduct of systematic reviews and provide guidelines in this regard within their respective fields, for example in marketing (Hulland, Houston, 2020). To achieve their objective, the authors utilised a bibliometric review, which is a type of domain-based review, itself a variant of a systematic literature review (SLR) (Paul, Criado, 2020). Assuming that only peer-reviewed scientific publications would be included in the study, the authors selected the Scopus scientific database. In line with the suggestion by Zupic and Čater (2015), the authors searched titles, abstracts and keywords. Following the guidelines set out by Munim et al. (Munim et al., 2020), included only journal articles in the analysis, thereby excluding books, book chapters, reviews, conference proceedings, conference papers and short surveys. The search was conducted across the entire available timeframe, i.e. from 1988 to the date of the search (February 2026). The Boolean operators OR and AND were used during the search. The initial search identified 315 publications, and after narrowing the scope to articles in English, 187 publications remained. The query strings used in the database are presented in Table 1.

Table 1.
Steps and criteria for searching for publications in the Scopus database

Step	Keywords (query string)	Number of publications
1. Keyword search without limitations	(TITLE-ABS-KEY("enterprise risk management" OR "ERM" OR "corporate risk management" OR "integrated risk management")) AND (TITLE-ABS-KEY("communication" OR "risk communication" OR "information exchange" OR "organizational communication" OR "managerial communication" OR "stakeholder communication" OR "internal communication" OR "external communication"))	315
2. Limited to document type	(TITLE-ABS-KEY ("enterprise risk management" OR "ERM" OR "corporate risk management" OR "integrated risk management")) AND (TITLE-ABS-KEY ("communication" OR "risk communication" OR "information exchange" OR "organizational communication" OR "managerial communication" OR "stakeholder communication" OR "internal communication" OR "external communication")) AND (LIMIT-TO (DOCTYPE , "ar"))	193
3. Limited to document type and language	(TITLE-ABS-KEY ("enterprise risk management" OR "ERM" OR "corporate risk management" OR "integrated risk management")) AND (TITLE-ABS-KEY ("communication" OR "risk communication" OR "information exchange" OR "organizational communication" OR "managerial communication" OR "stakeholder communication" OR "internal communication" OR "external communication")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	187

Source: own study based on Scopus.

In the next stage of the study, the authors carried out an abstract screening (Figure 1). At this stage, 114 publications unrelated to the study topic were excluded. A total of 73 publications were ultimately included in the main study. The authors included the acronym ERM in the query string to mitigate the risk of omitting pivotal documents. Literature shows that authors frequently use solely the acronym ERM in titles, keywords, and abstracts, rather than the full term Enterprise Risk Management. Excluding this acronym from the search string could result in the automatic rejection by the Scopus database of relevant, highly cited works where the full text was not explicitly stated. Since the acronym ERM is widely utilised across numerous academic disciplines, the initial search results in Scopus exhibited a high level of information noise. To ensure the theoretical purity of the sample and the precision of the results, publications where the abbreviation ERM referred to concepts other than Enterprise Risk Management were excluded from the analysis. These included medical and biological terms (e.g. Epiretinal Membrane, Epithelial Rests of Malassez, ERM proteins, Erythromycin Resistance Gene), mathematical and computer science models (e.g. Empirical Risk Minimization, Entity Relationship Model, Enterprise Rights Management), and engineering or environmental monitoring frameworks (e.g. Exploding Reflector Model, Environmental Radiation Monitoring). The rejected publications presented the results of studies focusing, amongst other things, on: The Effective Regions of Movement (ERM), The Efficient Residual Mixing (ERM) Block, The Electronic Records Management (ERM), The Emotion-in-Relationships Model (ERM), The Empirical Risk Minimization (ERM), The Employee Relationship Management (ERM), The Enhanced CT Radiomics Model (ERM), The Enterprise Rights Management (ERM), The Entity Relationship Model (ERM), The Entropic Risk

Measure (ERM), The Environment Reconstruction Methodology (ERM), The Environmental Radiation Monitoring (ERM), The Environmental Resources Management (ERM), The Epiretinal Membrane (ERM), The Epithelial rests of Malassez (ERM), The ERM proteins (Ezrin/Radixin/Moesin - ERM), The Erythromycin Resistance (ERM) Gene, The Exploding Reflector Model (ERM), The Exposure Reference Map (ERM), The Extreme Rain Multiplier (ERM), The Multiview Ensemble Learning (ERM-ME), The Recurrent Epiretinal Membranes (ERMs), The Relative Motion (ERM) Model, The Resource Management (ERM) Scheme, The Retinal Glial Cells ERM, The Slice Selection and Edge Resource Management (JSS-ERM), The Synapse Emergency Room Mobile (Synapse ERm).

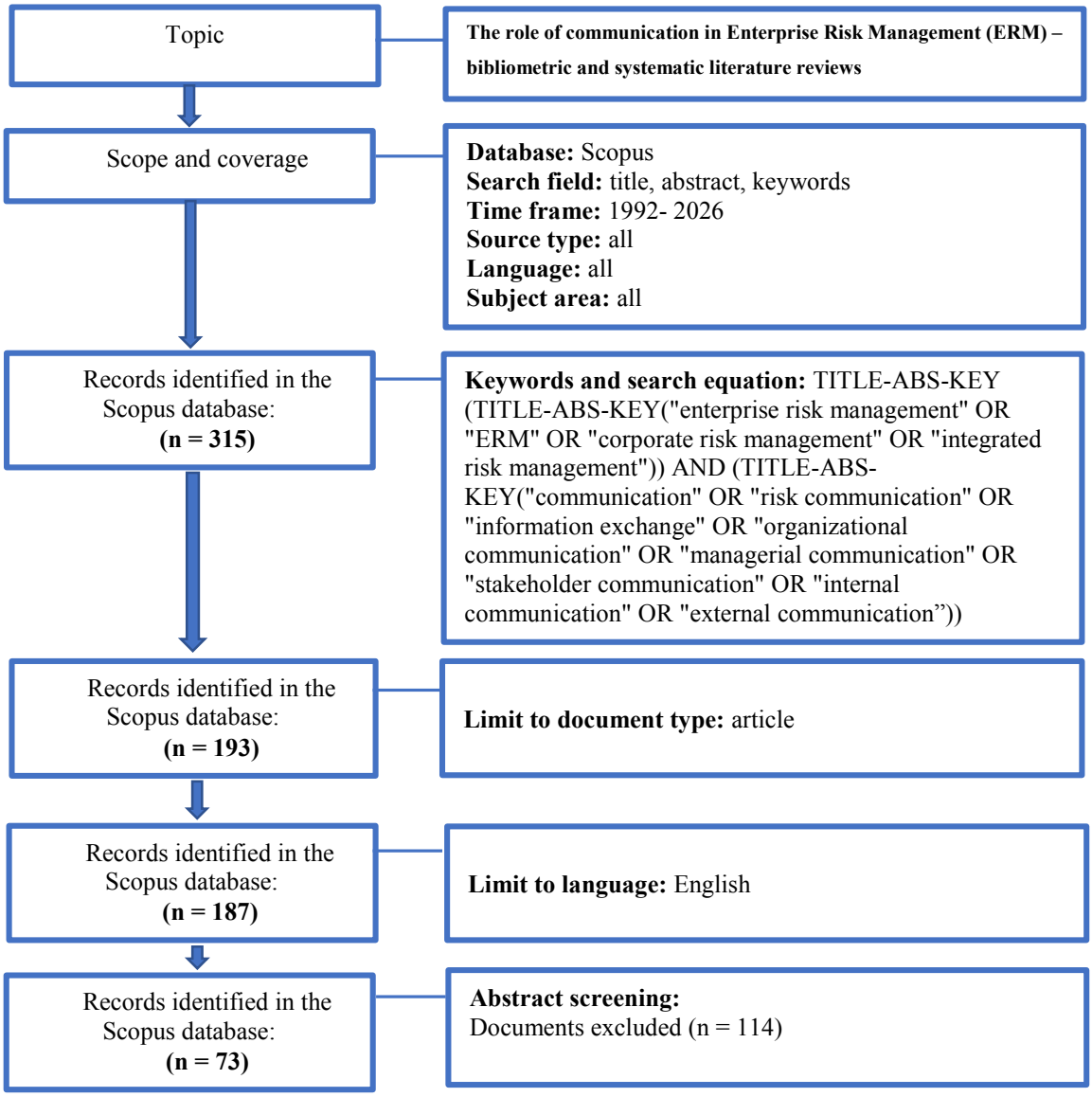


Figure 1. Steps and criteria for searching for publications in the Scopus database.

Source: own study based on Scopus.

In the next step, the authors carried out a bibliometric analysis using the VOSviewer software (version 1.6.20). Bibliographic data on the 73 articles under study were obtained from the Scopus database in CSV format. The authors applied the method of co-occurrence analysis of author keywords to identify thematic structures within the field. The authors applied a minimum occurrence threshold of 3, resulting in 33 keywords meeting the inclusion criteria. These words were grouped into 4 clusters, total link strength = 364 (Table 4). The full counting method was used. Network visualisation enabled the identification of thematic links indicating 4 thematic clusters reflecting the main research trends in the analysed area, whilst overlay visualisation allowed for the examination of temporal trends based on the average year of publication. To improve data quality, the authors used a thesaurus file to merge synonymous terms (humans, human) and remove non-substantive keywords (article, priority journal).

3. Results

First, the authors carried out a time-series analysis of the identified articles. The 73 articles included in the study were published between 1992 and 2026 (Figure 2).

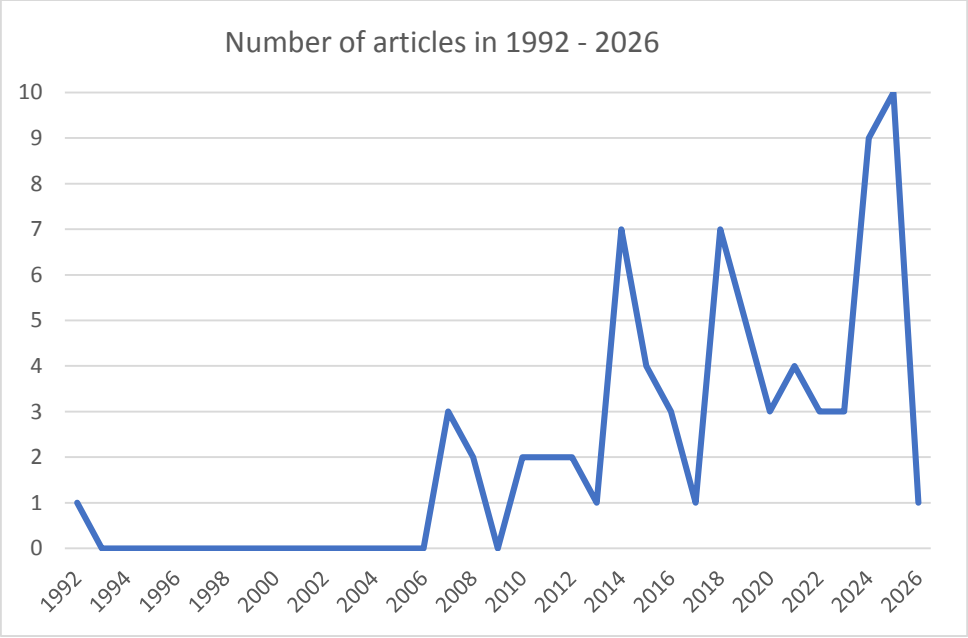


Figure 2. Number of articles in 1992-2026.

Source: own study based on Scopus.

The first article appeared in 1992 and was authored by Hawkins, H., Jayjock, M.A., and Lynch, J., entitled 'A rationale and framework for establishing the quality of human exposure assessments', published in the American Industrial Hygiene Association Journal (53(1), pp. 34-41). This article was included by the authors in the research procedure because the occupational exposure assessment presented therein provides input data for the evaluation

of potential human health risks. This stage forms an integral part of the comprehensive risk assessment, the results of which – as the authors of that paper emphasise – determine the decision-making processes of government agencies and corporations within the field of risk management (Hawkins, Jayjock, Lynch, 1992). However, over the following 14 years (1993-2006), not a single article was published. It was only in later years that the number of publications on this topic increased, reaching a peak of 10 articles in 2025.

Articles on the role of communication in risk management that are also indexed in Scopus have been published in a total of 64 academic journals. Table 2 presents a list of journals in the Scopus database containing the highest number of publications on the subject under study between 1992 and 2026.

Table 2.
List of scientific journals containing the highest number of publications on the subject under study in the SCOPUS database between 1992 and 2026

Title of journal	**Database: SCOPUS**		
	Number of publications on the subject under study in the database (a)	**Total number of articles published in the journal (b)**	**Proportion of publications (a) in the total number of articles (b)**
Reliability Engineering and System Safety	3	9 740	0,03%
Administrative Sciences	2	1 849	0,11%
Environmental Science and Policy	2	4 145	0,05%
Journal of Construction Engineering and Management	2	5 153	0,04%
Natural Hazards	2	9 538	0,02%

Source: own study based on Scopus.

The remaining 59 scientific journals each contained one article on the subject under study. An analysis of the Scopus database metadata also made it possible to identify the predominant research areas represented by the articles under study (Figure 3).

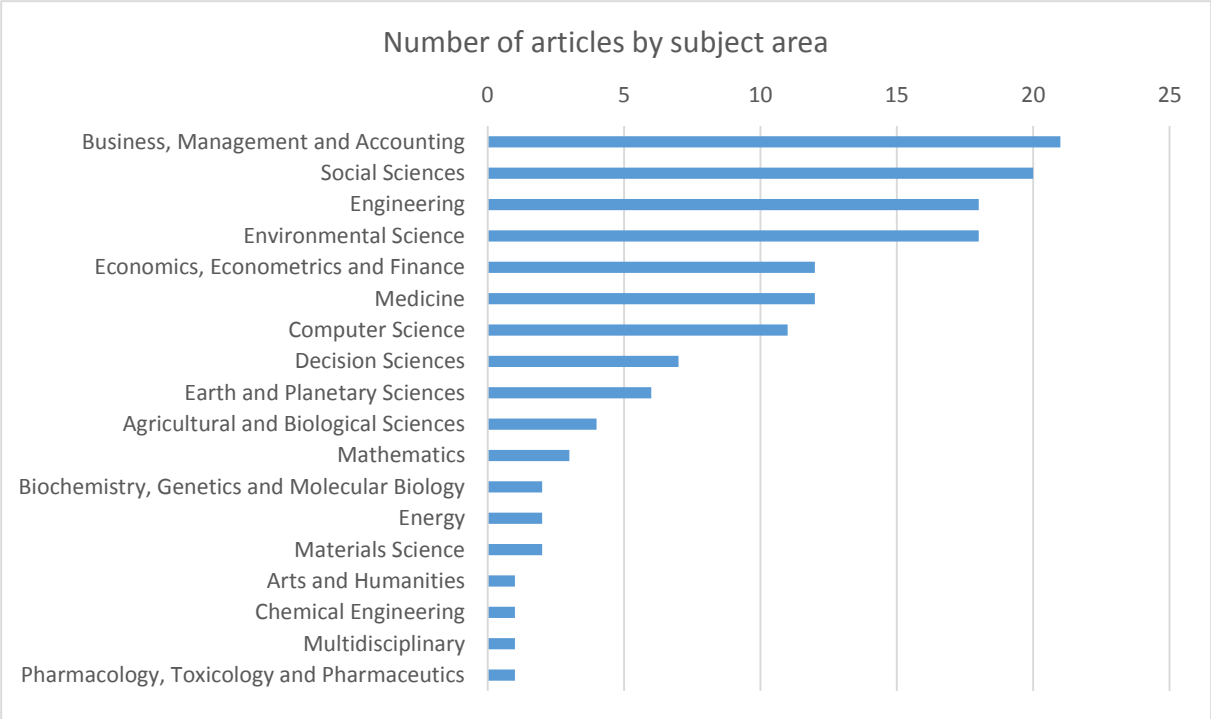


Figure 3. Number of articles by subject area.

Source: own study based on Scopus.

The largest number of articles (21) were assigned to the Business, Management and Accounting subject area. The next highest numbers were assigned to the following subject areas: Social Sciences (20), Engineering (18), Environmental Science (18), Economics, Econometrics and Finance (12), Medicine (12) and Computer Science (11).

In the next step, taking into account the mechanisms of aggregating bibliographic descriptions of articles, the authors carried out a geographical analysis of the publication output, identifying the most prolific authors (Figure 4), their countries of origin (Figure 5) and research centres (Figure 6).

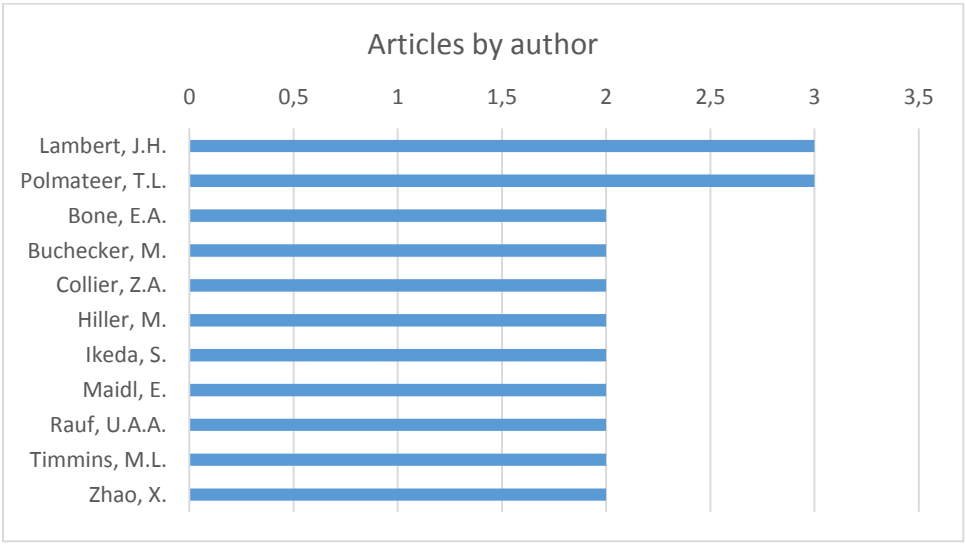


Figure 4. Articles by author.

Source: own study based on Scopus.

The articles on the subject under study (73) were written by a total of 161 authors. James H. Lambert of the University of Virginia, Charlottesville, United States, and Thomas L. Polmateer of Charlottesville, United States, were the most prolific authors, having co-authored three articles on the subject under study (Figure 4).

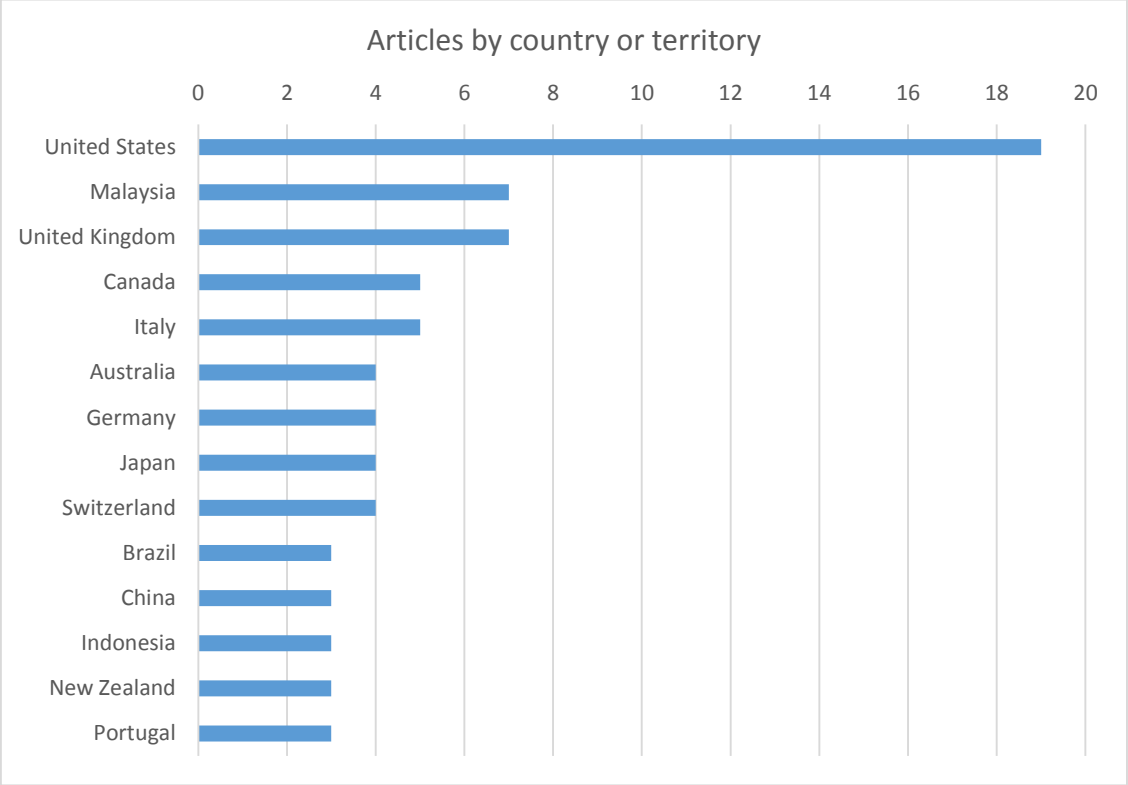


Figure 5. Articles by country or territory.

Source: own study based on Scopus.

The largest number of authors came from the United States (19), Malaysia (7), the United Kingdom (7), Canada (5) and Italy (5) (Figure 5). The remaining authors of the publications under review represented 21 countries.

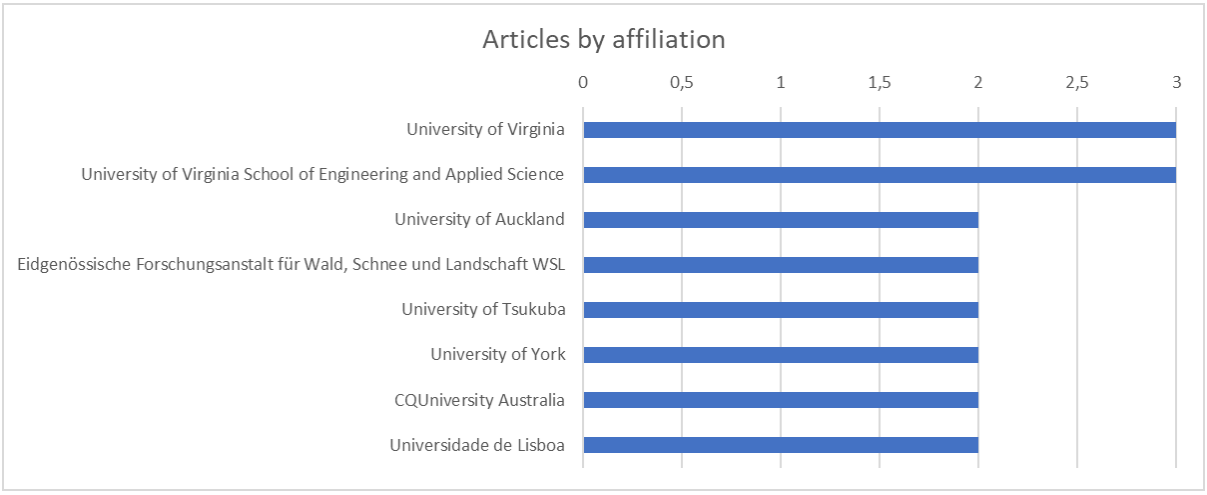


Figure 6. Articles by affiliation.

Source: own study based on Scopus.

The largest number of authors came from the University of Virginia (3), the University of Virginia School of Engineering and Applied Science (3), the University of Auckland (2), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) (2), the University of Tsukuba (2), the University of York (2), CQUniversity Australia (2) and the University of Lisbon (2). The remaining authors represented 142 research institutions (Figure 6).

In the next stage of the research, the authors identified the most frequently cited publications on the subject under study (Table 3).

Table 3.
List of the five most frequently cited publications and their authors

Authors' names	Title of publication	Year	Name of the journal	Number of citations	H-index
Schelfaut K., Pannemans B., van der Craats I., Krywkow J., Mysiak J., Cools J.	Bringing flood resilience into practice: The FREEMAN project	2011	Environmental Science and Policy	145	160
Erdem, S., Rigby, D., Wossink, A.	Using best-worst scaling to explore perceptions of relative responsibility for ensuring food safety	2012	Food Policy	74	145
Arena, M., Arnaboldi, M., Palermo, T.	The dynamics of (dis)integrated risk management: A comparative field study	2017	Accounting Organizations and Society	70	164
Zhao, X., Hwang, B.-G., Low, S.P.	Investigating enterprise risk management maturity in construction firms	2014	Journal of Construction Engineering and Management	57	147
Zhao, X., Singhaputtangkul, N.	Effects of firm characteristics on enterprise risk management: Case study of Chinese construction firms operating in Singapore	2016	Journal of Management in Engineering	55	106

Source: own study based on Scopus.

The most frequently cited article (145 citations) is the paper by K. Schelfaut, B. Pannemans, I. van der Craats, J. Krywkow, J. Mysiak and J. Cools, entitled 'Bringing flood resilience into practice: The FREEMAN project', which was published in 2011 in the journal "Environmental Science and Policy", 14(7), pp. 825-833. Next in line are the frequently cited articles by S. Erdem, D. Rigby, A. Wossink, 'Using best-worst scaling to explore perceptions of relative responsibility for ensuring food safety' (2012) Food Policy, 37(6), pp. 661-670 (cited 74 times) and M. Arena, M. Arnaboldi, T. Palermo, The dynamics of (dis)integrated risk management: A comparative field study, (2017) Accounting, Organizations and Society, 62, pp. 65-81 (cited 70 times).

An analysis of the keyword co-occurrence map conducted using VOSviewer (Figure 7) identified four thematic clusters reflecting the main research trends in the analysed field (Table 4).

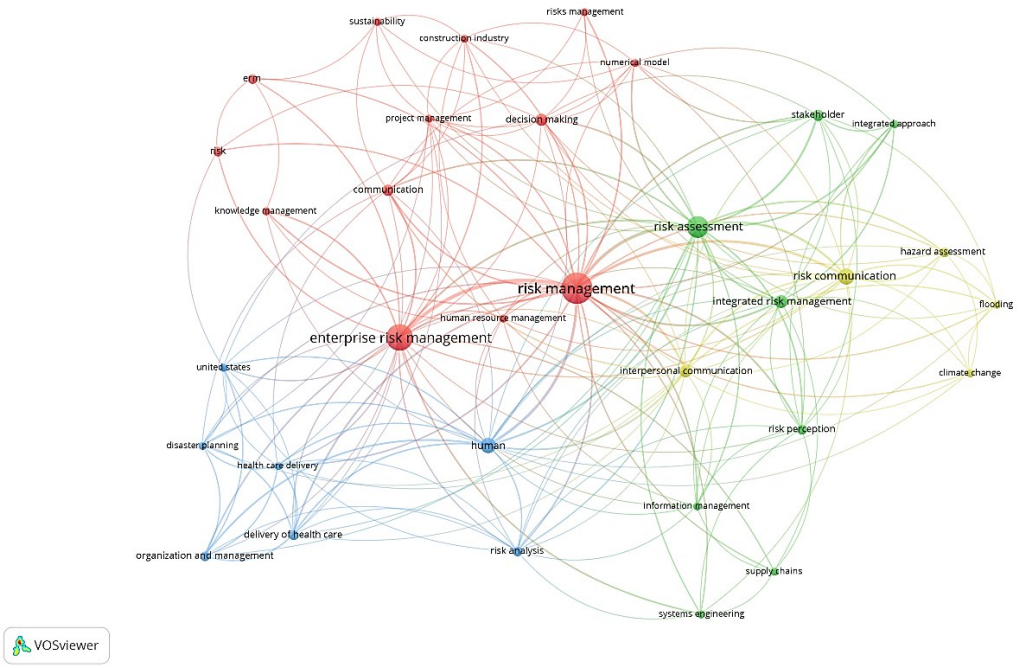


Figure 7. Co-occurrence - network visualization.

Source: own study.

In accordance with standard bibliometric interpretation practices, cluster labels were assigned on the basis of the dominant keywords in each group and their semantic relationships. The strong links between clusters suggest that research into risk management is interdisciplinary in nature.

Table 4.
Clusters and keywords

Cluster	Keywords
Cluster 1 (red) Internal communication in decision-making processes and ERM	communication construction industry decision making enterprise risk management (ERM) human resource management knowledge management numerical model project management risk risk management (risks management) sustainability
Cluster 2 (green) Information management and communication with stakeholders	information management integrated approach integrated risk management risk assessment risk perception stakeholder supply chains systems engineering

Cont. table 4.

Cluster 3 (blue) Communication in crisis management and healthcare	delivery of health care disaster planning health care delivery human organization and management risk analysis United States
Cluster 4 (yellow) Public communication on climate and environmental risks	climate change flooding hazard assessment interpersonal communication risk communication

Source: own study.

It should be emphasised that the interpretation of the identified clusters required the authors to exercise caution due to the presence of very broad concepts such as 'human', 'United States', 'construction industry' and 'sustainable development'.

Cluster 1 (red) *Internal organisational communication in decision-making processes and ERM* is the dominant cluster, forming the core thematic focus of the research. The dominant keywords are: risk management, enterprise risk management, decision-making, project management, communication and sustainable development. The cluster's subject matter relates to the dominant research trend focusing on the integration of risk management with organisational processes and with strategic decision-making under conditions of uncertainty. This cluster occupies a central position on the map and connects with all other clusters, meaning that it serves as the theoretical foundation and core of the research. Communication appears in this cluster as a supporting element rather than as the main subject of research into integrated risk management. The presence of concepts such as knowledge management and construction suggests that research in this cluster is also presented in a sectoral context.

Cluster 2 (green) *Information management and communication with stakeholder* encompasses research that adopts an interdisciplinary approach, combining technical aspects with process-based risk management. The dominant terms are risk assessment, integrated risk management, stakeholders, integrated approach, risk perception and information management. Research in this cluster focuses on practical risk assessment tools and methods, as well as on the role and involvement of stakeholders. The presence of terms such as 'supply chains' and 'systems engineering' indicates interdisciplinary research combining engineering and management perspectives. It can be noted that there is a lack of connection between risk assessment and the integrative tool that is communication.

Cluster 3 (blue) *Communication in crisis management and healthcare* encompasses research into healthcare systems and public administration, focusing on the application of risk management within social and institutional contexts, often in relation to specific geographical areas. The dominant keywords are: healthcare provision, risk analysis, crisis planning, organisation and management, and people. Research focuses on the impact of direct interactions on effectiveness in extreme situations (disasters). The occurrence of geographical terms, such

as the United States, suggests that empirical research is being conducted in various regions. Communication within this cluster is primarily examined in the context of environmental and social risks, rather than in the context of the internal integration of the Enterprise Risk Management system.

Cluster 4 (yellow) – *Public communication on climate and environmental risks* – is the smallest of the four clusters. The dominant keywords are risk communication, risk assessment, climate change, floods and interpersonal communication. Research in this cluster focuses on environmental risk and communication processes, i.e. on studies of hazard communication, including in the context of climate change and natural hazards. This indicates a growing focus of research on the social and environmental dimensions of risk management. Communication plays an informational and warning role here.

In the next step, the authors carried out a co-occurrence analysis – overlay visualisation (Figure 8).

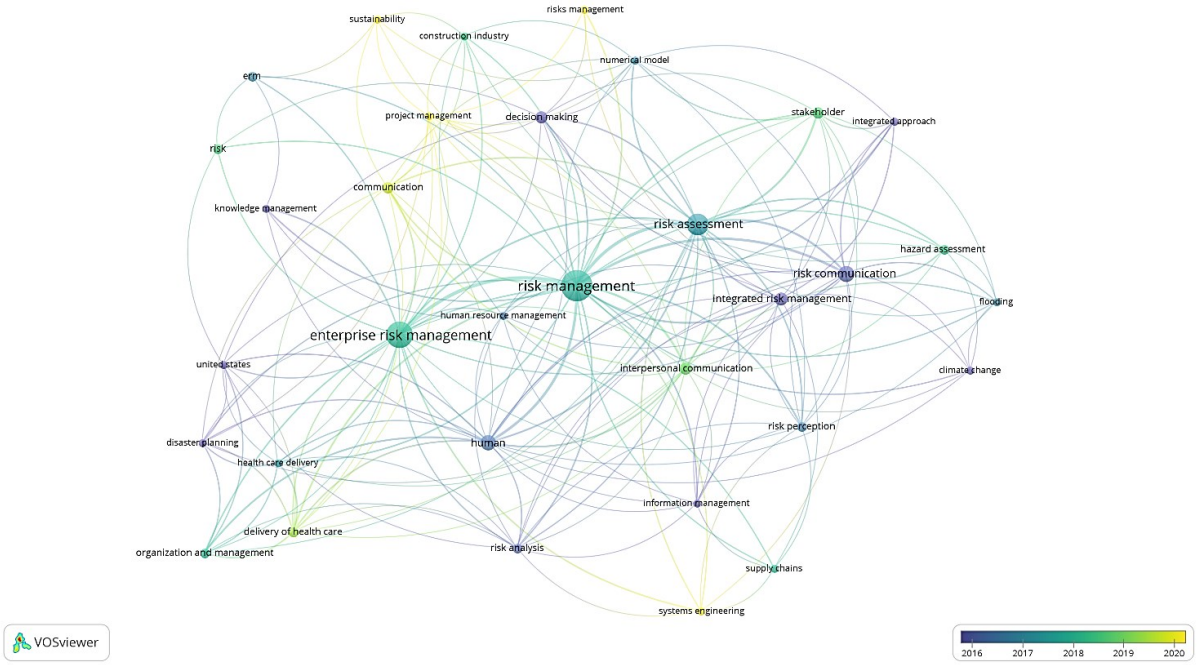


Figure 8. Co-occurrence - overlay visualization.

Source: own study.

Given that the time scale of the visualisation (2014-2020) reflects the average publication year for each concept, three publication periods can be identified: 1. Publications from 2014-2016 (blue), 2. Publications from 2016-2018 (green) and 3. Publications from 2018-2020 and later (yellow). The first period is dominated by the terms ‘risk perception’, ‘risk communication’, ‘climate change’, ‘flooding’ and ‘disaster planning’, indicating researchers’ interest in crises, environmental threats and public communication. Communication was not perceived as an organisational element. The second period is dominated by the terms ‘risk management’, ‘enterprise risk management’, ‘risk assessment’ and ‘stakeholder’. During this period, communication begins to be linked to risk management, ERM and stakeholders,

but does not constitute an element of ERM. In contrast, the third period is dominated by the terms communication, project management, sustainability, construction industry and systems engineering, suggesting that communication is considered in the context of projects, sustainable development and management systems. During this period, communication is examined as an element of management, but still not as the core of ERM.

4. Conclusions

The bibliometric analysis carried out suggests that researchers have shown little interest in the role of communication in Enterprise Risk Management. Research in this field is currently in its early stages. It is a young, rapidly developing field in which many research topics have yet to be explored. Almost all the articles were written between 2007 and 2026, which means that the issue of communication in the context of integrated risk management did not constitute a distinct research trend between 1992 and 2006. The field was very underdeveloped. It is only since 2007 that a growing interest in the subject matter and a focus on a systemic approach to risk can be observed. This can be explained by the growing importance of corporate governance, increased regulatory pressure, or the rise in the significance of the ERM concept following the 2008 financial crisis. However, the increase in the number of publications between 2017 and 2025 suggests that the importance of communication in risk management—and thus in organisational management—is growing, as is interest in organisational resilience and the importance of risk integration in conditions of uncertainty. The COVID-19 pandemic may have had an undeniable impact, particularly on the growth of research into the role of communication in crisis management. This leads to the conclusion that the field of research focusing on the role of communication in risk management is currently undergoing a phase of intensive development. At the time of the study – in February 2026 – only one article in the field under investigation had been published in 2026. Based on the analysis of the overlay visualisation, it can be concluded that research into communication in risk management has its origins in environmental and hazard-related contexts. It was only in subsequent years that researchers began to link communication with organisational management and risk management (and with ERM), treating it as a support for both of these processes. Research also began to take the stakeholders' perspective into account. Subsequent studies point to the growing importance of communication as an element of corporate risk management, including in the context of project management and sustainable development. However, communication is still not perceived as a key element of corporate risk management. Nor is it sufficiently embedded within the structure of this process, which points to the need to redefine it as a mechanism for integrating the risk management process within the organisation.

Furthermore, two main areas of research can be identified. The first area focuses on research into risk management in organisations from an organisational and strategic perspective, whilst the second focuses on the role of communication in the context of public organisations and environmental risks. The very limited links between these areas suggest that communication does not form the core of research in the context of risk management, nor has it been unequivocally recognised as an element or mechanism that integrates aspects of ERM, strengthens decision-making, or facilitates the building of relationships with the organisation's internal and external stakeholders.

Based on the analysis carried out, it can be concluded that the role of communication in risk management has evolved from a marginal, passive reporting function to a key element supporting the integration and coordination of this process. Initially, the role of communication was limited to reporting information, and only later was it expanded to include its use in decision-making and stakeholder engagement. Currently, communication is considered within the context of integrated and systemic approaches to risk management. However, the bibliometric analysis carried out indicates that, despite this evolution, communication remains scattered across various research streams and is not fully defined as an integrated structural element of corporate risk management systems. Four phases of the evolution of communication in the field of risk management can be identified:

- Phase I (up to around 2005) – risk management focused primarily on risk identification and quantitative analysis. The role of communication was marginal, and communication itself was used mainly for reporting purposes. Communication served merely as a supporting tool, rather than an integral part of risk management.
- Phase II (approx. 2005-2015) – during this period, the development of the ERM concept can be observed, leading to a holistic approach to risk and its integration with corporate governance and strategic decisions. Communication serves as a supporting element for processes within the organisation and is beginning to be recognised in the context of decision-making, knowledge management and governance. It is still not a mechanism for integrating ERM
- Phase III (approx. 2015-2020) – two sub-areas can be observed here. The concept of ERM continues to develop. The role of communication begins to be linked to stakeholders involved in the ERM process and to information management. However, communication is still not an element that integrates ERM (the core of ERM). It operates in parallel with risk analysis processes. There is also a noticeable development in research on climate change, disasters and communication during crises. Research focuses on the role of public communication, mainly external.
- Phase IV (post-2020) – as a result of the Covid-19 pandemic, the accelerating pace of digitalisation and growing global uncertainty, the role of communication is becoming increasingly important. Communication is regarded as a very important, indeed critical, element of ERM, but it still does not serve as a mechanism for integrating all elements of the ERM system.

In summary, it can be said that the role of communication in risk management has evolved from a passive reporting function to a key component supporting integration and coordination. However, despite this evolution, communication has not yet been fully defined as a structural element of corporate risk management systems.

This study highlights the need to intensify research in this area by, amongst other things, defining the role that communication plays in ERM, as well as the role it plays in decision-making and in relations with stakeholders. Research gaps can be identified within the identified clusters (Table 5).

Table 5.
Research gaps in the identified clusters

Cluster	Research gaps
Cluster 1	Lack of conceptualisation of communication as a central element of the ERM framework. Lack of a standardised framework integrating communication with the organisation's risk management systems. Lack of models for the flow of information (communication) between the operational and strategic levels of ERM.
Cluster 2	Lack of integration between communication and the risk assessment process.
Cluster 3	The lack of transfer of communication models from the public sector to risk management in private sector companies.
Cluster 4	Lack of integration between internal risk communication and external risk communication – a focus primarily on external risk communication.

Source: own study.

The first cluster includes the concept of communication, but it is not the central focus. The cluster concentrates on the organisational aspects of the Enterprise Risk Management structure, whilst not treating communication as a fundamental, central, integrating element of that structure. Furthermore, communication is not identified as a mechanism or model that facilitates the flow of information between the operational and strategic levels of the decision-making process. In the second cluster, the focus is primarily on risk assessment methodology, which is not considered in conjunction with the communication process. Communication is not a key element in this cluster either. The concept of a stakeholder appears, but it is not considered in the context of information flow. In the third cluster, communication is presented as an element of risk management in the public sector. However, there is a lack of literature presenting the adaptation of the communication model used in this sector to ERM risk management in the private sector. In the fourth cluster, risk communication is examined primarily in the context of climate change, flooding and hazard assessment. This cluster focuses on communicating risk to the public in crisis situations. However, there is a lack of connection between external risk communication and internal communication. There is a lack of focus on the integration of communication with ERM.

In summary, it can be observed that the topic of communication features in the literature on risk management; however, it is very rarely viewed as a mechanism for structural integration within corporate risk management systems. The research gaps identified have helped to pinpoint future research directions, which should focus on:

- Developing a communication model as a mechanism for integrating ERM components. This model should take into account the flow of information between the operational and strategic levels, as well as the integration of risk assessment with decision-making. The next step is to verify in practice the impact of these models on the effectiveness of ERM.
- Measuring the effectiveness of communication within ERM. It is necessary to develop indicators of risk communication effectiveness and measures of the impact of communication on risk reduction. Another important research area is the construction of models for assessing the communication maturity of ERM systems.
- The integration of internal and external communication. Another key research focus appears to be the assessment of the impact of stakeholder communication on a company's internal processes, including ERM.
- Identifying the impact of organisational culture (including risk culture) on risk communication within ERM. A key research focus is the identification of communication barriers in the implementation and operation of ERM.
- To highlight the potential for using digital tools in risk communication as part of risk management, and to identify the impact of using these tools on the effectiveness of the ERM process. The use of digital tools (including AI tools) in the integration and analysis of risk data, as well as in risk communication, has been little studied. There is a lack of research identifying the impact of their use on the effectiveness of the ERM process. Real-time risk communication is also an important research topic, as it facilitates rapid and informed decision-making, particularly in crisis situations (including during pandemics or natural disasters).
- Identifying any differences in the role of communication within ERM depending on the country, region, industry, regulatory differences or cultural differences. The research appears to focus solely on the role of communication in various sectors.
- Conducting a bibliometric analysis using other databases.

In drawing their final conclusions, the authors sought to exercise caution in generalising their findings, as the study presented is based solely on data from the Scopus database. The analysis does not cover resources from other relevant databases, such as Web of Science, EBSCO, Emerald, ScienceDirect or Google Scholar, and also excludes monographs, book chapters, conference proceedings and publications in languages other than English. Consequently, the search excluded so-called 'grey literature' and numerous practical and industry-specific publications, in which the topics of ERM and risk communication are very frequently and extensively discussed.

The authors are aware of the limitations of the study. These include, amongst others: the study being restricted to a single database (Scopus); the study being restricted to a single type of document (articles); the study being restricted to a single language (only English-

language texts were analysed); and the researcher's subjective selection of keywords and cut-off thresholds. Bibliometric mapping on a small sample (73 documents) may overemphasise dominant keywords, potentially narrowing the thematic diversity and the scope for analytical generalisations.

References

1. Alatassi, B., Pillai, R. (2024). Corporate governance and risk management: An evaluation of board responsibilities in western and Islamic banks. *Economics and Business Review, Vol. 10(1),* pp. 125-152, doi:10.18559/ebr.2024.1.1004
2. Amiraslani, H., Deller, C., Ittner, C.D., Keusch, T. (2025). Board risk oversight and Environmental and Social Performance. *Journal of Accounting and Economics, Vol. 79(2-3),* 101754, doi: 10.1016/j.jacceco.2024.101754
3. Bem, D.J. (1995). Writing a review article for Psychological Bulletin. *Psychological Bulletin, 118*(2), 172-177. https://doi.org/10.1037/0033-2909.118.2.172
4. Beretta, S., Bozzolan, S. (2004). A framework for the analysis of firm risk communication. *The International Journal of Accounting*, *Vol. 39(3),* pp. 265-288, doi: 10.1016/j.intacc.2004.06.006
5. Bromiley, P., Mcshane, M., Nair, A., Rustambekov, E. (2015). Enterprise Risk Management: Review, Critique, and Research Directions. *Long Ragne Planning*, *Vol. 48(4)*, pp. 265 -276, doi: 10.1016/j.lrp.2014.07.005
6. COSO (2020). *Enterprise Risk Management. Compliance Risk Management: Applying The COSO ERM Framework*. Retrieved from: https://www.coso.org/_files/ugd/3059fc_5f9c50e005034badb07f94e9712d9a56.pdf, 28.11.2025.
7. Fakhruddin, B., Clark, H., Robinson, L., Hieber-Girardet, L. (2020). Should I stay or should I go now? Why risk communication is the critical component in disaster risk reduction. *Progress in Disaster Science*, *Vol. 8(1), 100139*, ISSN 2590-0617, doi: 10.1016/j.pdisas.2020.100139
8. Gleißner, W., Berger, T.B. (2024). Enterprise Risk Management: Improving Embedded Risk Management and Risk Governance. *Risks, Vol. 12(12), 196,* doi: 10.3390/risks12120196
9. Goerlandt, F., Li, J., Reniers, G. (2020). The Landscape of Risk Communication Research: A Scientometric Analysis. *International Journal of Environmental Research and Public Health*, *Vol. 17(9),* 3255, PMID: 32392734; PMCID: PMC7246897, doi: 10.3390/ijerph17093255

10. Gordon, L.A., Loeb, M.P., Tseng, C.-Y. (2009). Enterprise risk management and firm performance: A contingency perspective. *Journal of Accounting and Public Policy, Vol. 28(4),* pp. 301-327, doi: 10.1016/j.jaccpubpol.2009.06.006
11. Hawkins, N.C., Jayjock, M.A., Lynch, J. (1992). A rationale and framework for establishing the quality of human exposure assessments. *American Industrial Hygiene Association Journal*, *Vol. 53(1),* pp. 34-4. doi: 10.1080/15298669291359276.
12. Hulland, J., Houston, M.B. (2020). Why systematic review papers and meta-analyses matter: an introduction to the special issue on generalizations in marketing. *Journal of the Academy of Marketing Science*, *Springer, Vol. 48(3),* pp. 351-359, doi: 10.1007/s11747-020-00721-7
13. Jiang, Y., Mao, H., Xiao, G., Yang, S. (2024). To disclose or not to disclose: Investor sentiment and risk disclosure. *Economics Letters, Vol. 241, 111818,* doi: 10.1016/j.econlet.2024.111818
14. Leiss, W. (1996). Three phases in the evolution of risk communication practice. *The Annals of the American Academy of Political and Social Science*, *Vol. 545*(1), pp. 85-94, doi:10.1177/0002716296545001009
15. Łusiakowski, K. (2024). Three-line model in enterprise risk management system. *Research Reviews of Czestochowa University of Technology. Management*, *Vol. 55,* pp. 117-134, doi: 10.17512/znpcz.2024.3.09
16. Machnik-Słomka, J., Rzemek, A. (2025). Application of Digital Tools in Enterprises in the Context of Communication Management. *Scientific Papers of Silesian University of Technology. Organization and Management Series, No. 238,* pp. 425-439, doi:10.29119/1641-3466.2025.238.20
17. Marynissen, H., Ladkin, D. (2012). *The Relationship between Risk Communication and Risk Perception in Complex Interactive and Tightly Coupled Organisations: A Systematic Review* (June 3, 2012). The Second International Conference on Engaged Management Scholarship, Cranfield, UK, June 21th-24th 2012. Retrieved from: https://ssrn.com/abstract=2084823, 29.11.2025.
18. Munim, Z.H., Dushenko, M., Jimenez, V.J., Shakil, M.H., Imset, M. (2020). Big data and artificial intelligence in the maritime industry: A bibliometric review and future research directions. *Maritime Policy & Management*, *47(5),* pp. 577-597, doi:10.1080/03088839.2020.1788731
19. Ndlela, M.N. (2018). A Stakeholder Approach to Risk Management. *Crisis Communication, Vol. 2018 Aug. 29*, pp. 53-75, PMCID: PMC7122203, doi: 10.1007/978-3-319-97256-5_4
20. Nielson, N.L., Kleffner, A.E., Lee, R.B. (2005). The evolution of the role of risk communication in effective risk management. *Risk Management and Insurance Review*, *Vol. 8, No. 2,* pp. 279-289, doi: 10.1111/j.1540-6296.2005.00060.x

21. Paul, J., Criado, A.R. (2020). The art of writing literature review: What do we know and what do we need to know? *International Business Review*, *Vol. 29(4), 101717,* doi:10.1016/j.ibusrev.2020.101717.
22. Powell, D., Leiss, W. (2004). *Mad Cows and Mother's Milk. The Perils of Poor Risk Communication*. Montreal/Kingston/London/Ithaca: McGill-Queen's University Press.
23. The Institute of Internal Auditors (IIA) (2020). *The IIA's Three Lines Model: An update of the Three Lines of Defense*. Retrieved from: https://www.theiia.org/en/content/position-papers/2020/the-iias-three-lines-model-an-update-of-the-three-lines-of-defense/, 30.11.2026.
24. Xu, R., Yu, Y., Wang, J. (2025). When investors talk, firms listen: How risk disclosure caters to investor sentyment. *Finance Research Letters*, *Vol. 85, Part E, 108299,* doi: 10.1016/j.frl.2025.108299
25. Zupic, I., Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods*, *Vol. 18(3)*, pp. 429-472, doi:10.1177/1094428114562629

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF THE SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANISATION AND MANAGEMENT SERIES NO. 253

MANAGING AN EU-FUNDED FMCG R&D PROJECT: FRESHPOT FEDS.01.02-IP.01-0111/24 CASE STUDY

Jakub KOWALSKI[1*], Grzegorz KRZOS[2]

[1] Wroclaw University of Economics and Business; jakub.kowalski@ue.wroc.pl, ORCID: 0000-0002-8126-7553
[2] Wroclaw University of Economics and Business; Grzegorz.Krzos@ue.wroc.pl, ORCID: 0000-0001-8423-934X
* Corresponding author

Purpose: The aim of this article is to present the results of a study on the management of the 'Freshpot' R&D project entitled: 'Innovations in sales technology: the development of smart, self-service healthy-food shops, using artificial intelligence for automatic product recognition, stock optimisation and nutritional advice (FEDS.01.02-IP.01-0111/24), implemented in the FMCG/food tech sector and co-financed by EU funds. The article aims to answer the question of how the project is managed and how the adopted management model influences the course of implementation and the achievement of intermediate outcomes.
Design/methodology/approach: The study uses a single case study approach, analysis of project documentation and participant observation, supplemented by an interview with a project team member. The scope of the analysis includes a comparison of the plan set out in the grant application with the actual course of the project's implementation as at 30 November 2025.
Findings: The article identifies project management methods and tools, including the structure of roles, division of responsibilities, schedule monitoring, milestone control and technological risk management.
Research limitations/implications: The project is still ongoing, so the analysis will not cover full commercialisation or the final assessment of all indicators. The study focuses on intermediate effects, in particular on a selected milestone.
Practical implications: The article may be used to assess the effectiveness of managing other publicly funded R&D projects.
Social implications: At this stage, the social implications of the project should be understood as prospective. The project has the potential to increase the availability of health-promoting food, reduce food waste and educate consumers, but these effects require validation in later project stages and after operational deployment.
Originality/value: The originality of the article does not lie in proposing a new project management methodology, but in providing an empirical case study of a real EU-funded R&D project combining FMCG, food-tech, vending automation, artificial intelligence and the formal requirements of EU-funded projects.
Keywords: project management; R&D project; FMCG; artificial intelligence; EU funds.
Category of the paper: Case study; Research paper.

1. Introduction

Research and development projects funded by the European Union combine two distinct management logics. The first is the experimental logic of R&D work, based on technological uncertainty, testing of assumptions, prototyping and the gradual mitigation of research risks (Wageman, 2024; Wang et al., 2010; Mohagheghi, 2017). The second is the formal logic of a grant project, linked to the necessity of implementing the project in accordance with the funding application, schedule, budget and resources, indicators, documentation and rules on the eligibility of expenditure (Coca et al., 2024; Dubel, 2022). The combination of these two perspectives means that the management of publicly funded R&D projects requires both flexibility and formal discipline (Coca et al., 2026).

A particularly interesting case for analysis is the R&D project carried out by Freshpot (Project funding application Freshpot, 2024), concerning the development of smart, self-service healthy-food shops. The project involves the development of artificial intelligence technology, vending machines, an automatic product recognition system, mechanisms for optimising stock levels, and the personalisation of the food offering. This undertaking is therefore an example of a project in which technological complexity is combined with the formal requirements of an EU-funded project.

The main research question of the article is: how is the Freshpot R&D project managed, and how does the adopted management model influence the course of project implementation and the achievement of intermediate outcomes? The article does not assess the ultimate market success of the solution, as the project is still ongoing at the time of the study. The analysis focuses on management mechanisms and selected intermediate outcomes, in particular the implementation of Task 1 and the achievement of the milestone assigned to it.

Task 1 was selected as the central empirical object because, as of 30 November 2025, it was the only completed R&D stage of the project. It also represented the industrial research phase in which the key technological assumptions of the project were verified for the first time. The milestone assigned to Task 1 was measurable and directly linked to the feasibility of subsequent development work. Therefore, the analysis of Task 1 allows the study to assess an intermediate but critical point in the project lifecycle, without making premature conclusions about final commercialisation or long-term market outcomes.

The article is based on a case study, an analysis of project documentation and participant observation. The approach adopted allows for a comparison of the assumptions set out in the grant application with the actual course of the project's implementation, and an assessment of how management activities supported the achievement of results despite the constraints, uncertainties and deviations typical of research and development projects.

2. Theoretical background

The management of research and development projects differs from the management of routine or investment projects. This is primarily due to the high level of technological uncertainty that accompanies R&D work (O'Connor et al., 2013; Semeniuk, 2026). At the planning stage, it is possible to define the project's objective, intended functionalities and expected outcomes; however, the final form of the solution depends on the results of research, testing, prototyping and the validation of the adopted assumptions (Cividino et al., 2019) In this type of project, the iterative nature of the work is of particular importance, as subsequent design decisions are made on the basis of the results of earlier technical trials and analyses.

R&D projects also require systematic testing of technological hypotheses. This means that the project team not only carries out pre-planned activities but also verifies whether the adopted solutions are technically feasible, effective and capable of further development. Consequently, in R&D projects, there is a higher risk than in standard projects of changes to the scope, modifications to the schedule, shifts in priorities, or the need to redesign selected elements of the solution (Lucena, 2026; Lasso et al., 2022). The expert knowledge of team members therefore becomes a vital resource, as it enables the interpretation of research results, the making of technical decisions and the mitigation of the risk of project failure.

R&D projects funded by the European Union have their own distinct characteristics. In addition to technological uncertainty, they are subject to the formal logic of a grant-funded project. The beneficiary is obliged to implement the project in accordance with the approved grant application, the technical and financial schedule, the budget, the rules on cost eligibility, and the output and outcome indicators (Gonzalez-Varona et al., 2023; Pina, 2024). This means that the research freedom inherent in R&D projects must be balanced by the obligation to document progress, justify expenditure, report results, and demonstrate that activities comply with the project's objectives.

In practice, managing an EU-funded R&D project requires a combination of flexibility and control. On the one hand, the team must be able to respond to research findings, emerging technical issues and changes in implementation conditions. On the other hand, every significant decision should be assessed in terms of its impact on the project scope, budget, schedule, indicators and the eligibility of expenditure. Mechanisms for monitoring progress, managing risk, documenting decisions and checking the achievement of milestones are therefore of particular importance (Lopez et al., 2024; Szczepaniak, 2020).

In the context of this article, a key point of reference is the PRINCE2 methodology, which emphasises project management through roles, responsibilities, stages, deliverables, progress monitoring and risk management (AXELOS, 2017). This methodology assumes that a project should be conducted within a structured decision-making framework, with a clearly defined division of responsibilities and mechanisms for monitoring the implementation of stages.

3. Research methodology

The study is qualitative, descriptive-analytical and exploratory in nature. The primary research method employed in the article is a case study of the Freshpot project, treated as an example of an R&D project carried out in the FMCG/food tech sector and co-financed by the European Union.

The empirical material used in the study comes from two main sources. The first is an analysis of project documentation, including in particular the grant application, the schedule, payment applications, the report on the implementation of R&D work, and documents confirming the achievement of the milestone for Task 1. The second source of data is the author's participant observation, resulting from involvement in the process of preparing, monitoring and analysing the project's implementation, supplemented by an interview with a member of the project team.

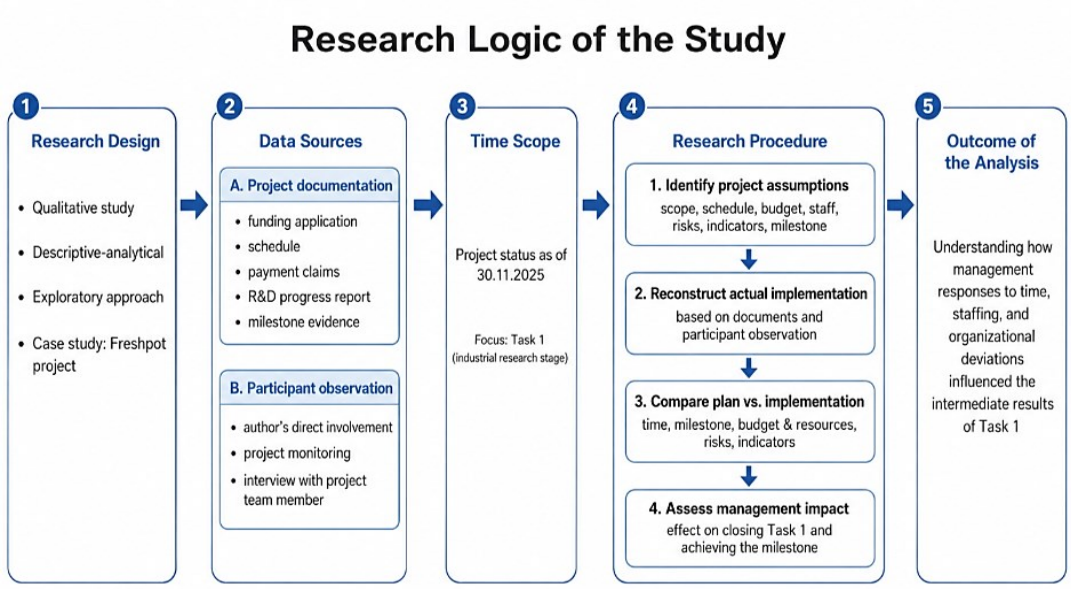


Figure 1. Flowchart of the research methodology.

Source: Author's own work.

In this study, participant observation means structured direct observation by the authors during project preparation, monitoring and analysis. To limit researcher bias, observations were triangulated with project documentation, payment applications, R&D reports, milestone evidence and an interview with a project team member. Factual findings were separated from interpretative conclusions, and the analysis relied primarily on documented project evidence.

The time frame of the study covers the status of the project as at 30 November 2025. As the Freshpot project is still ongoing at the time of the study, the analysis does not cover the final market success or the full achievement of all result indicators. The subject of the study is the implementation of Task 1, i.e. the completed stage of industrial research, and the impact of management on the achievement of the milestone assigned to it.

The research procedure was carried out in four steps:

- In the first step, the project assumptions derived from the grant application were identified, including the planned scope of Task 1, the schedule, budget and resources, risks, indicators and the milestone.
- In the second step, the actual course of Task 1 implementation was reconstructed on the basis of project documentation, payment applications, R&D reports and information obtained through participant observation.
- In the third step, the plan was compared with the actual implementation in selected areas: implementation time, milestone, budget, risks and indicators.
- In the fourth step, the impact of management actions on the achievement of the project's intermediate outcome—the completion of Task 1 and the achievement of its milestone—was assessed.

The adopted methodology allows the project to be understood as a process managed under conditions of technological uncertainty and the formal requirements of a grant-funded project. This makes it possible not only to describe the course of Task 1's implementation, but also to indicate how managerial responses to time, staffing and organisational deviations influenced the achievement of the industrial research phase's results.

4. Freshpot project characteristics

The Freshpot project is a research and development initiative in the FMCG/food tech sector. Its aim is to develop smart, unmanned shops or vending machines offering healthy food, utilising artificial intelligence technologies to automate the purchasing process, optimise stocking levels and personalise the offering for users (Figure 2). The project addresses the need for quick access to fresh and nutritious food products, particularly in places where users have limited time to make a purchase (Project funding application Freshpot, 2024). A key element of the project is an AI system for automatic product recognition. The solution is designed to identify products selected by the user and automatically fill the shopping basket (Project funding application Freshpot, 2024).

The project also involves the development of stock optimisation mechanisms. Their aim is to support decisions regarding the stocking of vending machines based on sales data, predicted demand and product availability (Project funding application Freshpot, 2024).

In accordance with the project's objectives, it has been scheduled to run from 1 November 2024 to 30 October 2026. It is planned to be carried out in several research and development phases, comprising one industrial research phase and three experimental development phases. The industrial research phase was intended to develop core technologies, verify key assumptions and build the first prototypes. Subsequent development phases are intended to lead

to further development, integration, testing and preparation of the solution for implementation in real-world conditions (Project funding application Freshpot, 2024).

Task 1 provides the technological foundation for subsequent project stages, as product recognition, product digitisation and configurable heating are prerequisite components for later stock optimisation, user applications and nutritional advisory functions. Therefore, Task 1 can be treated as a technological gate between industrial research and further experimental development.



Figure 2. A nano-shop, the technology for which is currently being developed as part of an R&D project based on the licence for the first Freshpod shop.

Source: https://freshpod.pl/

From the perspective of this article, the project carried out by Freshpot is an interesting case study, as it combines technological complexity with the formal requirements of an EU-funded project. The remainder of this article focuses not on the entire project duration, but on the completed Task 1, covering the industrial research phase and the achievement of its assigned milestone (Project funding application Freshpot, 2024).

5. Project management model

In accordance with the assumptions set out in the funding application, the project concerning smart, self-service healthy-food shops is managed using the PRINCE2 methodology.. The adoption of this methodology means that the project has been structured in terms of roles, responsibilities, implementation stages, project deliverables, progress monitoring and risk management. (AXELOS, 2017). In practice, this allows the R&D project to be conducted in an organised manner, whilst retaining the ability to respond to the changes and uncertainties typical of research and development work.

Three levels of management have been identified within the project. The first is the strategic level, established by the organisation’s management board. It is responsible for overseeing the project from the perspective of the company’s objectives, ensuring the resources necessary for

the project's implementation, and making decisions of key importance for the project's future direction. The second level is the operational level, for which the project manager is responsible. Their role involves the day-to-day coordination of project implementation, monitoring the schedule, controlling the budget, overseeing documentation, preparing reporting materials, and ensuring that the project is implemented in accordance with the grant agreement. The third level is the project deliverables level, comprising the R&D manager and the research and development team. At this level, the core substantive work is carried out, including technology development, algorithm preparation, prototype construction, solution testing, analysis of results, and documentation of R&D outcomes (Project funding application Freshpot, 2024).

This three-tier management structure is consistent with the PRINCE2 methodology, as it allows for the separation of responsibilities for strategic oversight, day-to-day project management, and the delivery of substantive results. This allows the R&D team to focus on solving technological problems and achieving R&D outcomes, whilst the project manager is responsible for the formal, organisational and financial aspects of the project. The management board, meanwhile, retains control over key decisions and the alignment of the project with the organisation's objectives.

The Freshpot project also utilised management mechanisms characteristic of a structured project approach. These include project meetings, schedule monitoring, milestone tracking, progress reporting, indicator monitoring, maintaining R&D documentation, cost control, risk identification and corrective decision-making. These mechanisms allow for ongoing assessment of whether the project is being implemented in accordance with the assumptions and whether there are any deviations requiring a management response (Project funding application Freshpot, 2024).

Milestones are of particular importance, as they serve as checkpoints within the project. They enable an assessment of whether a given stage has led to the achievement of the intended technical and organisational outcomes. Project and R&D documentation also plays an important role. In a project co-financed by EU funds, documentation is not merely a formal obligation but serves as a tool for control and knowledge management. It allows the course of work to be reconstructed, the achievement of results to be confirmed, compliance with the R&D Agenda to be demonstrated, and material progress to be linked to the expenses incurred.

The project management model adopted by Freshpot can therefore be described as formally structured, phased and product-based, in line with the principles of the PRINCE2 methodology. At the same time, given the research and development nature of the project, this model must be applied flexibly. This means that monitoring of the schedule, budget and indicators is combined with an ongoing response to technological, personnel and organisational risks. Understood in this way, management allows us to maintain the discipline of a grant-funded project, whilst adapting the course of work to the actual challenges arising during the course of R&D implementation.

6. Plan versus implementation

The scope of the study covers the implementation of Task 1 of the Freshpot project, i.e. the industrial research phase, the aim of which was to develop the basic technologies and design for a smart, self-service vending machine for healthy food. The analysis was conducted using the 'plan – implementation – deviation – cause – management response – impact on the project' framework. Adopting this structure allows not only for a description of the project's progress but also for an assessment of how project management influenced the achievement of Task 1's outcomes. Below is an analysis of the individual areas:

Area 1: Task 1 implementation timeframe:

- Plan according to the application – in accordance with the original schedule, Task 1 was to be carried out as an industrial research phase between 1 November 2024 and 31 July 2025, i.e. over a period of 9 months.
- Implementation as at the date of the audit – the actual implementation of Task 1 began on 1 March 2025 and ended on 30 November 2025. This means that Task 1 itself retained its planned duration of 9 months, but its start and end dates were postponed by approximately 4 months compared to the original schedule. As of the date of the audit, Task 1 had been completed and the project was already in the process of implementing the next stage.
- Deviation – there was a time deviation from the original schedule dates. However, the duration of Task 1 itself was not exceeded.
- Cause – the cause of the delay was the later start of the project, resulting from the protracted process of assessing the grant application and the subsequent commencement of implementation.
- Management response – the management response was to maintain the original structure and duration of Task 1 whilst postponing its implementation. The beneficiary monitored the impact of the delay on subsequent project phases and anticipated the possibility of accelerating further tasks, including by potentially outsourcing part of the work to subcontractors. Management therefore involved maintaining control over the scope and outcomes of the phase despite the change in the implementation schedule.
- Impact on the project – the postponement did not prevent the achievement of Task 1's results or the completion of the milestone. However, it did affect the schedule of the entire project, as subsequent tasks had to be rescheduled or coordinated within a shorter timeframe. From a project management perspective, the most important thing is that the external delay was absorbed without any loss of the substantive scope of Task 1.

Area 2: Task 1 milestone

- Plan as per the proposal – the milestone for Task 1 was to develop a prototype system with AI for product recognition and digitisation, including a refrigerator, an ambient storage unit and a configurable heater. Achievement of the milestone was to be confirmed by measurable technical parameters: AI recognition accuracy of at least 95%, microwave programming accuracy of at least 95%, and a false positive rate (FPR) of no more than 5%.
- Status as of the test date – the milestone has been achieved. Quantitative verification confirmed that the required parameters had been met: AI recognition accuracy was 95.2%, microwave programming effectiveness was 99.2%, and the FPR rate was 4.60%.
- Deviation – there was no negative deviation from the milestone parameters. All threshold values were met. In the case of microwave programming accuracy, the result was significantly above the minimum threshold. In the case of AI recognition accuracy and FPR, the values were close to the thresholds but fell on the correct side of the required parameters.
- Cause – achieving the milestone was made possible by an iterative approach to technology development, encompassing database construction, testing of image recognition models, development of a multi-camera system, integration of hardware and software components, and validation of the heating module's operation.
- Management response – involved the team focusing on the parameters critical to the completion of Task 1. In practice, this meant prioritising the functions necessary to achieve the milestone, conducting tests, documenting results, and postponing less critical elements to later stages.
- Impact on the project – The test results formally met the Task 1 thresholds, but AI recognition accuracy and FPR were close to the required limits. Therefore, the results should be treated as confirmation of milestone achievement, not yet as full validation of operational robustness under commercial conditions.

Area 3: Budget and resources for Task 1

- Plan as per the proposal – the budget for Task 1, understood as the industrial research phase, primarily covered R&D personnel costs, operating costs and additional overheads, potential subcontracting, and other costs allocated to the industrial research phase. The largest budget item was project personnel. The application envisaged the involvement of an R&D team with programming, analytical, technical and design expertise.
- Implementation as at the date of the audit – as at the closure of Task 1, expenditure was incurred primarily in relation to personnel and operating costs. No budget overrun was recorded for Task 1. At the same time, Task 1 was completed without the employment of one of the planned staff members – a developer. The remaining staff continued their

work and took on some of the duties not carried out by the missing team member. In practice, this meant that the key scope of Task 1 was completed with fewer people than originally planned.

- Deviation – a budget and resource deviation occurred. The most significant deviation concerned personnel costs, as one of the planned staff members was not hired. From a human resources perspective, there was a staffing deviation consisting of the planned team not being fully staffed. This did not result in a missed milestone or the interruption of Task 1, but it did affect the way the team's work was organised.
- Cause – The main cause of the deviation was the lack of an effective recruitment process for a new employee, as candidates did not meet the requirements set for them. Consequently, part of the personnel budget was not utilised in accordance with the original plan. Additionally, some of the costs may have remained unspent due to the team carrying out the work using its own resources and focusing on priority tasks.
- Management response – the management response was to prevent costs from rising despite staffing constraints. Instead of immediately increasing the budget or seeking costly external solutions, the work was reorganised internally. Some of the responsibilities were taken over by other developers, and the scope of activities was reorganised according to the priorities necessary to achieve the milestone.
- Impact on the project – the budget for Task 1 was not exceeded, which has a positive impact on the formal and financial assessment of the project's implementation. At the same time, the underutilisation of part of the personnel budget was not organisationally neutral, as it meant a greater workload for the remaining team members.

Area 4 – Risks

- Plan as per the proposal – the proposal anticipated risks typical of an R&D project, in particular: inaccuracy and insufficient effectiveness of AI algorithms, system integration issues, delays in electronics design, component unavailability, regulatory risks, operational risks, organisational risks, missed deadlines and increased component costs. Preventive measures were to include, amongst other things, testing, iterative algorithm refinement, modular design, schedule monitoring, cost control and ongoing team management.
- Implementation as at the date of the study – During the period analysed, some of the risks materialised to a limited extent. This primarily concerned technological risks related to AI algorithms, including isolated instances of false detection of products with similar packaging. Limited issues also arose in the areas of electronics design component availability and the schedule. However, there were no significant issues with system integration, regulatory compliance, user acceptance or the team's ability to carry out the tasks set out in the R&D Agenda.

- Deviation – Deviations were partial and non-critical in nature. The identified issues did not prevent the completion of Task 1 or the achievement of the milestone. Technological risks highlighted the need for further optimisation of AI models and refinement of diagnostic mechanisms, whilst schedule risks resulted in a delay in project delivery compared to the original plans.
- Cause – The primary cause of the risks was the technological complexity of the project, encompassing the integration of the AI system, training data, the sales application, electronics and hardware components. In the case of AI algorithms, the problem was the quality and unambiguity of the input data, particularly for products with similar appearances or packaging. Component risks stemmed from limited availability or the need to change the originally planned hardware solutions.
- Management response – In response to product detection issues, clearer labels were designed, additional barcode verification was implemented, and data collection from detection sessions was initiated to further train the models. In the electronics area, additional analyses of the power supply architecture and EMC were carried out. For components, an alternative supplier and a solution meeting the project requirements were selected. With regard to the schedule, the impact of the delay on subsequent stages of work was monitored.
- Impact on the project – The risks did not have a critical impact on the implementation of Task 1. They were treated as a natural part of the R&D process and used to improve the solution.

Area No. 5 – Indicators

- Plan as per the application – the application set out output and outcome indicators. Output indicators included, among others, the number of R&D projects carried out, the number of micro-enterprises supported, enterprises receiving support in the form of grants, and the number of enterprises supported in the implementation of R&D work. Outcome indicators included, among others, the value of private investment complementing public support, the number of product and process innovations introduced, revenue from the sale of new or improved products/services, the value of expenditure on R&D activities, publications, and applications for industrial property protection.
- Progress as at the date of the review – at the Task 1 stage, some of the output indicators were achieved, relating primarily to the launch and implementation of the R&D project and the provision of support to the enterprise. Financial indicators, such as the value of private investment and the value of expenditure on R&D activities, were partially achieved, as expenditure was incurred as the project progressed.

- Deviation – the failure to achieve the final indicators should not be interpreted as a negative deviation at the Task 1 stage. Indicators such as product innovation, process innovation, sales revenue, publications or intellectual property applications are logically linked to later stages of the project or to the period following its completion.
- Reason – the reason for the partial achievement of the indicators is the phased nature of the project. Task 1 was of an industrial research nature and served to develop the technological basis and prototypes, rather than the full commercialisation of the solution.
- Management response – the management response involved the ongoing monitoring of indicators through payment applications, project documentation and reporting. The indicators were treated as a tool for monitoring project progress, rather than merely as a formal requirement.
- Impact on the project – analysis of the indicators confirms that Task 1 contributed to the achievement of formal project progress, but could not yet result in the full implementation of the innovation.

7. Discussion and Summary

The case of Freshpot's smart and automated nano-shop food shop project demonstrates that managing an EU-funded R&D project requires combining two distinct operational logics. The first stems from the experimental nature of research and development work, which is fraught with technological uncertainty, requires testing of assumptions, prototyping, iterative refinement of solutions, and responding to results obtained during the course of the work. The second stems from the formal logic of a grant-funded project, in which it is necessary to comply with the funding application, schedule, budget, indicators, milestones and project documentation.

An analysis of the implementation of Task 1 indicates that the Freshpot project is managed in a phased, product-based and formal manner, utilising mechanisms characteristic of the PRINCE2 methodology and EU-funded projects. The phased approach is evident in the division of the project into successive R&D tasks, corresponding to the gradual development of the technology. The product-based nature of management is evident in the focus on specific deliverables, such as prototypes, system modules, algorithms, R&D documentation and milestones. The formal dimension of management, on the other hand, stems from the need to monitor the schedule, budget, eligible costs, indicators and compliance with the grant agreement.

In direct response to the research question, the Freshpot R&D project is managed through a three-tiered structure of responsibility, comprising the organisation's board, the project manager, the R&D manager and the R&D team. The board is responsible for the strategic level and key decisions regarding the direction of the project. The project manager is responsible for the operational level, covering the schedule, documentation, budget, reporting and compliance with the grant project requirements. The R&D manager and the R&D team, on the other hand, are responsible for delivering the project outputs, i.e. carrying out technological work, testing solutions, preparing prototypes and achieving substantive results.

The adopted management model influenced the course of the project primarily by enabling the monitoring of deviations. During the period under review, two significant deviations occurred: a delay in the implementation of Task 1 and a change in the composition of the project team. However, these did not prevent the stage objectives from being achieved. Task 1 was closed, the milestone was achieved, and the budget was not exceeded. This means that the effectiveness of management did not lie in completely avoiding problems, but in the ability to limit, document and compensate for them through corrective actions.

A strength of Freshpot's management model is the clear division of roles and responsibilities. It allows responsibility for substantive outcomes to be separated from responsibility for the formal management of the project. The R&D team can focus on solving technological problems, whilst the project manager is responsible for monitoring the schedule, budget, indicators, grant accounting and documentation. The phased nature of the project and the focus on deliverables and milestones are also of significant importance, as they enable progress to be assessed in circumstances where the final technological outcome is not fully known at the start of the project.

The case of Freshpot also highlights the importance of formal monitoring. Payment applications, reports on the implementation of R&D work, technical documentation and the monitoring of indicators do not serve a purely administrative function, but are tools for project management. They allow the course of work to be reconstructed, the achievement of results to be confirmed, expenditure to be justified and the project's compliance with its objectives to be demonstrated. In EU-funded R&D projects, documentation thus becomes one of the key mechanisms for mitigating formal and organisational risks.

At the same time, the nano-shop project highlights typical challenges associated with managing R&D projects. These include, above all, technological uncertainty, the need to integrate hardware and software, ensuring the appropriate quality of training data for AI models, maintaining continuity of work despite staff changes, and documenting decisions and changes within the project. Of particular significance is the tension between the need for flexible responsiveness to the outcomes of R&D work and the necessity of maintaining formal compliance with the grant project. In practice, this means that R&D project management must simultaneously enable adaptation and ensure accountability.

The findings should distinguish between demonstrated results and prospective effects. This study confirms the completion of Task 1, milestone achievement, budgetary control and management of schedule and staffing deviations. Broader effects, such as stock optimisation, food-waste reduction, nutritional advice and commercial value, remain prospective and require further validation.

A limitation of the study is that the Freshpot project was still ongoing at the time of the analysis. The article therefore does not assess the project's full commercial results, the final implementation of the technology, or the achievement of all outcome indicators. The analysis was limited to the project management approach and intermediate effects, in particular the implementation of Task 1 and the achievement of the milestone assigned to it. However, this approach allows the project to be captured during its implementation and assesses how management mechanisms influence the achievement of interim results.

Further research should include an evaluation of the project upon its completion. In particular, it is worth analysing whether the final project indicators were achieved, whether the solution was successfully implemented, whether the projected revenues were generated, and how the AI technology performed in real-world test locations. It would also be important to compare the planned and actual commercialisation outcomes, the effectiveness of the product recognition system under operational conditions, and the impact of stock optimisation on reducing food waste.

In summary, the Freshpot case study contributes to our understanding of R&D project management by demonstrating that an effective management model should combine a structured framework of roles, stages, deliverables and milestones with operational flexibility. A formal management methodology does not eliminate technological uncertainty, but it allows it to be controlled and translated into measurable results. In the case studied, this enabled the completion of Task 1, the achievement of a milestone, and the creation of a foundation for continuing further development work.

References

1. AXELOS (2017). *Managing Successful Projects with PRINCE2*. London: The Stationery Office.
2. Cividino, S., Egidi, G., Zambon, I., Colantoni, A. (2019). Evaluating the Degree of Uncertainty of Research Activities in Industry 4.0. *Future Internet, 11,* pp. 196. doi: 10.3390/fi11090196.
3. Coca, P., García-Domínguez, A., Claver, J. (2024). Analysis of Restrictions on Public Funding and Management of R&D Projects Arising from Legislation: The Case of the Spanish Context. *Administrative Sciences*. doi: 10.3390/admsci14110294.

4. Coca, P., García-Domínguez, A., Claver, J. (2026). Regulatory Feedback and Adaptive Constraints in Publicly Funded R&D Project Management Systems: A Multicriteria Decision Analysis. *Syst., 14*. doi: 10.3390/systems14020135.
5. Dubel, P. (2022). The Hurdles to Obtaining European Funds by Polish Beneficiaries – Quantitative Research. *Studia Europejskie - Studies in European Affairs*. doi: 10.33067/se.1.2022.6.
6. González-Varona, J.M., Martin-Cruz, N., Acebes, F., Pajares, J. (2023). How public funding affects complexity in R&D projects. An analysis of team project perceptions. *Journal of Business Research*. doi: 10.1016/j.jbusres.2023.113672.
7. Lasso, S., Cash, P., Daalhuizen, J., Kreye, M.E. (2022). Uncertainty and Activity Selection in New Product Development: An Experimental Study. *IEEE Transactions on Engineering Management, 69*, pp. 1405-1416. doi: 10.1109/tem.2020.2989208.
8. López, C., Moheimani, A., Ishizaka, A. (2024). Managing risks in technological R&D projects with Probability-Impact AHPSort. *Annals of Operations Research, 346*, pp. 1285-1320. doi: 10.1007/s10479-024-06086-2.
9. Lucena, M.C. (2026). An Exploratory Pilot Survey on Technical Quality Control Practices in Agile R&D Projects. *ArXiv*, abs/2601.06689. doi: 10.48550/arxiv.2601.06689.
10. Mohagheghi, V., Mousavi, S., Vahdani, B., Shahriari, M. (2017). R&D project evaluation and project portfolio selection by a new interval type-2 fuzzy optimisation approach. *Neural Computing and Applications, 28*, pp. 3869-3888. doi: 10.1007/s00521-016-2262-3.
11. O'Connor, G., Rice, M. (2013). A Comprehensive Model of Uncertainty Associated with Radical Innovation. *Journal of Product Innovation Management, 30,* pp. 2-18. doi: 10.1111/jpim.12060.
12. Pina, D.G. (2024). Ten simple rules for successfully managing EU research grants. *PLOS Computational Biology, 20*. doi: 10.1371/journal.pcbi.1012335
13. Project funding application Freshpot (2024). *Innowacje w technologii sprzedaży: budowa inteligentnych i bezobsługowych sklepów ze zdrowa żywnością, z zastosowaniem sztucznej inteligencji do automatycznego rozpoznawania produktów, optymalizacji zapasów i doradztwa żywieniowego.* Internal project documentation.
14. Semeniuk, O. (2026). Conceptualising adaptive uncertainty management in information technology projects. *Business Navigator*. doi: 10.32782/business-navigator.84-9.
15. Szczepaniak, W. (2020). Safety of the EU Project Management System in Public Universities. *System Safety: Human - Technical Facility - Environment, 2*, pp. 39-46. doi: 10.2478/czoto-2020-0006.
16. Wageman, S. (2024). *Risk management on R&D projects*.
17. Wang, J., Lin, W., Huang, Y.-H. (2010). A performance-oriented risk management framework for innovative R&D projects. *Technovation, 30,* pp. 601-611. doi: 10.1016/j.technovation.2010.07.003.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE RULES OF CONCESSIONS MAKING IN NEGOTIATIONS

Andrzej KOZINA

Cracow University of Economic; kozinaa@uek.krakow.pl, ORCID: 0000-0001-8973-8279

Purpose: one of the most important tools applied in negotiation processes are concessions made by their participants, which enables them to achieve efficient deals. Therefore, very sound and promising objective of the paper is to present the author's concept of classifying and describing the rules (principles)of concessions making within negotiation processes.
Design/methodology/approach: since the paper is of a theoretical nature, the basic methodological tools used for its elaboration are the comparative and critical analysis of the literature on the considered problem, supported by author's theoretical findings and practical experience from socio-economic negotiations.
Findings: developing a comprehensive, precise as well as universal concept of giving in in negotiation processes as a part of their normative model by distinguishing and describing the rules of making concessions, including the three kinds of those rules, i.e. concerning the way of giving in, size and value of concessions.
Practical implications: the presented set of rules of concessions making may be successfully used within a wide variety of practical negotiation processes, ensuring achieving their required effectiveness.
Originality/value: unlike numerous researches and works on the issue of giving in within negotiation processes, presenting mainly fragmentary and selective findings related to that issue, the classification and description of the rules of concessions making within negotiations presented in the paper is of a synthetic, insightful and complex nature.
Keywords: socio-economic negotiations, negotiation process, the rules of concessions making.
Category of the paper: Viewpoint.

1. Introduction

This paper examines the processes of conducting socio-economic negotiations, or more precisely, one of the typical tools used within those processes: mutual concessions made by participants. These are among the most important detailed tools in conducting negotiations, as without them, it is essentially impossible to reach an agreement that satisfies all parties involved.

Concessions play a dual role in negotiations: on the one hand, they serve as a signal, an offer to reach a compromise or consensus, and on the other, they serve as an attempt to determine the limits of concessions acceptable to the negotiating partner(s). Concessions are therefore a key condition for reaching an agreement, involving the surrender of some of one's demands in exchange for benefits from the other party. Proper concessions should be well-considered, gradual, and balanced, and (if possible) lead to a model negotiation conclusion, i.e. a win-win situation.

The objective of the paper is to systematize and describe the rules (principles) of making concessions in socio-economic negotiations, based on proposals contained in the literature and the author's own reflections stemming from his negotiation experience, gained both theoretically and practically.

To systematize such rules three basic types of them were identified: those concerning the method of making concessions, their size (scope), and their value (significance). These are presented in the main part of the paper, after explaining the essence and nature of concessions and their importance for the efficient implementation of the negotiation process, in the context of a typology of tools for conducting them.

2. Research methods and literature review

Given that the primary research method employed in this paper was a comparative and critical analysis of the literature on making concessions in negotiations, two fundamental methodological issues - namely, the research methods and the literature review - have been combined into a single section.

The analysis of the literature on making concessions in negotiations was a multi-stage procedure based on several analytical criteria. The aim of this procedure was to identify the bibliographic items most relevant to explaining the nature of concessions as specific negotiation tools and to precising the principles of using them.

First, a preliminary review of the state of research on making concessions during the negotiation process was conducted to identify the quantity and scope of research studies within the considered area to define the scope and directions of their further analysis. As it turned out the issue of making concessions in negotiations is undoubtedly one of the most frequently discussed problems in literature. A number of classic bibliographical works on the subject can be cited, e.g., (Bartos, 1964; Dawson, 1999; De Dreu, 1995; Karrass, 1984, pp. 39-53; Kennedy, 1998; Pruitt, Carnevale, 1993), as well as numerous contemporary studies published in recent years, including: (Bhatia et al., 2023; Cronin, 2026; Cueves, 2022; Karrass, 2025; Mertes, Kunz, Hüffmeier, 2023; Shonk, 2025).

Secondly, a detailed and systematic review of the literature on the subject under consideration was conducted. A very extensive list of publications was compiled using popular electronic bibliographic databases and put in chronological order. Given the large number of those studies, a precise selection was made by excluding publications that were least relevant to the paper's objective and those containing repetitive content.

Thirdly, the primary criterion used to analyze and select the research studies of interest was the distinction - commonly adopted in the literature (e.g., Rządca, 2003, pp. 25-26) - between two opposing research approaches in the field of negotiation: the descriptive and the normative ones.

The first approach explains the nature, specificity, conditions, etc. of making concessions in the negotiation process. Consequently, the research works adopting a descriptive approach were used to characterize concessions as specific negotiation tools in the subsequent part of the paper. It can also be noted that concessions are often not considered in isolation, but rather perceived within a broader context, including their types, conditions, strategies, etc. Selected literature of that kind is summarized below.

1. C.K.W. De Dreu (1995), discusses concessions in bilateral negotiations, while in the works (Kersten, Gimon, 2012; Yasumura et al., 2009), they are analyzed in multilateral negotiations. In the first of the mentioned cases, making concessions is considerably easier (almost intuitive) whereas the second requires a precise analysis of the positions held by all negotiation participants.
2. In the paper (Hendon, Roy, Ahmed, 2003), discusses concessions in the context of international negotiations. In this case, what matters is not so much the substantive issues subject to negotiation, but rather the socio-cultural context of the negotiations—factors that determine the manner in which concessions are made, as well as their scope, pace, sequence, and so on.
3. Concessions are considered, on the one hand, in the context of integrative negotiations, i.e. as tools for striving to reach an agreement that satisfies all negotiating participants (Cueves, 2022; Ma et al., 2006), and, on the other hand, in the process of distributive negotiations (Bhatia et al., 2023; Mertes, Kunz, Hüffmeier, 2023; Tey et al., 2021) in the pursuit of achieving unilateral benefits at the expense of other negotiating parties. These issues will be discussed in greater detail in the next part of the paper.
4. In the work (De Dreu, 1995), concessions are viewed from the perspective of the bargaining power of the negotiating parties, i.e., the realistic possibility of achieving their goals. The role of concessions is considered both when one negotiator has an advantage over the other participants, which creates opportunities to obtain significant concessions, and when negotiating from a weaker position, which significantly limits the possibility of obtaining concessions.

5. Most studies on the discussed issue are qualitative in nature, focusing primarily on formulating principles for making concessions, analyzing their determinants, effectiveness, benefits, and significance, etc. However, there are also quantitative studies that create formal models based on attempts to measure the size or scope of concessions (Badica, C., Badica, A., 2012; Ma et al., 2006). Several studies consider concessions in the context of electronic negotiations (Carbonneau, Vahidov, Yu, 2021; Yasumura et al., 2009).
6. Finally, some works present the results of empirical research, mainly of a comparative nature, on the ways of making concessions in practical negotiation cases, as well as their scope, importance, benefits, conditions, etc. in relation to particular, specific negotiations (Badica, C., Badica, A., 2012; Bartos, 1964; Hendon, Roy, Ahmed, 2003).

On the other hand, the normative approach is focused on indicating how concessions should be made in negotiations. In other words, they indicate recommended behaviors regarding concessions by formulating practical principles for making them. Extensive literature representing the normative approach was elaborated, including on the one hand a number of books and scientific articles, such as (Dawson, 1999; Karrass, 1984, pp. 39-53; Kennedy, 1998; Kersten, Gimon, 2012; Pruitt, Carnevale, 1993, pp. 29-31; Rządca, Wujec, 1998, pp. 69-74), and on the other hand, advisory (consultative) works, e.g. (Cronin, 2026; Karrass, 2025; Malhorta, 2016; Shonk, 2025; Szopa, 2013). Those works were used to systematize the principles for making concessions in the fourth (main) part of the paper.

3. Concessions as specific tools of negotiations

As a starting point for further considerations, we should adopt the typology of negotiation tools according to their degree of generality, as presented in Table 1. It contains the interpretations and meaning of particular tools of that kind, starting from the most general, i.e. negotiation strategies and styles, to the most detailed, and within them the most interesting in this paper, i.e. concessions.

Table 1.
Systematics of negotiation tools

Type	Interpretation
Negotiation strategy	Program defining the key goals and principles of the negotiation process, as well as the assumptions and expectations regarding its course. It includes a scenario of anticipated events and the expected actions and behaviors of the negotiation participants. It also identifies the conditions (opportunities and constraints) for conducting negotiations, resulting from the positions of the parties, the immediate context, and the external environment. It outlines the procedure for conducting negotiations in the form of synthetic guidelines and schedule.

Cont. table 1.

Negotiation style	The general way of conducting negotiation process, determining all actions undertaken within that process and the selection of means for implementing these actions, in particular the initial assumptions, the way of perceiving the scope and goals of negotiations, the selection of their tools, means of communication with negotiation partners, etc. It depends on the specificity of a given situation - the problem, goals, partner, etc., on the one hand, and on the individual characteristics of the negotiator on the other.
Negotiation principles	Statements specifying how negotiation processes should or should not be conducted. There are three types of such rules. 1. General, e.g. concerning developing partnerships with the other party, building mutual trust, preventing crisis situations, etc. 2. Detailed, e.g. relevant to subsequent sub-processes, phases, and stages of negotiations. 3. Specific rules for implementing particular activities, e.g. assessing bargaining power, delegating authority to representatives, formulating offers or arguments, etc.
Negotiation techniques	Systematically applied, detailed negotiation methods, based on practical experience and theoretical generalizations. Adapted to subsequent stages of negotiation process: opening, main phase, and closing, as well as of twofold nature. 1. Collaboration-focused, with a predominance of integrative and fair play-based actions, in searching for mutually beneficial deals. 2. Competition-oriented (confrontational) – seeking to obtain unilateral concessions from other partners, pursuing own goals, sometimes at all costs, by exerting pressure on the others, issuing ultimatums, manipulating, threatening, etc.
Detailed negotiation tools	• offers (proposals) presented to the partners in the negotiation process and counteroffers made to them, • arguments and counterarguments necessary to convince the other parties and persuade them to accept the proposal, • **mutual concessions** between the parties within an agreed and acceptable scope (limits), and • questions asked of the negotiating partners and answers to their questions.

Source: own elaboration based on (Kozina, 2018, pp. 123, 235-236).

As very detailed (specific) negotiation tools, concessions should therefore constitute a precise concretization of the adopted negotiation strategy. Their significance differs when two opposing types of strategy are employed: cooperation and competition. In the former, mutual concessions constitute the most important means by which the negotiating parties achieve mutual benefits, best satisfy their needs, and pursue their goals and interests at a satisfactory level. When employing a competition strategy, the negotiating parties pursue only their own goals, ignoring the needs and expectations of their partners and striving to extract the largest possible concessions from them.

There is also a relationship between the scale of concessions and confrontational negotiation techniques. Many of these techniques are aimed at extracting the largest possible concessions from partners in all phases of the negotiation process. Initial concessions are demanded at the beginning of negotiations as a condition for starting talks. In the middle phase, when a lively exchange of concessions occurs, the parties strive to gain an advantage in terms of the scope of concessions to their own advantage, at the expense of their partners. Finally, at the conclusion of negotiations, demands for additional concessions are made, which are a condition for reaching an agreement, as if "on the line."

It should be added that the significant importance of mutual concessions on the part of negotiation participants stems from one of their fundamental interpretations, namely, perceiving them as a process of exchange of values between the parties through mutual

agreements and concessions. Such exchange involves both tangible and intangible values, under agreed-upon terms (Kozina, 2018, pp. 15-17).

For example, negotiations are defined as a tool used to seek conditions for obtaining what we want from someone who wants something from us (Kennedy, 1999, p. 9). From another perspective, the basic mechanism for reaching an agreement is the exchange of concessions, mutually setting conditions, the fulfillment of which determines the parties' further actions (Nęcki, 2000, pp. 17-18).

The following sections of this paper systematize the most important rules (principles) of concession in negotiations. They are divided into three groups:

1) the manner of making concessions, i.e. specifying how, when, in what order, and for what reasons (why), for what purpose, etc., they are made (or not made),
2) their size (scope), i.e., defining their potential limits, taking into account the realistic possibilities of achieving the negotiation goals and interests and the subjective and objective constraints in this regard,
3) the values (importance) they reflect, from the perspective of the needs, goals, and interests of the negotiators and the effectiveness of the negotiation process itself.

These rules constitute, on the one hand, recommendations (guidelines) specifying how concessions should be made, and, on the other, warnings, i.e., statements about how they should not be made.

4. The way of concessions making

Both the way of concessions making and its process (dynamics) are much more important than the concessions themselves, i.e., their size (scope) or value (significance). Whether and by how much, for example, we extend a payment deadline, reduce the price, expand the scope of a warranty, etc., is far less important than how we do it, when, why, etc., or whether we don't do it. If the manner of concession is inappropriate, it can raise the partner's expectations for subsequent proposals containing concessions in their favor, and even lead to an escalation of their demands. Below the most important principles of concession in negotiations are listed i.e. reflecting the recommended way for making concessions.

1. You should not accept offers of preliminary concessions as a condition for initiating negotiations if your partner lacks a real advantage to present such a condition.
2. You must insist on concessions from your partner, even if the terms of their initial offer seem attractive to you.
3. A negotiator who does not immediately make concessions when presenting their offer encourages the other party to delay the opening of negotiations until the proposed offer is subject to his\her influence.

4. If you make a concession to your partner, you should immediately ask for a reciprocal concession, meaning an equivalent one. Don't expect this to happen later, as any concession to the other party quickly loses value. In negotiation literature, this practice is sometimes called the "prostitute principle," meaning that the value of a service is valued more before it is performed, but its value plummets afterward.
5. To obtain a concession, your partner should present appropriate (convincing) arguments. You shouldn't make concessions solely because the other party demands them. Giving in to this type of pressure undermines the credibility of previous arguments and can lead to escalation of your partner's concessions.
6. You shouldn't be afraid of retracting a previous concession or refusing your partner's demands for a concession. Repeated, firm responses of "no" are intended to deter their demands for further concessions.
7. It is necessary to adopt an appropriate pace of concessions:
   - quick concessions at the beginning, then stopping, will frustrate the partner, as the initial concessions created additional expectations that were later unmet;
   - slow concessions, followed by an acceleration in the pace of concessions, strengthens the partner's position by convincing them of the effectiveness of a hard-line negotiation;
   - concessions at an alternating pace (sometimes faster, from time to time slower) provokes pressure from the partner, who is unaware of how their behavior affects the other party's concessions;
   - concessions should always be made slowly, gaining something in return - this allows for consistency with the partner, signals how they can obtain a concession, and prevents them from escalating their concessions.
8. Furthermore, concessions should not be made easily, as the partner will likely be dissatisfied if the concession is made too easily and quickly. People usually value what comes easily less than what they have had to fight for long and hard. Moreover, doing so will prevent your partner from demanding further concessions.
9. Before making any concession, always consider all its potential consequences, both positive and (especially) negative.
10. Not every concession from a partner needs to be reciprocated. Mutual concessions are not always necessary, and equal concessions are not always fair, however that may be understood. When a partner insists on an exchange of equal concessions, it should be acknowledged that this is not possible.
11. Escalating concessions at the end of negotiations should be avoided. Both experienced and inexperienced negotiators are sometimes inclined to do so, influenced by the mutual escalation of demands.

12. Do not show satisfaction with the concessions made by the partner, especially the first one, no matter how favorable it may be.
13. It is important to thoroughly understand all the other party's requirements before making any concessions. It may turn out that the partner does not expect them at all.
14. Sometimes, simply entering into negotiations can constitute a significant concession to the partner, especially if they have weaker bargaining power.

5. The size of concessions

When entering into negotiations, it's advisable to apply the "aim high" principle, i.e., assume that high expectations lead to the best results in negotiations, while low expectations produce the worst effects. Therefore, it's recommended to initially set a high level of expectations (the highest possible offer) to achieve the best possible end result, while maintaining the impression that this offer is within reasonable limits and acceptable to the partner. This adds strength, resilience, and self-confidence. The reasons for applying this principle are as follows:

- it may simply be possible to achieve the best solution,
- it allows for greater room for maneuver (to lower the level of demands),
- it creates the impression that the offer is more valuable and attractive, and that the partner can make a great deal,
- it prevents stalemates (often arising because negotiators, contrary to their own intentions, lack the courage to demand more),
- the partner then feels (is convinced) that they have obtained certain concessions.

A necessary condition for the effectiveness of this principle is belief in the attractiveness, credibility, and reliability of their offer. When initial demands are indeed excessive, a willingness to make concessions should be demonstrated to encourage the partner to negotiate.

The less one knows about the partner, the greater the initial demands should be, as they may be willing to accept them or have many surprising arguments up their sleeve. This makes it easier to establish a good relationship with them, encourage cooperation, and then make larger concessions (Dawson, 1999, pp. 15-20).

Here are the basic rules of concessions making regarding their size (or scope).

1. It is recommended to remember that when entering into negotiations, we face dilemmas: whether to give in at all, to what extent, why, at what pace, when, etc., and the impossibility of predicting the partner's reaction to our proposals. Our partner also faces similar dilemmas.
2. When initially defining the limits of concessions, it is recommended to avoid dividing the difference between the initial proposals of the negotiating parties in half, i.e., it is advisable to avoid easy (hasty) compromises.

3. You should first obtain a concession from your partner. As a rule, the negotiator who gives in first gives in more (more), as concessions are most often alternated.
4. Concessions should be small, as too much should not be given at once. The partner ought to seek our possible further concessions. Furthermore, people primarily notice the fact of a concession, attaching much less importance to its size. On the other hand, too small concession may be interpreted by the partner as "throwing them a sop" and become irritated.
5. You should never offer everything you have to give at once, a so-called unilateral disarmament, just because your partner expects a "final" proposal or says they "don't like (or don't like) negotiating." Statements like this are usually considered bluffing.
6. You should never make small concessions at the beginning of negotiations to "test the waters," as this can lead to an escalation of your partner's demands, and your attempts to persuade them to accept further concessions only strengthen their position. This weakens your bargaining position.
7. Whenever your partner demands concessions, you should call for something in return, some kind of compensation. That is, you should receive something equivalent to your own for each concession. This should be done in a measured, calm, and unemotional manner, politely asking the other party, "If I can do this for you, what will you do (be able to do) for me?" without making categorical demands. The benefits of this approach are as follows:
   - it prevents your partner from escalating further concessions,
   - you may actually get something in return; you can gain a lot, not lose anything,
   - it increases the value of your concession – by emphasizing its importance, you create the conditions for obtaining something in return later in the negotiation. "Giving" does not result in "receiving", "taking" does not result in "giving".
8. You should avoid making reckless, unilateral concessions in response to your partner's seemingly insignificant demands, such as "no problem", "it's a minor thing", etc. Every concession, even a small one, should be rewarded. At the same time, you should be wary of such concessions from your partner, as they may be vague or even fictitious, constituting empty promises, etc.
9. Subsequent concessions should be of varying sizes. If they are consistent and equal, your partner will never stop demanding more. It's a mistake to make even the same concession twice. Therefore, you should avoid easily predictable patterns or patterns of concessions on your part. Failure to follow this rule can lead to an escalation of your partner's demands, i.e., a "snowball effect", and ultimately, result in a disastrous negotiation failure.

10. On the other hand, you should not make concessions in a completely unpredictable manner (one large concession, the next minimal, or vice versa), as your partner will expect significant concessions each time, and failure to make them will result in dissatisfaction.
11. The size of each concession should be gradually reduced, making smaller and smaller increments, from relatively large concessions, through smaller ones, to minimal ones. This approach is intended to provide greater satisfaction to the partner and to instill in them the belief that they should not delay signing the agreement because they are approaching the limits of their capabilities, that they have achieved as much as was possible in the given situation.
12. The final concession should be small to create a favorable negotiating atmosphere. Too large a concession may be perceived as a lack of flexibility on our part.

6. The value of concessions

Concessions can have varying values (material or intangible) for the negotiating parties, depending on their goals and interests, and consequently, their priorities, ranging from the most important to the least significant. These values are relative, meaning that something that may be extremely important to one party may be completely irrelevant to another.

Creating value in the negotiation process is possible when a party offers something that is of little value to them but of great value to the other party—and vice versa. By exchanging these values, each party loses little but gains a great deal (Negotiations..., 2003, p. 53).

The following key rules for making concessions in negotiations can be listed, depending on their value.

1. Before making any concessions, it is advisable to establish the types and hierarchy of values sought in the negotiations and attempt to obtain similar information from other negotiating participants.
2. If possible, make concessions that are beneficial to all negotiating parties.
3. It's best to offer concessions that don't cost us anything, such as:
   - listening carefully to your partner,
   - committing to considering your options and limitations,
   - assuring them that, despite your best intentions, a concession is not possible,
   - appealing to an authority figure who has acted in a similar situation,
   - providing the most comprehensive explanation of your position and stance possible,
   - answering any questions or concerns your partner may have,
   - giving them more time to "catch their breath".

4. You should emphasize the importance of your concessions by telling your partner how difficult it is to give up some of your demands. Sometimes, the "great sacrifice gambit" technique is used, i.e., making a minor concession the main one in negotiation, through the most credible justification possible, and demanding that your partner compensate for it.
5. It's also important to remember that the value of concessions can change over time, influenced by various factors, e.g. the partner's actions, one's own moves, mistakes made, contextual conditions, etc.
6. Demanding a concession of significant value should be supported by strong and credible arguments, unless the partner wishes to obtain a concession of similar value in return, i.e., proposes an equivalent exchange.
7. Furthermore, ensure that the partner understands and properly assesses the value of our concession by asking appropriate questions and providing appropriate explanations.
8. It is recommended not to be the first to give in on important matters, as this significantly weakens our bargaining position (power). It is even better not to make such concessions at all.
9. Furthermore, such a concession may be perceived by the partner as a signal that the issue is not that important, so further concessions are possible, or perceived by the other party as a weakness or as an overly persistent and therefore suspicious pursuit of an agreement.
10. Therefore, it is possible and necessary to demonstrate initiative by offering and accepting concessions on less important matters.
11. It is beneficial to inform your partner beforehand of your intention to make a concession on an issue that is less important to you. This saves time and demonstrates goodwill and a willingness to negotiate.
12. Furthermore, giving in on such an issue may allow you to obtain a concession from your partner on an issue that is more important to you. The need for this also stems from the fact that partners often have different priorities in negotiations, and they will not be afraid of losing face.
13. Do not assume that your opponent understands the benefits of the concessions you make. If not, you must demonstrate them convincingly and clearly, even repeatedly.
14. The final concession should be minor; so as to leave your partner satisfied without offering too much.
15. Remember the concessions you've made and remind your partner from time to time (even repeatedly) of their importance and the costs you incurred. The previously mentioned "prostitute principle" also applies in this case.

7. Conclusions

The suggested classification of concessions making rules adequately reflects their specific characteristics, functions, and importance in the negotiation process. Furthermore, it comprehensively and thoroughly captures the scope and possibilities of their use in this process, effectively supporting its implementation. It is universal in nature as well, meaning it can be successfully applied in all types of socio-economic negotiations. It also appears that the adopted criteria for the typology of concession rules have proven effective, allowing for a comprehensive characterization of these rules.

In the author's opinion, the approach to concession rules in negotiations presented herein can be a significant contribution to the creation of a general normative model, which, in addition to concessions, should also include other specific negotiation tools, such as offers, arguments, and questions, systematizing the principles of their application.

It should be added that, in specific negotiation situations, the presented concession principles must be specified depending on a number of specific features of the negotiations, such as their type, parties, subject matter (scope), goals, significance, conditions, etc. These desires determine the three important dimensions of concessions identified in the article: their size and value, and the manner of concession itself. Considering these features, as well as the intensity and scope of their impact on concessions in negotiations, determines the scope of research developing the proposed approach to their general principles.

The author also intends to verify the proposed concession principles in comparative empirical research, encompassing both typical, recurring negotiation situations, such as in trade and marketing, and specific, rare negotiation cases, such as in mergers and acquisitions. Such research will confirm the usefulness and applicability of the proposed principles.

Acknowledgements

The publication was financed from the funds granted to the College of Economy and Public Administration of the Cracow University of Economics, as part of a subsidy for the maintenance of research potential - the project entitled “Managing Relationships within Local Self-government” (no 036/GAP/2023/POT).

References

1. Badica C., Badica, A. (2012). A Set-Based Approach to Negotiation with Concessions. *BCI '12: Proceedings of the Fifth Balkan Conference in Informatics.*
2. Bartos, O.J. (1964). *Concession-Making In Experimental Negotiation. Scientific Report Prepared for Air Force Office of Scientific Research.* University of Hawaii.
3. Bhatia, N., Chow, R.M., Weingart, L.R., Diabes, M.A. (2023). Your Cost or My Benefit? Effects of Concession Frames in Distributive Negotiations. *Negotiation and Conflict Management Research*, *Vol. 16, No. 2,* pp. 165-188.
4. Carbonneau, R., Vahidov R., Yu, B. (2021). Concession Crossover in Electronic Negotiations *Control and Cybernetic. Vol. 50, No. 1.*
5. Cronin, N. (2026). *Concessions in Negotiation: What They Are & How to Use Them Strategically.* Retrieved from: https://www.alignednegotiation.com/insights/concessions-in-negotiation-meaning, 04.05.2026.
6. Cuevas, J.M. (2022). *Negotiation Strategy Series: 4 Exchanging Concessions and Making Agreements.* Retrieved from: https://blog.som.cranfield.ac.uk/execdev/negotiation-strategy-series-4-exchanging-concessions-and-making-agreements, 10.05.2026.
7. Dawson, R. (1999). *Sekrety udanych negocjacji*. Poznań: Zysk i S-ka.
8. De Dreu, C.K.W. (1995). Coercive Power and Concession Making in Bilateral Negotiation. *Journal of Conflict Resolution*. *Vol. 39, No. 4*, pp. 648-670.
9. Hendon, D.V., Roy M.H., Ahmed, Z.U. (2003). Negotiation Concession Patterns: A multi-country, Multiperiod Study. *American Business Review*, *Vol. 2l*, pp. 75-83.
10. Karras, C.L. (1984). *Give & Take. The Complete Guide to Negotiating Strategies & Tactics*. New York: Thomas Y. Crowell Company.
11. Karrass, C. (2025). *Everything You Need to Know About Concessions in Negotiation.* Retrieved from: https://www.karrass.com/blog/making-concessions, 21.04.2026.
12. Kennedy, G. (1998). *Negocjator*. Warszawa: Studio EMKA.
13. Kersten, G.E., Gimon, D. (2012). Concession-Making in Multi-Bilateral Negotiations and Multi-Attribute Auction. *Informatyka Ekonomiczna. Vol. 25, No. 3,* pp. 61-83.
14. Kozina, A. (2018). *Zasady negocjacji*. Kraków: Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie.
15. Ma, L, Showail, S., Campagna, R., McLean Parks J. (2006). Concessions in Negotiations: The Roles of Initial Assessment and Signaling on Outcomes of a Negotiated Agreement. *SSRN Electronic Journal*, *No. 7*.
16. Malhorta, D. (2016). *Four Strategies for Making Concessions in Negotiation*. Harvard Law School: Program on Negotiation. Retrieved from: https://www.pon.harvard.edu/daily/negotiation-skills-daily/four-strategies-for-making-concessions\, 12.04.2026.

17. Mertes, M., Kunz D., Hüffmeier, J. (2023). A Deep Dive into Distributive Concession Making and the Likelihood of Impasses in Negotiations. *Collabra: Psychology*, *Vol. 9, No. 1*.
18. Nęcki, Z. (2000). *Negocjacje w biznesie.* Kraków: Antykwa.
19. *Negocjacje. Harvard Business Essentials* (2003). Konstancin-Jeziorna: MT Biznes Ltd.
20. Pruitt, D.G., Carnevale, P.J. (1993). *Negotiation in Social Conflict*. Buckingham: Open University Press.
21. Rządca, R.A. (2003). *Negocjacje w interesach*. Warszawa: PWE.
22. Rządca, R.A., Wujec, P. (1998). *Negocjacje*. Warszawa: PWE.
23. Shonk, K. (2025). *Making Concessions in Negotiation: Best Practices*. Harvard Law School: Program on Negotiation. Retrieved from: https://www.pon.harvard.edu/uncategorized/making-concessions-in-negotiation-best-practices/, 24.04.2026.
24. Szopa, M.J. (2013). *Wygrać w negocjacjach, czyli sztuka ustępowania.* Retrieved from: https://www.researchgate.net/publication/256305378_Wygrac_w_negocjacjach_czyli_sztuka_ustepowania, 25.05.2026.
25. Tey, K.S., Schaerer, M., Madan, N., Swaab, R.I. (2021). *The Impact of Concession Patterns on Negotiations: When and Why Decreasing Concessions Lead to a Distributive Disadvantage.* Amsterdam: Elsevier. Retrieved from: https://www.elsevier.com/open-access/userlicense/1.0/, 10.04.2026.
26. Yasumura, Y., Kamiryo, T., Yoshikawa, S., Uehara, K. (2009). Acquisition of a Concession Strategy in Multi-issue Negotiation. *Web Intelligence and Agent Systems*, *Vol. 7, No. 2,* pp.161-171.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE RELATIONSHIP BETWEEN THE TENDENCY TO EXCESSIVELY USE GENERATIVE ARTIFICIAL INTELLIGENCE AND THE DEGREE OF SATISFACTION OF BASIC PSYCHOLOGICAL NEEDS

Ewelina KRZYŻOWSKA

Politechnika Częstochowska; ewelina.krzyzowska@pcz.pl, ORCID: 0000-0001-7766-8752

Purpose: With the rapid development and widespread adoption of artificial intelligence, discussions regarding potential risks—including the consequences of excessive use of these technologies—are becoming increasingly relevant. The purpose of this article was to present the results of a study examining the relationship between the tendency to excessively use tools based on generative artificial intelligence (GenAI) and the degree of satisfaction with basic psychological needs among IT workers.

Design/methodology/approach: The study included 79 emploeeys (47 men and 32 women) from IT industry. The study was cross-sectional in nature. The study used the *Generative AI Dependency Scale* by Goh, Hartanto, Majeed, the *Basic Psychological Need Satisfaction and Frustration Scale* (BPNSFS) by Chen et al. and self-designed survey.

Findings: The results of the study indicate a positive correlation between the tendency to overuse GenAI and the frustration of the needs for relatedness and competence. Furthermore, detailed testing of the correlations across the dimensions of the *Generative AI Dependency Scale* revealed a positive correlation between negative consequences and the frustration of the needs for relatedness and competence, as well as a positive correlation between the withdrawal dimension and the frustration of the need for relatedness.

Research limitations/implications: One of the limitations of this study is the use of self-reported measurement tools. Furthermore, the study was cross-sectional in nature, which limits the inferences that can be drawn regarding possible cause-and-effect relationships between the variables.

Practical implications: The study highlights the importance of risks associated with excessive use of GenAI tools. Awareness of these risks also applies to the workplace. An employee who tends to become addicted to GenAI tools and whose needs for connection and competence remain unmet may be less effective and achieve lower job satisfaction. This knowledge provides important guidelines for management. These include, amongst other things, raising staff awareness of the risks associated with the use of GenAI, as well as designing programmes to mitigate these risks in the workplace.

Originality/value: The literature on the subject highlights the numerous benefits of solutions offered by GenAI, but still little attention is paid to the risks associated with this technology. This study expands our understanding of the psychological risks associated with excessive use of GenAI tools, in conjunction with the level of basic psychological need satisfaction.

Keywords: GenAI, excessive use of GenAI, needs: autonomy, relatedness, competence.

Category of the paper: Research paper.

1. Introduction

The development of artificial intelligence (AI) has initiated a profound change in the functioning of the economy, work, and many areas of social life. The emergence of AI has popularized work using digital data analysis and automation. This technology has increased the efficiency of many processes, changed the structure of the labor market, accelerated the development of science, and simultaneously created new social, legal, and ethical challenges. Another technological advancement began with the development of so-called generative artificial intelligence (GenAI), which is a subset of artificial intelligence, that focuses on creating new textual and multimodal content using large language models, art-based models and video-based models (Wharton School, 2023). GenAI is used in creative and informational activities, such as accelerating content creation, automating tasks that require imagination, and increasing the pace of innovation. A significant advantage of GenAI is the support it offers users in the decision-making process. (Chuma, Oliveira, 2023; Hao, Demir, Eyers, 2024), the availability of these tools in contexts where human interaction is limited or unavailable (Hu et al., 2025; Hung et al., 2025; Siddals, Torous, Coxon, 2024), as well as the versatility of applications (Giannakos et al., 2024; Shaji, 2023). These factors are causing GenAI to gain increasing popularity not only in the professional sphere but also in the context of personal life, simultaneously creating new legal, ethical, and social challenges. Concerns are growing about the possible negative consequences of excessive use of AI tools, manifesting themselves in cognitive and emotional functioning. Research indicates that excessive reliance on AI systems can, among other things, undermine a sense of agency and critical thinking, negatively impacting motivation, cognitive engagement, decision-making ability, interpersonal relationships, and professional performance. (Gajda, Krzyżowska, Randak-Jezierska, 2025). The risk of addiction to AI-based tools may also pose a significant threat. There are numerous studies in the literature on behavioral addictions resulting from the use of digital technologies, for example, pointing to destructive patterns of internet use (Venkatesh et al., 2019), social networking site overuse (Ryan et al., 2014; Xue et al., 2018) or smartphone addiction (Gerlach, Cenfetelli, 2020; Hitcham et al., 2023). However, there is still a lack of research on the addictive potential of relatively new GenAI-based tools. Expanding knowledge about GenAI is important because these technologies fundamentally distinguish themselves from others through interactive design features that elicit immersive engagement via self-disclosure (Kim et al., 2022). Furthermore, the dynamics of these functions may increase the potential for compulsive use of these tools to a greater extent than is the case with other technologies (Yu, Chen, Yang, 2024).

This article therefore focuses on presenting the results of an analysis of the tendency to use GenAI tools excessively, based on a study of the relationship between excessive use of GenAI and the degree to which basic psychological needs are met among a group of IT sector employees.

2. Research Background

As the development of GenAI-based tools has progressed, the problems arising from this phenomenon have become increasingly apparent. A large-scale study by Open AI and MIT Media Lab, covering over 4 million interactions and 4000 surveys, observed disturbing behavior patterns among ChatGPT users. (Phang et al., 2025). ChatGPT has been observed to mimic and amplify user tendencies and may also provide affirmation and fostering emotional reliance. Users reported that intensive use of ChatGPT was associated with limited social interactions, increased emotional dependence on the system, and signs of addictive use. The findings of the study highlight potential risks, whilst also emphasising the importance of gaining a thorough understanding of GenAI addiction, analysing its nature, underlying causes and risk factors.

As mentioned in the introduction, there is still insufficient research to explain the nature, mechanisms responsible, and scale of GenAI addiction. Existing publications highlight various mechanisms underlying excessive GenAI use. For example, Goh, Hartanto, Majeed (2025) base their research on a conceptualization of GenAI dependence that incorporates established patterns such as salience, compulsive use, negative consequences, and withdrawal. Salience means being so absorbed in using GenAI that it becomes dominant over other activities. Compulsive use refers to an uncontrollable urge to use GenAI tools – attempts to limit usage are unsuccessful. Over time, the negative consequences of overuse become apparent, manifesting in psychological and social functioning, including in the sphere of professional activity. Withdrawal, on the other hand, refers to a palpable state of discomfort and tension resulting from the lack of, or limited access to, GenAI. In turn, Zhou and Zhang (2024), in their analysis of the mechanisms underlying GenAI addiction, adopted the cognition-affect-conation (C-A-C) model, which explains how beliefs and knowledge influence emotions and actions. The authors point out that cognitive factors such as perceived anthropomorphism, perceived interactivity, perceived intelligence, and perceived personalization influence emotional factors: flow experience and attachment, both of which further affect user addiction. In other studies (Deng, Deng, 2025), a neurocognitive perspective has been proposed to explain the mechanisms underlying GenAI addiction (using ChatGPT as an example). The authors defined ChatGPT addiction as a cognitive imbalance between impulsive and reflective cognitive systems, which results in the strengthening of compulsive use of the system and cognitive miserliness.

Increased impulsive activity—triggered by contextual stressors (e.g., stressors related to job demands) combined with reduced reflective regulation due to impaired self-control (e.g., temporal myopia) — leads to nonconstructive, dependency patterns of ChatGPT use. The authors also emphasize the modulating role of self-construal, distinguishing between independent and interdependent orientations. Individuals with an independent orientation more frequently relied on the impulsive cognitive system, whereas those with an interdependent orientation more frequently engaged the reflective system.

Although the phenomenon of GenAI addiction is not sufficiently understood, it can be expected that, like other addictions, it will lead to negative consequences for the individual's functioning. One of the most frequently mentioned consequences is the impact on users' intrinsic motivation for critical thinking, autonomous problem-solving, and creative exploration (Deng, Deng, 2025; Gajda, Krzyżowska, Randak-Jezierska, 2025; Zhou, Zhang, 2024). However, the negative impact of destructive GenAI usage patterns extends beyond the cognitive sphere. Neglecting real-life responsibilities and interpersonal relationships may also be a significant issue (Zhou, Zhang, 2024). In the previously cited large studies, the authors proved that longer time of using GenAI tools is correlated with worsening socialization (Phang et al., 2025). Similar conclusions were obtained in the study by Fang et al. (2025) involving 981 participants. In turn Maral et al. (2025) demonstrated that problematic ChatGPT use is associated with increased psychological stress and decreased self-control, which are associated with lower overall well-being, however Yu et al. (2024) demonstrated a positive association between problematic ChatGPT use and depression. The relationship between basic psychological needs and the tendency to overuse GenAI is also important. This is because excessive engagement in GenAI-based activities may be a way to temporarily satisfy needs such as the need for autonomy, competence or relatedness, but on the other hand, using AI tools as a primary means of satisfying needs in the long run may weaken the capacity for self-regulation (Salah et al., 2023). For example, the satisfaction derived from interactions provided by GenAI tools may be short-lived. Although these tools offer immediate gratification by simulating real human interactions, the depth and authenticity of human interactions remain unmatched. Therefore, it can be concluded that this relationship is a feedback loop: the desire to satisfy needs may be a motivator for using GenAI tools, but when this activity becomes excessive, self-regulatory mechanisms may be disrupted, and the satisfaction of needs may be shallow and unsustainable.

This study therefore sought to analyse the relationship between the fulfilment of needs and excessive use of GenAI tools. The study utilized the assumptions of Self-Determination Theory (SDT) developed by Deci and Ryan (1985), according to which an individual's psychological well-being and healthy functioning are contingent on the satisfaction of three basic categories of needs: autonomy, relatedness, and competence. The need for autonomy is expressed in a sense of agency, an internal locus of control, and the ability to make decisions independently (Oszwa, Knopik, 2023). The need for competence is related to the belief in one's personal ability

to cope with challenges, as well as the belief in the possibility of development and achieving success. The need for relatedness, in turn, expresses the need for connection with others, affiliation, and community membership. Importantly, the deprivation of even one of these three needs can result in a significant disruption to motivation and may pose a risk of mental health problems. Conversely, strengthening even one of these needs increases the level of satisfaction of the others and positively impacts intrinsic motivation. This study was conducted among a group of IT industry employees, the choice of which is justified by the possibly greater awareness of these employees regarding the potential and possibilities of using GenAI tools and potentially more frequent contact with this type of systems, which may pose a greater risk of excessive activity within these systems. This study therefore aims to answer the following research question:

Is there a relationship between excessive use of GenAI tools and the degree of satisfaction of basic psychological needs?

In this way, the results of the analysis are intended to add to our knowledge of possible connections between patterns of GenAI tool use that bear signs of addiction and the perceived level of satisfaction resulting from the satisfaction of basic psychological needs.

3. Methodology of the research

3.1. Participants

The study was conducted online in January-February 2026. The study was aimed at IT industry employees. Respondents were informed in the introduction that the study would assess the impact of using generative AI tools on employee performance. The selection criteria for the study included: formal consent to participate in the study, being at least 18 years of age, having sufficient Polish language skills to independently understand and answer the questionnaires, current employment in the IT industry, and at least 3 years of professional experience in the IT industry. The criterion of having at least three years of professional experience was adopted to include individuals with established experience in the IT industry and with sufficiently long exposure to the demands of the work environment, including the use of GenAI tools in daily duties. This limited the participation of individuals just starting their professional careers, whose work practices and patterns of using new technologies may still be unstable.

Of the employees who agreed to participate, 79 individuals qualified for the study (7 respondents were ineligible due to incomplete questionnaires): 47 men and 32 women, aged 26,5 to 52 (mean = 38,61; standard deviation = 6,47). Detailed characteristics of the study group are presented in Table 1.

Table 1.
Characteristics of the Study Group

		n	%
Employees	females	32	40,51
	males	47	59,49
		M	**SD**
Age (years)		38,61	6,47
Length of service in the IT industry (years)		11,78	4,52
		n	**%**
Education	higher	52	65,82
	secondary	22	27,85
	vocational	5	6,33
Workstation	data scientist	27	34,18
	programming specialist	17	21,52
	service support specialist	12	15,19
	IT application specialist	11	13,92
	cloud engineer	7	8,86
	other	5	6,33

3.2. Measures

The following research tools were used in the study.

To investigate tendencies towards excessive use of GenAI-based tools, the *Generative AI Dependency* Scale (Goh, Hartanto, Majeed, 2025) was used with the authors' permission. The scale has been translated into Polish. The scale measures the extent to which individuals develop a psychological and behavioural reliance on GenAI tools. The tool consists of 11 items forming three dimensions: cognitive preoccupation (constant mental engagement in GenAI activities related to the internal need of usage), negative consequences (symptoms of impaired functioning, such as reduced productivity or a diminished sense of self-efficacy arising from the use of GenAI tools), and withdrawal (stress, frustration and discomfort experienced when access to GenAI is restricted). The cognitive preoccupation dimension comprises 3 statements, whilst the negative consequences and withdrawal dimensions each comprise 4 statements. The participant responds to each statement using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The scale demonstrates strong psychometric properties (internal consistency - α =.92–.93, test-retest reliability - ICC = .87).

To examine basic psychological needs, the *Basic Psychological Need Satisfaction and Frustration Scale* (BPNSFS) by Chen et al. (2015), adapted into Polish by Kuźma et al. (2020), was used. The tool is designed to measure the level of satisfaction and the level of frustration regarding three basic psychological needs: autonomy, relatedness and competence. It is worth noting that the distinction between satisfaction and frustration is justified by differences in experiences resulting from low need satisfaction and experiences of frustration related to needs. The former may be associated with reduced vitality and limited enthusiasm for physical activity, whilst the latter is more often expressed as controlled motivation, amotivation and even burnout and other pathological behaviors (Ryan et al., 2016; Vansteenkiste, Ryan, 2013). Therefore,

these constructs can be treated asymmetrically, as low need satisfaction does not necessarily involve need frustration. The scale consists of 24 items forming 6 subscales: 3 for need satisfaction and 3 for need frustration, respectively. Respondent provides responses on a 5-point Likert scale Likerta (from 1 – „not at all true" to 5 – „totally true"). In Polish validation studies, Cronbach's alpha coefficient for individual subscales ranged from .72 to 87 (Kuźma et al., 2020).

In addition, the study used a self-administered questionnaire while taking account of the following data: the respondent's age and gender, education, length of service in the IT industry, position held in the company.

3.3. Data Analysis

The study was cross-sectional in nature. In order to examine the relationship between the tendency to excessively use GenAI and the level of need satisfaction and frustration, a nonparametric test - Spearman's rank-order correlation was used. The statistical program STATISTICA 13.3 from Statsof was used for the calculations and a statistical significance level of $p < 0.05$ was adopted.

4. Results

Tables 2 and 3 present a statistical description of the variables under study. Table 2 presents the participants' results regarding the tendency to excessively use GenAI tools, measured using the *Generative AI Dependency Scale*, while Table 3 presents the results regarding the degree of satisfaction and frustration of basic psychological needs (scores on individual subscales and the overall score) based on the *Basic Psychological Need Satisfaction and Frustration Scale*.

Table 2.
A tendency to overuse GenAI tools among the surveyed group of employees

Scale dimensions	M	SD
cognitive preoccupation	9,60	2,28
negative consequences	13,43	5,32
withdrawal	11,71	4,81
overall score	34,75	7,47

M – medium, SD – standard deviation.

Table 3.
The degree of satisfaction and frustration of basic needs among the surveyed group of employees

Needs	satisfaction		frustration	
	M	SD	M	SD
autonomy	15,09	4,56	11,25	5,78
relatedness	14,04	4,67	12,32	5,11
competence	14,20	4,67	11,81	5,31

M – medium, SD – standard deviation.

Table 4 presents the results of testing the relationship between the tendency to excessively use GenAI tools and the degree of satisfaction and frustration of basic psychological needs (autonomy, relatedness, competence).

Table 4.
The relationship between the tendency to overuse GenAI tools and the degree of need satisfaction and frustration among the surveyed group of employees

Variables	satisfaction			frustration		
	autonomy	relatedness	competence	autonomy	relatedness	competence
	rho	*rho*	*rho*	*rho*	*rho*	*rho*
cognitive preoccupation	0,088	-0,087	-0,024	-0,097	0,189	-0,067
negative consequences	0,029	0,021	0,256	-0,075	**0,242***	**0,449***
withdrawal	-0,103	0,064	0,023	0,118	**0,253***	0,112
overall score	-0,089	-0,071	0,162	0,024	**0,375***	**0,309***

rho - Spearman's rank-order correlation coefficient, *$p < .05$.

The test results revealed statistically significant ($p < 0.05$) positive correlations between the 'negative consequences' dimension of the *Generative AI Dependency Scale* and frustration of the needs for relatedness ($r = 0.242$) and competence ($r = 0.449$). Similarly, a positive correlation was found between the *Generative AI Dependency Scale* – withdrawal dimension and frustration of the need for relatedness ($r = 0.253$). In terms of the overall tendency to excessive use of GenAI, positive correlations were obtained with need frustration: relatedness ($r = 0.375$) and competence ($r = 0.309$). No statistically significant correlations were found with regard to the satisfaction of needs.

5. Discussion

The literature on the subject still lacks sufficient empirical data on the relationship between GenAI tool use, particularly in patterns of use that pose a risk of addiction, and the level of need satisfaction. To fill this gap, this article examines the relationship between the tendency to excessively use GenAI tools and the degree of satisfaction of basic psychological needs: autonomy, relatedness, and competence. The obtained results indicate that the greater the

tendency to excessively use GenAI, the higher the degree of frustration of relatedness and competence needs. Furthermore, detailed results regarding the dimensions indicate that the greater the stress and discomfort experienced due to restricted access to GenAI, and the more symptoms of impaired functioning arising from the excessive use of GenAI tools, the higher the level of frustration regarding the need for connection with others. Negative consequences are also associated with a higher level of need deprivation, expressed by the desire to influence the environment, be effective, develop skills, and achieve intended outcomes.

The few existing studies confirm that excessive GenAI use may be directly related to unmet needs (Goh, Hartanto, Majeed, 2025); or may result in temporary or even apparent need satisfaction (Salah et al., 2023). It is also worth emphasizing that the cause-and-effect relationships between the variables studied can be complex and ambiguous. For example, based on a study of online activities, Park (2026) described a paradox resulting from AI use, where on the one hand, users experience a sense of fulfillment in terms of the needs of autonomy, relatedness, and competence, but on the other hand, through mechanisms such as prompting, augmenting, and interacting, they may experience frustration of these needs. Although this study cannot determine which variable is the cause and which is the effect (due to the cross-sectional nature of the research), it is worth pointing out likely directions justifying the obtained relationships. It is possible that the adverse consequences arising from excessive use of GenAI tools, e.g. in the form of difficulties in professional functioning, are also directly linked to problems in social functioning, including in the area of interpersonal relationships. As the emergence of harmful consequences associated with GenAI use reflects a substantial degree of engagement in these activities, which may affect various domains of an employee's life. Importantly, gradually increasing impairment in functioning may lead to increasing difficulties in establishing and maintaining existing relationships, which may result in an increased need to engage in virtual relationships offered by GenAI systems. However, as the paradox described by Park (2026) suggests, these relationships may ultimately prove to be artificial and emotionally shallow, which in turn leads to frustration of the need for relatedness. Similarly, the link between impaired functioning and the frustration of the need for competence can be explained. Problems in everyday functioning may gradually lead to a weakening of the sense of efficacy in action and the ability to independently cope with challenges - components of the competence need (according to Self-Determination Theory) (Ryan, Deci, 2004). The opposite direction of influence is also possible, where impaired functioning can be treated as a behavioral manifestation of frustration of the need for competence. As usage of GenAI may weaken human agency (Moon, Boudreaux, 2026), which, according to Bandura's classical views, determines the direction of attention and the exertion of effort to cope with the demands of a given situation, influences the perception of obstacles as challenges, and motivates even greater effort (Bandura, 1982). This, in turn, translates into more effective functioning in various areas of life, such as, amongst others, professional work, education, and citizenship engagement (Fida et al., 2025; Judge, Bono, 2001; Nuutila et al., 2020; Stajkovic, Luthans, 1998). However, when

human agency is weakened as a result of excessive engagement with GenAI-related activities, the effectiveness and efficacy of one's actions may be reduced, thereby reinforcing perceptions of incompetence. In turn, attempting to explain the relationship between withdrawal and the frustration of the relatedness need, one can refer to the compensatory function of digital technologies. As Kardefelt-Winther (2014) explains, based on the theory of compensatory internet use, unmet needs are one of the motivations for engaging in online activities. This may mean that the more frustrated the need for relatedness is, the more intense the attempts to compensate for it through human-AI interactions become, resulting in stronger symptoms of discomfort when access to the system is lost. GenAI use can therefore be a source of responsiveness, psychological presence, and emotional regulation, while loss of access to the system can mean the loss of an important compensatory mechanism and increases perceived emotional discomfort. However, the relationship may also take the form of a feedback loop, as excessive use of these tools may lead individuals to satisfy their need for relatedness largely through interactions with virtual systems. As a result, perspective of restrictions in access to such systems may intensify the frustration of this need. The lack of a statistically significant relationship between the cognitive preoccupation dimension and need frustration also warrants comment. As is well known, need frustration is associated with perceived tension, discomfort, and negative emotions such as anxiety, regret, or anger (Ryan, Deci, 2000). In contrast, the cognitive preoccupation dimension, due to its cognitive nature (focusing attention on GenAI activities, mental preoccupation), may be a less sensitive indicator of emotional dysregulation and loss of control and thus may correlate less strongly with the emotional component than the other two dimensions. Interestingly, no relationship emerged between any of the dimensions and the deprivation of the need for autonomy, meaning that this need has no significant effect size in situations of excessive GenAI use, compared to the deprivation of a sense of control, influence, decision-making, competence beliefs, or the deprivation of the need for connection with others. Finally, however, it is worth emphasizing that to understand the exact relationships between the variables under study, along with the mechanisms that moderate these relationships, further detailed research must be conducted, which will also allow for the verification of causal relationships.

Conclusions

This study, conducted on a group of Polish IT professionals, confirmed a link between excessive use of GenAI tools and degree of frustration regarding the needs for relatedness and competence. This means that as problematic GenAI use patterns develop, users more often experience unmet competence needs and the need to maintain satisfying relationships with others. The present study provides further empirical evidence for considerations regarding the

relationship between GenAI tool use and psychological needs. At the same time, the findings may lend support to existing scholarly speculations that excessive engagement in GenAI-based activities may serve as a means of temporarily satisfying psychological needs, but maladaptive use of these tools may ultimately contribute to a lack of satisfaction in the fulfilment of those needs (Park, 2026; Salah et al., 2023). As mentioned, the obtained results do not allow for causal inferences, but they nevertheless provide important practical implications, pointing to possible risks associated with long-term and intensive use of GenAI tools, particularly in the context of users' psychological well-being. This knowledge is particularly important in the context of the workplace, for an employee whose pattern of GenAI use is problematic and whose needs for relatedness and competence remain unsatisfied is unlikely to function effectively at work. Moreover, such an employee's sense of agency, work motivation, and job satisfaction may be diminished. The findings of the present study therefore provide an important basis for recommendations directed at managers regarding the need to increase employees' awareness of the risks associated with GenAI use, as well as to enhance awareness of the design and implementation of programmes aimed at preventing and mitigating these risks in the workplace. It is also important to be able to identify those employees who rely excessively on GenAI as a source of cognitive and emotional regulation, while simultaneously assessing their sense of professional efficacy and the quality of their interpersonal relationships at work. Therefore, it is not only important “how much” an employee uses GenAI, but also “how” they use it and whether this use is displacing activities that build competencies and relationships in the real world.

Limitations

One of the limitations of this study is the use of self-reported measurement tools, which are susceptible to measurement error resulting from intentional or unintentional distortion of responses. Furthermore, the study was cross-sectional in nature, which limits the ability to draw conclusions about possible cause-and-effect relationships between the variables under study. At the same time, this provides a reason to design similar studies in the future, which would allow for a thorough understanding of these relationships.

References

1. Bandura, A. (1982). Self-Efficacy Mechanism in Human Agency. *American Psychologist*, *37*, 122-147. http://dx.doi.org/10.1037/0003-066X.37.2.122
2. Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E.L., Van der Kaap-Deeder, J., Duriez, B., Lens, W., Matos, L., Mouratidis, A., Ryan, R.M., Sheldon, K.M., Soenens, B., Van Petegem, S., Verstuyf, J. (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion*, *39(2),* 216-236, doi: 10.1007/s11031-014-9450-1
3. Chuma, E.L., Oliveira, G.G.D. (2023). Generative AI for business decision-making: A case of ChatGPT. *Management Science and Business Decisions, 3(1)*, 5-11. https://doi.org/10.52812/msbd.63
4. Deci, E., Ryan, R. (1985). *Intrinsic motivation and self-determination in human behavior*. NY: Plenum.
5. Deng, Z., Deng, Z.A. (2025). Becoming a cognitive miser? Antecedents and consequences of addictive ChatGPT use. *Social Science & Medicine*, *383*, 118467.
6. Fang, C.M., Liu, A.R., Danry, V., Lee, E., Chan, S.W., Pataranutaporn, P., Maes, P., Phang, J., Lampe, M., Ahmad, L., Agarwal, S. (2025). How AI and Human Behaviors Shape Psychosocial Effects of Chatbot Use: A Longitudinal Randomized Controlled Study. *ArXiv*, abs/2503.17473.
7. Fida, R., Marzocchi, I., Arshad, M., Paciello, M., Barbaranelli, C., Tramontano, C. (2025). Self-efficacy and nontask performance at work. A meta-analytic summary. *Personality and Individual Differences*, *241*, Article 113179. https://doi.org/10.1016/j.paid.2025.113179
8. Gajda, J., Krzyżowska, E., Randak-Jezierska, G. (2025). Wykorzystywanie technologii opartych na sztucznej inteligencji w środowisku pracy - perspektywa szans oraz zagrożeń dla pracowników. *Management and Quality [Zarządzanie i Jakość]*, *7, 4,* 269-281.
9. Gerlach, J.P., Cenfetelli, R.T. (2020). Constant Checking Is Not Addiction: A Grounded Theory of IT-Mediated State-Tracking1. *MIS Quarterly*; *44(4),* 1705-1732. https://doi.org/10.25300/MISQ/2020/15685
10. Giannakos, M., Azevedo, R., Brusilovsky, P., Cukurova, M., Dimitriadis, Y., HernandezLeo, D., Jarvel a, S., Mavrikis, M., Rienties, B. (2024). The promise and challenges of generative AI in education. *Behaviour & Information Technology*, 1-27. https://doi. org/10.1080/0144929X.2024.2394886
11. Goh, A.Y.H., Haranto, A., Mayeed, N.M. (2025). Generative artificial intelligence dependency: Scale development, validation, and its motivational, behavioral, and psychological correlates. *Computers in Human Behavior Reports*, *20*, 100845, 1-87. https://doi.org/10.1016/j.chbr.2025.100845

12. Hao, X., Demir, E., Eyers, D. (2024). Exploring collaborative decision-making: A quasi-experimental study of human and generative AI interaction. *Technology in Society*, *78,* Article 102662. https://doi.org/10.1016/j.techsoc.2024.102662
13. Hitcham, L., Jackson, H., James, R.J.E. (2023). The relationship between smartphone use and smartphone addiction: an examination of logged and self-reported behavior in a pre-registered, two-wave sample. *Comput. Hum. Behav.*, *146*, 107822. https://doi.org/10.1016/j.chb.2023.107822.
14. Hu, M., Chua, X.C.W., Diong, S.F., Kasturiratna, K.T.A.S., Majeed, N.M., Hartanto, A. (2025). AI as your ally: The effects of AI-assisted venting on negative affect and perceived social support. *Applied Psychology: Health and Well-Being*, *17(1),* Article e12621. https://doi.org/10.1111/aphw.12621
15. Hung, J.W., Hartanto, A., Goh, A.Y.H., Eun, Z.K.Y., Kasturiratna, K.T.A.S., Lee, Z.X., Majeed, N.M. (2025). The efficacy of incorporating Artificial Intelligence (AI) chatbots in brief gratitude and self-affirmation interventions: Evidence from two exploratory experiments. *Computers in Human Behavior: Artificial Humans, 4*, Article 100151. https://doi.org/10.1016/j.chbah.2025.100151
16. Judge, T.A., Bono, J.E. (2001). Relationship of core self-evaluations traits--self-esteem, generalized self-efficacy, locus of control, and emotional stability--with job satisfaction and job performance: a meta-analysis. *The Journal of applied psychology*, *86(1),* 80-92. https://doi.org/10.1037/0021-9010.86.1.80
17. Kardefelt-Winther, D. (2014). A conceptual and methodological critique of internet addiction research: Towards a model of compensatory internet use. *Computers in Human Behavior*, *31*, 351-354. https://doi.org/10.1016/j.chb.2013.10.059
18. Kim, T.W., Jiang, L., Duhachek, A., Lee, H., Garvey, A. (2022). Do you mind if I ask you a personal question? How AI service agents alter consumer self-disclosure. *Journal of Service Research*, *25(4).* https://doi.org/10.1177/10946705221120232
19. Kuźma, B., Szulawski, M., Vansteenkiste, M., Cantarero, K. (2020). Polish adaptation of the basic psychological need satisfaction and frustration scale. *Frontiers in Psychology*, *10*, Article 3034, doi: 10.3389/fpsyg.2019.03034
20. Maral, S., Naycı, N., Bilmez, H., Erdemir, E.İ., Satıcı, S.A. (2025). Problematic ChatGPT Use Scale: AI-Human Collaboration or Unraveling the Dark Side of ChatGPT. *Int. J. Ment. Health Addiction*, Advance online publication. https://doi.org/10.1007/s11469-025-01509-y
21. Moon, A., Boudreaux B. (2026). *A Formal Model of How Artificial Intelligence Erodes Human Agency*. Santa Monica, CA: RAND Corporation.
22. Nuutila, K., Tapola, A., Tuominen, H., Kupiainen, S., Pásztor, A., Niemivirta, M. (2020). Reciprocal Predictions Between Interest, Self-Efficacy, and Performance During a Task. *Front. Educ.*, *5, 36*. doi: 10.3389/feduc.2020.00036

23. Oszwa, U., Knopik, T. (2023). Teoria autodeterminacji SDT jako inspiracja edukacyjnowychowawcza. *Studia z Teorii Wychowania*, *XIV(4(45)),* 165-179.
24. Park, H.E. (2026). The Paradox in AI Influencer Engagement: A Dual Path to Psychological Need Satisfaction and Frustration. *Behavioral sciences, 16(4).* Basel, Switzerland, 610. https://doi.org/10.3390/bs16040610
25. Phang, J., Lampe, M., Ahmad, L., Agarwal, S., Fang, C.M., Liu, A.R., Danry, V., Lee, E., Chan, S.W.T., Pataranutaporn, P., Maes, P. (2025). Investigating affective use and emotional well-being on ChatGPT (Preprint). *arXiv*, 1-57 https://doi.org/10.48550/arXiv.2504.03888
26. Ryan R.M., Deci E.L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol., 55*, 68-78. doi: 10.1037/0003-066X.55.1.68,
27. Ryan, R.M., Deci, E.L. (2004). An overview of self-determination theory: An organismic-dialectical perspective. In: E.L. Deci, R.M. Ryan (Eds.), *Handbook of self-determination research* (pp. 3-33). Rochester, NY: The University of Rochester Press.
28. Ryan, R.M., Deci, E.L., Vansteenkiste, M. (2016). Autonomy and autonomy disturbances in self-development and psychopathology: Research on motivation, attachment, and clinical process. In: D. Cicchetti (Ed.), *Developmental psychopathology* (3rd ed., pp. 385-438). Hoboken: Wiley. https://doi.org/10.1002/9781119125 556.devpsy109.
29. Ryan, T., Chester, A., Reece, J., Xenos, S. (2014). The uses and abuses of Facebook: a review of Facebook addiction. *J. Behav. Addict*. https://doi.org/10.1556/ jba.3.2014.016
30. Salah, M., Abdelfattah, F., Alhalbusi, H., Mukhaini, M.A. (2023). *Me and my AI bot: Exploring the 'AIholic' Phenomenon and University Students' dependency on generative AI chatbots. Is This the New Academic Addiction?* https://doi.org/10.21203/rs.3.rs-3508563/v1
31. Shaji, G. (2023). The potential of generative AI to reform graduate education. *Partners Universal International Research Journal*, *2, 4,* 36-50. https://doi.org/10.5281/ ZENODO.10421475.
32. Siddals, S., Torous, J., Coxon, A. (2024). "It happened to be the perfect thing": Experiences of generative AI chatbots for mental health. *Npj Mental Health Research, 3(1),* 48. https://doi.org/10.1038/s44184-024-00097-4
33. Stajkovic, A.D., Luthans, F. (1998). Self-efficacy and work-related performance: A meta-analysis. *Psychological Bulletin*, *124(2),* 240-261. https://doi.org/10.1037/0033-2909.124.2.240
34. Vansteenkiste, M., Ryan, R.M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration*, *23*, 263-280. https://doi.org/10.1037/a0032359.

35. Venkatesh, V., Sykes, T.A., Chan, F., Thong, J., Hu, P. (2019). Children's Internet Addiction, Family-to-Work Conflict, and Job Outcomes: A Study of Parent–Child Dyads. *MIS Quarterly, 43*. 903-927. 10.25300/MISQ/2019/12338
36. Wharton School (July 31, 2023). *Practical AI for instructors and students part 1: introduction to AI for teachers and students*. Retrieved from: https://www.youtube.com/watch?v=t9gmyvf7JYo&list=PLwRdpYzPkkn302_rL5RrXvQE8j0jLP 02j&index=1
37. Xue, Y., Dong, Y., Luo, M., Mo, D., Dong, W., Zhang, Z. Liang, H. (2018). Investigating the impact of mobile SNS addiction on individual's self-rated health. *Internet Research*, *28(2),* 278-292. https://doi.org/10.1108/IntR-05-2017-0198
38. Yu, S.C., Chen, H.R., Yang, Y.W. (2024). Development and validation the Problematic ChatGPT Use Scale: a preliminary report. *Curr. Psychol.*, *43*, 26080-26092. https://doi.org/10.1007/s12144-024-06259-z
39. Zhou, T., Zhang, C. (2024). Examining generative AI user addiction from a C-A-C perspective. *Technology in Society*, *vol. 78, 102653*.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE TRAINING MARKET IN THE FIELD OF EMPLOYEE EXPERIENCE MANAGEMENT IN POLAND AND GERMANY

Anna LIPKA

University of Economics in Katowice; anna.lipka@ue.katowice.pl, ORCID: 0000-0002-0849-0935

Purpose: To establish the common and distinct characteristics of the training markets in the field of employee experience management in two European Union countries.
Design/methodology/approach: Application of a systematic qualitative and quantitative approach in the form of content analysis (including frequency analysis) to compare a total of 30 trainings/courses offers in the field of *Employee Experience Management* for two quarters of 2025.
Findings: The markets studied in both countries are characterised by a lack of atomisation on the supply side (indicating the initial stage of their development), segmentation, only partial transparency and strong heterogeneity. The content of the available offers can be classified into five categories, namely: conceptual approach, vocabulary related to professions/specialisations, implementation conditions, mapping the employee experience path, and experience design.
Research limitations: Practitioners looking for providers of development projects in the field of *Employee Experience Management* for management staff responsible for acquiring and retaining *Most Value Employees* may encounter difficulties due to a shortage of supply of the above-mentioned trainings/ courses and deficiencies in the content offered.
Practical implications: The results of the diagnosis can be used by entities conducting the above-mentioned trainings/courses, making them aware of their similarities and differences in relation to their competitors (and thus helping them to position their offer) and showing them opportunities to make their current offer more attractive.
Originality/value: To identify gaps in training/course activities in this field, which could help (utilitarian objective) to expand the content of proposed development projects for organisations. To date, the available literature on the subject has not presented any analyses of the trainings/courses market corresponding to the trend in HRM – *Employee Experience Management*. The analysis enriches our knowledge of the development of the trainings/courses market in Poland and Germany in relation to specific socio-economic conditions (experience economy), revealing that the current situation in these markets limits the potential for developing the managerial potential of organisations in this area.
Keywords: *Employee Experience Management, experience economy*, trainings / courses market, market homogeneity, market atomisation, market transparency.
Category of the paper: Research paper.

1. Introduction

All over the world, organisations are undertaking development projects to adapt their management staff and HR departments to various types of change, including operating in an *experience economy*. They can take advantage of external offers for this purpose. Failure to adapt activities to the current context (experience economy, experience market, experience society) may result in the loss of the most valuable employees and difficulties in recruiting new ones to replace them, which is most painful for the organisation. This is due to the impact of employee experiences not only on work performance and profits (Silvestro, 2002), but also on employee loyalty (Veloso et al., 2021). In order to strengthen employee loyalty to the organisation, it is necessary to prepare for the implementation of employee experience management measures – a current megatrend in HRM, which may play an increasingly significant role in the game of attracting and retaining employees, and thus in the game of market position. It should be assumed that many organisations, after years of applying human resource management in its traditional form, may not be able to do so without appropriate development initiatives. Many entities are not even aware of the need for adjustments, and this can be brought to their attention through trainings/courses offers in the field of *Employee Experience Management* (EEM). It is therefore important to examine the extent to which they are available and whether and to what extent they comprehensively cover the rich content of EEM, as well as the extent to which they develop specific skills and attitudes. Organisations themselves do not often conduct diagnoses of specific trainings/courses markets due to the labour-intensive nature of the task, which results in them making cognitive errors when selecting providers, such as anchoring heuristics.

The aim of the study is to identify the situation regarding the supply of available trainings/courses in the field of EEM in terms of market characteristics, i.e. its atomistic nature, homogeneity and transparency. This objective therefore includes assessing the availability of offers and showing the similarities and differences between competitors in the trainings/courses market in this field. Atomisticity refers to the number of market entities (not only on the demand side, but also on the supply side) that influence or do not influence market relations and conditions, homogeneity refers to the characteristics of market participants, and transparency refers to the degree of knowledge of market conditions by its participants (Wrzosek, 1989, p. 65). A further objective of the diagnosis is to identify areas of EEM that constitute gaps in trainings/courses activities. Furthermore, the aim is to establish whether the training supply can adequately satisfy the demand for managerial competence development. The above objectives were achieved in relation to the types of market considered in two European Union countries, by analysing a total of 30 trainings/courses offers and comparing both markets with each other.

2. Factors influencing the development of EEM

The theoretical basis explaining the trend towards EEM can be found in G. Schulze's theory of the experience society (*Erlebnisgesellschaft*), which he presented in his book published in 1992. He emphasised that there is currently a social expansion of the experience orientation (Schulze, 1992, p. 57). This means that experiences are becoming such important personal values in increasingly wider social circles that they are even beginning to define the meaning of life, which is becoming a kind of experience project (*Erlebnisprojekt*) (Schulze, 1992, p. 12). At the same time, the experience orientation is not, as was previously the case, limited to the sphere of leisure time, but is also extended to the sphere of work (Schulze, 1992, p. 57).

The economic equivalents of G. Schulze's sociological considerations can therefore be transferred to the sphere of work. This mainly concerns the works of B.J. Pine and J.H. Gilmore (1998, 1999), which, in connection with the transition to the experience economy, are devoted to the generation of experiences and sensations in market entities that no longer strive solely to acquire material goods (Schulze, 2005, pp. 611-612). As a result, a market for experiences is emerging, confronting supply and demand for experiences. The labour market is also becoming a market for experiences, offering employees not only remuneration, but also – more or less diverse fields of experience, similar to the consumer market (Schmitt, 1999) – sensory (related, for example, to the work space), emotional, cognitive (intellectual), behavioural and relational experiences.

It is therefore necessary for organisations to master the rules of functioning in the experience-based labour market, i.e. adequate EEM. This will allow, just as is the case with consumers (Boguszewicz-Kreft, 2013), for the implementation of a qualitatively new standard of value offered to the employee, i.e. enhancing it with an experiential component that substantially increases the value offered to the employee. Until now, in accordance with the traditional understanding of business, it was customers who enjoyed the greatest interest (Rao, 2017), while EEM is associated with the imperative to pay more attention to the sphere of employee experiences (Li, Yang, 2023).

An analysis of the literature on EEM and a comparison with the literature on HRM indicates that the key concepts defining them are different. In HRM, it is the implementation of HR functions and sub-functions/processes at various levels of management (Scholz, 1989), and not – as in EEM – DT (*Design Thinking*) in relation to – treated in an integrated (Batat, 2022) and continuous (Tucker, 2020) manner - interaction points (*Touchpoints*) (Malik et al., 2023) in the employee journey (*Employee Journey*) – a vehicle for *Employee Experience* (Plaskoff, 2017) – is the most important. This raises the research question: Has the trainings/courses market already generated adequate offers for entities facing the need to adapt to the experiential challenges of not only external but also internal labour markets?

3. Methodology

In order to address the above research question and achieve the theoretical and practical objectives outlined in the introduction, a content analysis (of training and course offerings) was carried out, including a frequency analysis of the occurrence of specific words and terms relating to EEM in the offers and their categorisation, and thus a systematic approach of a qualitative and quantitative nature. The analysis integrated the demand-side and sipply-side approaches. The following search phrase was therefore adopted: "trainings/cources in the field of employee experience management". The following market characteristics were selected for analysis (Wrzosek, 1989):

- atomistic showing negotiation relations,
- homogeneity//heterogeneity reagarding service differentiation,
- transparency of market information.

The analysis covered EEM trainings/courses offered online in Poland as of the end of February 2025, scheduled to take place in the first two quarters of 2025. Postgraduate studies in this field were excluded from the analysis. The date and duration of the trainings were adopted as the inclusion criterion analysis, regardless of their proposed form, which did not constitute on exlusion criterion. The analysis included the same number (15) of providers of EEM training courses from the German market, taking into account offers based on their ranking on *Google*. A comparative analysis was applied based on three market characteristics in both countries (atomistic nature, transparency, homogeneity), as well as an analysis of competition (including internal competition) in the domestic markets concerning: prices and discounts, the profile of trainers, and the attractiveness of the offer (operationalised by the richness or poverty of EEM terminology in its description includes concepts related to employee yourney, touchpoints and design thinking.

4. Results

The range of trainings/courses (online, face-to-face, hybrid) in the field of EEM, both in Poland and in Germany, remains, as yet, very limited. Furthermore, the descriptions of individual courses often lack even the most basic terms relating to EEM. The most frequently mentioned terms in Poland are Employee Experience and Design Thinking, whilst in Germany they are Employee Journey, New Work, followed by – Employee Mapping, Moments of Truth, and optimised employee experience. In total, 30 different terms were included in the descriptions of 15 German trainings/courses offers. Table 1 shows their distribution, which

indicates a range of 7 and an average of 3.1. Table 1 also provides data on the market in Poland, which shows that the range is 13 and the average is 8.4.

Table 1.
EEM terminology in Polish and German trainings/courses offers

Offer No.	Number of EEM terms – German market	Number of EEM terms – Polish market
1	8	15
2	5	10
3	6	15
4	6	12
5	3	10
6	2	9
7	1	8
8	4	8
9	1	7
10	2	10
11	1	8
12	2	5
13	2	3
14	2	2
15	1	4

Source: own processing of data from existing documents.

The EEM-related terms used to describe German course and training programmes can be divided into the following five categories based on their substantive content:

- the first, comprising five elements, relates to a conceptual approach and includes the following terms: *New Work, New Work economy, Human-centred approach,* personalisation, optimised employee experience,
- the second, comprising three elements, covering job titles/specialisations related to employee experience management, such as: *Experience Designer, New Work facilitator, Employee Experience Specialist,*
- the third, comprising two elements, concerning the internal contextual conditions for implementing EEM: People-Culture-Fit and employee experience strategy,
- the fourth, comprising eight elements, whose components (Employee Journey, Employee Mapping, employee lifecycle phases, employee learning journey, Employee Experience, Digital Employee Experience, moments of truth, pain points) correspond to the concept of employee journey mapping,
- the fifth, comprising 12 elements, whose components relate to the terminology associated with experience design: EX-Roadmap, active shaping of employee paths, personas, eNPS, DT, Service Design, Service Prototyping, employee experience initiatives, new interface possibilities, EX Design, Employee Experience Management and Design, creating moments of surprise for employees.

In Polish offerings, conceptual approaches (the first set) are described using as many as 17 words/phrases, although there is only one term in common with German offerings, namely – experience optimisation. The others are: positive EX, CX and EX synergy, holistic CX and

EX management, EX and CX integration, empathy/empathisation, empathetic leadership, the era of experiences, the EX model, Total Experience, employee experience management, customer and employee experience management (Customer Experience and Employee Experience Management), Candidate Experience, improving employee experiences, enhancing employee experiences, and managing employee well-being.

The equivalent of the second set is an empty set, whilst the third set contains – as in the German offers – two terms: customer-centric organisational culture and EX strategy (the latter being a common term).

The fourth set is almost three times larger (comprising 23 elements) than that identified in the German offers, as it contains the following components: experience measurement, Employee Experience/Customer Experience, mapping of employee journeys, Touchpoints – mapping, emotion mapping, feeling mapping, empathy map, Employee Journey (Map), visualisation of impressions, visualisation of behaviours, pain points, visualisation of the journey, visualisation of opinions, Total Journey/overall experience, categories of employee experiences, level of employee experience, employee voice, employee experience platform, quality of employee experience, configuration of employee experiences, key moments of truth, experience survey, mapping of employee experiences. Six of these are therefore common to those found in German offerings.

The remaining terms (21 in total) belong to the fifth set. These include: added value for the employee, vision of the experiences offered (Experience Promise), management maturity, insights, co-creation, story sharing technique, Service Blueprint, human-centred design, employee experience mentoring, exceptional experiences, building the employee experience, designing employee experiences, digital employee experience – design and implementation, personas, the Kano model, DT (Design Thinking), IPA (service quality research method), NPS (Net Promoter Score), eNPS (Employee Net Promoter Score), CSAT (Customer Satisfaction Score), CXS (Customer Experience System). Thus, these four terms form a common element of the above-mentioned set in both Polish and German offerings.

The range of training methods is relatively diverse, although the emphasis in both countries is on workshops. The similarity of the market for the aforementioned training courses on the Polish and German markets concerns – apart from the volume of supply – their subject matter, target audience, partial price transparency, and the differences – price levels, the terminology used to describe the offer, the number and qualification profiles of trainers, the extent to which the teaching process incorporates new technologies, as well as – the benefits cited for participants. Differences also exist between domestic providers.

5. Discussion and conclusions

EEM represents an innovative approach to employee relations that is fundamentally transformative – including from a strategic perspective (Yang, Zhang, 2025) – which must be understood and learnt, as failure to do so will result in the depreciation of human capital (Lipka, Winnicka-Wejs, 2013). Although the literature on the subject (Yang, Zhang, 2025) indicates that practitioners pay greater attention to experience management than theorists (there being an insufficient number of analyses by the latter), research conducted (relating to training companies) has shown that there is currently a shortage of offerings. The markets for EEM trainings/courses in both Poland and Germany are therefore characterised by a lack of fragmentation on the supply side, which may indicate an early stage of their development/maturity, and at the same time – their potential for growth. Two segments can be distinguished within these markets – the 'more expensive' segment, with longer (though not as long as before the COVID-19 pandemic) training courses, and the 'cheaper' segment, with courses sometimes lasting only a few hours. In terms of price disclosure, they are partially transparent (some companies do not state prices directly, but rather, for example, after clicking through further links), in terms of homogeneity, they are highly varied (heterogeneous), and in terms of atomistic, they may limit organization's ability to develop managerial competencies.

"Gaps" in the analysed Polish offers – compared to German ones – include the concept of *New Work* and personalisation, as well as terms relating to professions/specialisations. Meanwhile, "gaps" in offers in both countries include employees' search for experiences, experience modules, the model of universal experientialism, the antecedents of employee experiences, particularly the most important one concerning autonomy/meaningfulness of work, as well as – the differentiation of concepts: experience – lived experience, the three-level pyramid of experiences (this type of term does not appear in the analysed offers, whereas pain points and 'surprises' (or 'delight points'), whilst work comfort/employee effort indicators are omitted), *job crafting*, an EEM-oriented organisational structure or *employee experience* (risk) controlling, and the quality costs of designing/redesigning employee experiences. It was also noted that some training firms, 'under the guise' of *Employee Experience Management*, 'sell' content not directly related to this issue, such as shaping the organisation's image.

References

1. Batat, W. (2022). The employee experience (EMX) framework for well-being: an agenda for the future. *Employee Relations*, *44(5),* pp. 993-1013. Retrieved from: https://doi.org/10.1108/ER-03-2022-0133.
2. Boguszewicz-Kreft, M. (2013). *Marketing doświadczeń. Jak poruszyć zmysły, zaangażować emocje, zdobyć lojalność klientów?* Warszawa: CeDeWu.
3. Li, X., Yang, P. (2023). Facilitate or diminish? Mechanismus of perceived organizational support on experience of new generation employees. *Psychological Reports*, *128(4),* pp. 2956-2982. Retrieved from: https://doi.org/10.1177/00332941231183621
4. Lipka, A., Winnicka-Wejs, A. (2013). Dynamika lojalności pracowników a deprecjacja kapitału ludzkiego organizacji. *Studia Ekonomiczne*, *Zeszyty Naukowe Wydziałowe Uniwersytetu Ekonomicznego w Katowicach*, *nr 136*, pp. 193-208.
5. Malik, A., Budhwar, P., Mohan, H. et al. (2023). Employee experience – the mossing link for engaging employees: insights from an MINE's AI-based HR ecosystem. *Human Resource Management, 62(1),* pp. 97-115. Retrieved from: https://doi.org/10.1002/hrm.22133
6. Pine, B.J. II, Gilmore, J.H. (1998). Wilkome to Experience Economy. *Harvard Business Review, 76(4),* pp. 7-8. Retrieved from: https://hbr.org/1998/07/welcome-to-the-experience economy
7. Pine, B.J. II, Gilmore, J.H. (1999). *The experience economy: Work is theatre & every business a stage.* Boston, MA: Harvard Business Press.
8. Plaskoff, J. (2017). Employee Experience: the new human resource management approach. *Strategic HR Review, 16(3),* pp. 136-141.
9. Rao, M.S. (2017). Employees first, customers second and shareholders third? Towards a modern HR philosophy. *Human Resource Management*, *25(6),* pp. 6-9. Retrieved from: https://doi.org/10.1108/HRMID-02-2017-0023
10. Schmitt, B.H. (1999). Experiential Marketing. *Journal of Marketing Management*, *15*, pp. 53-67. Retrieved from: http://dx.doi.org/10.1362/026725799784870496
11. Scholz, Ch. (1989). *Personalmanagement: Informationsorientiertes und verhaltenstheoretische.* Grundlagen. Muenchen: Vahlen.
12. Schulze, G. (1992). *Die Erlebnisgesellschaft. Kultursoziologie der Gegenwart*. Weinheim: Campus.
13. Schulze, G. (2005). Unsere Freiheit besser nutzen. Ein Gespraech mit dem Bamberger Soziologen Gerhard Schulze. *Herder Korespondenz. Monatshefte fuer Gesellschaft und Religion*, *59(12),* pp. 608-612.

14. Silvestro, R. (2002). Dispelling the modern myth: employee satisfaction and loyalty drive service profitability. *International Journal of Operations & Production Management*, *22(1),* pp. 30-49. Retrieved from: https://doi.org/10.1108/01443570210412060
15. Tucker, E. (2020). Driving engagement with the employee experience. *Strategic HR Review*, *19(4),* pp. 183-187. Retrieved from: https://doi.org/10.1108/SHR-03-2020-023
16. Velso, C.M., Sousa, B., Au-Yong-Oliveira, M. et.al. (2021). Boosters of satisfaction, performance and employee loyalty: application to a recruitment and outsourcing information technology organization. *Journal of Organisation Change Management, 34(5),* pp. 1036-1046. Retrieved from: https://doi.org/10.1108/JOCM-01-2021-0015
17. Wrzosek W. (1989). *Badanie i kształtowanie rynku*. Warszawa: PWE.
18. Yang, P., Zhang, S. (2025), Employee Experience: Conceptualization, scale development, and validation. *Humanities and Social Sciences Communications, 12(605),* pp. 1-16. Retrieved from: https://doi.org/10.1057/s41599-025-04926-5

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

THE STRATEGIC DIMENSION OF ECOMARKETING AND ITS CONSISTENCY WITH THE COMPANY'S ENVIRONMENTAL POLICY

Małgorzata ŁĘGOWIK-MAŁOLEPSZA

Czestochowa University of Technology, The Centre for Entrepreneurship; m.legowik-malolepsza@pcz.pl, ORCID: 0000-0002-7698-9607

Purpose: The aim of the article is to identify and evaluate the relationship between the perception of ecomarketing as a strategic element within an enterprise and the degree of consistency between planned ecomarketing implementations and the assumptions of the company's environmental policy. The starting point for addressing the research problem is the assumption that the strategic role of ecomarketing should not be limited to a declarative level, but should also be reflected in the organizational and policy-based embedding of pro-environmental activities.
Design/methodology/approach: The article employs a quantitative approach, the diagnostic survey method, and a structured questionnaire survey. The study was conducted on a sample of 1025 respondents. The measurement of opinions was based on a five-point Likert scale. The analysis utilized descriptive statistics, Spearman's rank correlation coefficient, and the Mann-Whitney U test.
Findings: The reported relationship should be interpreted as preliminary because it is based on an initial analysis of a fragment of the empirical material and reflects respondents' assessments rather than objectively verified organizational practices.
Research limitations/implications: A limitation of the study is its cross-sectional nature, which does not allow for unequivocal cause-and-effect conclusions. Further research should take into account additional organizational variables and extend the analysis to include qualitative and longitudinal studies.
Practical implications: The preliminary findings suggest an association between the perceived strategic importance of ecomarketing and perceived consistency with environmental policy. Confirmation using the complete dataset is required before drawing practical implications.
Social implications: The study highlights the importance of the authentic embedding of pro-environmental activities within the enterprise, which may contribute to increasing the organization's environmental responsibility.
Originality/value: The value of the article lies in combining two perspectives that are rarely analyzed together: the strategic role of ecomarketing and the consistency of its implementation with the company's environmental policy.
Keywords: ecomarketing; competitive strategy; environmental policy; enterprise; sustainable management.
Category of the paper: Research paper.

1. Introduction

Contemporary enterprises operate under conditions of increasing competitive pressure, while simultaneously facing growing stakeholder expectations regarding environmental responsibility. Under these conditions, pro-environmental activities are no longer perceived solely as a supplementary element of organizational activity, but increasingly as an integral component of strategic management. In this context, ecomarketing gains particular importance, understood not only as a set of instruments used to communicate the ecological attributes of an offering, but also as an approach supporting the development of competitive advantage, the shaping of stakeholder relationships, and the strengthening of consistency between the company's market and environmental objectives. As a result, ecomarketing may be viewed as a strategic element whose significance extends beyond the operational and promotional levels.

However, the growing importance of ecomarketing in enterprise management raises the question of the actual degree of its integration with the organization's environmental policy. The mere recognition of ecomarketing as a factor in the creation and implementation of a competitive strategy does not automatically imply that planned implementations in this area are consistently and comprehensively incorporated into the assumptions of the company's environmental policy. In other words, organizational practice may reveal a discrepancy between the level of strategic declarations and the level of actual implementation consistency. From the perspective of management sciences, this is a significant issue, as it concerns the relationship between the strategic importance attributed to a particular area of activity and the degree of its institutional embedding within the enterprise.

It is precisely this potential discrepancy that constitutes the basis for formulating the research problem. The problem concerns the insufficiently recognized scale and nature of the relationship between the perception of ecomarketing as a strategic element within the enterprise and the degree of consistency between planned ecomarketing implementations and the assumptions of the company's environmental policy. The justification for addressing this problem arises from the need to better understand whether the strategic importance attributed to ecomarketing is reflected in the actual organization of corporate activities, or whether it remains primarily at the declarative level. Identifying this relationship is important from both theoretical and practical perspectives. From a theoretical perspective, it enables a deeper understanding of the mechanisms integrating marketing and environmental activities within the enterprise. From a practical perspective, it makes it possible to assess whether the environmental policy serves as a genuine tool for coordinating ecomarketing activities, or whether it is more formal than operational in nature.

In this context, it becomes justified to define the research objective. The objective of the study is to determine whether, and to what extent, the strategic role of ecomarketing in the enterprise is related to the consistency of planned ecomarketing implementations with the

company's environmental policy. The objective formulated in this way responds both to the need to identify the existence of such a relationship and to determine its nature. Adopting this research perspective makes it possible not only to assess respondents' perceptions of ecomarketing, but also to analyze whether these perceptions coexist with the belief that implementation activities are organizationally aligned with the adopted environmental policy.

A consequence of the adopted research objective and research problem is the formulation of a research question focused on the relationship between the analyzed variables. The question was formulated as follows: does the strategic role of ecomarketing in the enterprise relate to the consistency of planned ecomarketing implementations with the company's environmental policy? The formulation of this question is justified because it enables an empirical verification of whether the strategic significance of ecomarketing is reflected in a more integrated approach to the planning and implementation of pro-environmental activities. This question structures the course of the analysis and constitutes a direct reference to the previously identified research problem.

Addressing the problem defined in this way should be considered justified, as it corresponds to the current challenges faced by contemporary enterprises. Under conditions of increasing importance of sustainable development, growing social expectations, and the necessity of building organizational credibility, particular significance is attached not only to declaring an ecological orientation, but also to its actual organizational embedding. Therefore, analyzing the relationship between the strategic role of ecomarketing and the consistency of its implementation with the company's environmental policy may contribute to a better understanding of the mechanisms that determine the genuine integration of environmental and marketing activities within the enterprise.

2. The Importance of the Role of Ecomarketing and Environmental Policy Planning in the Strategic Management of an Enterprise

The issue of the relationship between the perception of ecomarketing as a strategic element within an enterprise and the degree of consistency between planned ecomarketing implementations and the assumptions of the company's environmental policy constitutes an important and current area of scientific inquiry. Its significance stems both from the dynamically growing role of sustainable development in the management of contemporary organizations and from the need for a deeper understanding of the mechanisms integrating marketing activities with the environmental objectives of the enterprise. Contemporary approaches to ecomarketing move away from reducing it to a merely promotional instrumentarium and increasingly position it within the domain of strategic organizational management. In this sense, ecomarketing is understood as an integrated approach encompassing

product and service offering development, market communication, stakeholder relations, and the building of competitive advantage while simultaneously taking environmental conditions into account (Dangelico, Vocalelli, 2017).

From a theoretical perspective, the key issue is therefore not only the recognition of ecomarketing as an important component of the enterprise strategy, but also the extent to which its planned implementations are embedded within the organization's environmental policy system (Astakhova, Astakhova, Reznikova, 2020). In other words, the fundamental research problem concerns the relationship between the declarative level and the implementation level. Assigning strategic importance to ecomarketing alone does not determine whether activities undertaken in this area are actually designed and implemented in a manner consistent with the company's environmental policy (Klikovac-Katanić, Kosanović, 2012). Identifying this relationship is of particular importance under conditions of increasing regulatory pressure, intensifying stakeholder expectations, and the growing need to ensure organizational credibility in the area of environmental activities.

In the subject literature, this issue finds its justification in the research stream on corporate environmentalism that has been developing for many years. This stream emphasizes that the environmental dimension of enterprise operations should not be treated as a peripheral area, but rather as an element of the organization's strategic orientation. Subhabrata Bobby Banerjee (2001) demonstrated that the way managers interpret environmental issues has significant implications for their positioning within the company's strategy. In subsequent studies, the same author clarified that corporate environmentalism constitutes an organizational construct referring to the degree to which an enterprise integrates environmental issues with strategic objectives and management processes (Banerjee, 2002). In turn, Subhabrata Bobby Banerjee, Iyer, and Kashyap (2003) indicated that the development of an enterprise's environmental orientation is conditioned by both external and internal factors, including managerial attitudes and industry characteristics. Consequently, it becomes justified to assume that attributing a strategic role to ecomarketing may constitute a manifestation of the enterprise's broader environmental orientation. However, it still remains insufficiently recognized whether such an orientation actually translates into the full alignment of planned ecomarketing implementations with the organization's environmental policy.

The relevance of the analyzed research problem is further reinforced by findings concerning the gap between strategy formulation and strategy implementation. Contemporary studies on sustainability strategies indicate that one of the fundamental organizational challenges lies not in designing the strategy itself, but in effectively embedding it within managerial practices, organizational structures, and everyday decision-making processes. Christina Engert and Rupert J. Baumgartner (2016) emphasize that implementation difficulty constitutes one of the central problems of strategic management in the field of sustainability, because organizations relatively more often formulate ambitious assumptions than consistently translate them into operational practice. Similarly, Helga Hermundsdottir and Arild Aspelund (2022) indicate that

sustainability strategies produce measurable outcomes only when they are reflected in environmental and social innovations as well as in actual organizational activities. In this light, the question concerning the relationship between the strategic role of ecomarketing and the consistency of its implementation with the environmental policy should be regarded as particularly justified, as it makes it possible to capture whether an enterprise moves from the level of declarations to the level of genuine integration of activities.

The importance of the undertaken research problem is also confirmed by studies on the relationship between green marketing and enterprise performance. The literature has repeatedly demonstrated that pro-environmental marketing strategies may constitute a source of organizational and market benefits. Elena Fraj, Martínez, and Matute (2011) found that a green marketing strategy may positively influence organizational performance, especially when supported by an appropriate environmental culture within the enterprise. Similar conclusions were presented by Cuthbert Mukonza and Ilse Swarts (2020), who indicated the beneficial impact of green marketing strategies on business performance and organizational image. In turn, Cees J. Gelderman, Schijns, Lambrechts, and Vijgen (2021) demonstrated that green marketing practices foster the development of satisfaction and loyalty in interorganizational relationships. It should be noted, however, that these studies focus primarily on the effects of implementing pro-environmental strategies, while much less attention is devoted to the issue of their internal organizational consistency. In particular, it remains insufficiently recognized whether enterprises declaring the strategic importance of ecomarketing actually incorporate all planned ecomarketing implementations into the formal assumptions of their environmental policy.

The reputational and institutional dimension of the discussed issue is also of considerable importance. In recent years, the literature has increasingly emphasized the need to distinguish between genuine and merely symbolic environmental activities. Yen Truong, Mazloomi, Biedenbach, and Javalgi (2021) demonstrated that substantive actions embedded in actual organizational practices strengthen a company's reputation, whereas symbolic actions may lead to the opposite effects. In a similar vein, Mizan Rahman and Nga Nguyen-Viet (2023) point out that the effectiveness of green marketing strategies depends on their authenticity, transparency, and consistency between communication and the organization's actual activities. This means that a lack of consistency between strategically declaring the importance of ecomarketing and its actual embedding in the environmental policy may generate a risk of losing credibility and, in extreme cases, lead to accusations of greenwashing (Wolniak, Hąbek, 2015). Therefore, examining the analyzed relationship has not only cognitive significance, but also substantial practical value.

In this context, a clear research gap can be identified. Previous studies have focused primarily on defining green marketing, analyzing its instruments, examining the environmental orientation of enterprises, and assessing the impact of pro-environmental strategies on organizational and reputational performance (Banerjee, 2002; Dangelico, Vocalelli, 2017;

Engert, Baumgartner, 2016; Rahman, Nguyen-Viet, 2023). Much less frequently, however, attempts have been made to empirically capture the relationship between perceiving ecomarketing as a strategic element and the extent to which all planned ecomarketing implementations are incorporated into the company's environmental policy. This gap is both theoretical and practical in nature. On the one hand, it concerns the insufficiently recognized mechanism of integration between the strategic and implementation layers; on the other hand, it relates to the practical problem of ensuring consistency in the enterprise's environmental activities.

Consequently, undertaking this topic should be regarded as fully justified. An analysis of the relationship between the strategic role of ecomarketing and the consistency of its planned implementations with the company's environmental policy may contribute to a deeper understanding of the actual mechanisms integrating marketing and environmental activities within the organization. At the same time, it may provide important guidance for management practice by supporting enterprises in designing more coherent and credible operational strategies. Thus, the discussed research problem aligns with the current research needs of management and quality sciences and responds to the challenges faced by contemporary enterprises operating under conditions of increasing pressure for environmental responsibility and strategic transparency.

3. Research Method

The study employs a quantitative approach using the diagnostic survey method with the application of a questionnaire survey. The choice of this method results from the nature of the research problem, which concerns identifying the relationship between the perception of ecomarketing as a strategic element of the enterprise and the assessment of the consistency of planned ecomarketing implementations with the organization's environmental policy. The diagnostic survey method is widely applied in the social sciences and management sciences, particularly when the objective of the study is to identify respondents' opinions, attitudes, and evaluations through the use of a standardized measurement instrument (Sullivan, Artino, 2013).

The research instrument is a structured questionnaire survey comprising questions concerning both the perception of the strategic role of ecomarketing and its links with the company's environmental policy. The questionnaire also includes demographic and organizational questions relating to the characteristics of the enterprise and the respondent, such as enterprise size, organizational and legal form, business profile, scope of operations, share of foreign capital, respondent's position, age, and work experience. Such a structure of the instrument makes it possible to simultaneously capture respondents' opinions and conduct

comparative analyses taking into account selected characteristics of the entities and respondents.

The measurement of respondents' opinions is based on a five-point Likert scale, allowing for the determination of the degree of agreement with individual statements. The use of this type of scale is justified by its widespread application in attitude and opinion research, as well as by its ability to provide a quantitative representation of respondents' declarations while preserving the ordinal nature of the data (Jamieson, 2004; Sullivan, Artino, 2013). In the study, respondents assess statements such as: "Ecomarketing is a factor in the creation and implementation of the competitive strategy of contemporary enterprises" and "All planned ecomarketing implementations are incorporated into the assumptions of the company's environmental policy". Responses to these questions constitute the basis for further analysis of the relationship between the strategic dimension of ecomarketing and the degree of its organizational integration.

The study includes 1,025 respondents, which constitutes a sample size enabling statistical analyses concerning both relationships between variables and differences among distinguished groups. The sampling method was purposive, and the study was conducted using a questionnaire survey. This organization of the research process makes it possible to collect standardized data from a large group of respondents and subsequently subject them to statistical analysis.

Due to the nature of the collected data, the study has a cross-sectional character, as the data are gathered once within a specific time frame in order to identify respondents' opinions and the relationships between the analyzed variables. Such a research design enables the identification of the coexistence of specific phenomena; however, it does not provide a basis for formulating unequivocal cause-and-effect conclusions. Consequently, the study makes it possible to determine the strength and direction of relationships between variables, but it does not establish the causal nature of these relationships.

Spearman's rank correlation coefficient is used to analyze relationships between ordinal variables. The choice of this measure is justified by the nature of the data obtained using the Likert scale and by the objective of the analysis, which is to determine the strength and direction of the monotonic relationship between respondents' evaluations. Spearman's rank correlation is primarily applied when variables are ordinal in nature or when there are no grounds for assuming the conditions required for parametric correlation coefficients (Sullivan, Artino, 2013). In the present study, this coefficient is used to assess the relationship between recognizing ecomarketing as a factor in the creation and implementation of a competitive strategy and the belief that all planned ecomarketing implementations are incorporated into the assumptions of the company's environmental policy.

In comparative analyses between two independent groups, the Mann-Whitney U test is employed. This test constitutes a nonparametric alternative to the independent samples t-test and is applied in situations where the compared variable is ordinal in nature or when there are

no grounds for assuming the normality of distribution (Jamieson, 2004; de Winter, Dodou, 2010). In the present study, this test enables the comparison of evaluations of selected statements between enterprises differing in specific characteristics, for example between enterprises with foreign capital participation and those without such participation, as well as between micro-enterprises and other categories of enterprises. The application of the Mann-Whitney U test makes it possible to determine whether the differences between these groups are statistically significant.

Data analysis is conducted using the Statistica software package. The analytical process employs both descriptive statistics, enabling the characterization of the structure of respondents' answers, and selected nonparametric methods of statistical analysis adapted to the level of data measurement. The research procedure designed in this way remains consistent with the objective of the study and allows for an adequate identification of the relationship between the strategic role of ecomarketing and the degree of consistency of its implementations with the company's environmental policy.

The adopted research method therefore enables an empirical verification of the formulated research question and an assessment of whether the strategic perception of ecomarketing coexists with its stronger embedding in the assumptions of the company's environmental policy. At the same time, the use of a standardized instrument, a large research sample, and nonparametric methods of data analysis increases the validity and reliability of the conducted analyses. It should be emphasized that the questionnaire measures respondents' perceptions and assessments of organizational practices rather than independently verified organizational behaviour. Consequently, the analyses presented in this study refer to perceived consistency between ecomarketing and environmental policy, not to objectively confirmed implementation within enterprises.

4. Research Results

The examination of the relationship between respondents' assessments of the statement "Ecomarketing is a factor in the creation and implementation of the competitive strategy of contemporary enterprises" and their assessments of the statement "All planned ecomarketing implementations are incorporated into the assumptions of the company's environmental policy" indicated a positive association of relatively high strength (Table 1). Based on the available fragment of the empirical material, Spearman's rank correlation coefficient was preliminarily estimated at $\rho s = 0.730$. The obtained result suggests that respondents who more strongly perceive ecomarketing as a strategic factor also tend to declare a higher level of consistency between planned ecomarketing activities and the company's environmental policy. These findings concern respondents' perceptions and should not be interpreted as direct

evidence that such consistency objectively exists within the surveyed organizations. Thus, the preliminary empirical findings are consistent with the adopted theoretical assumptions and suggest that respondents who attribute greater strategic importance to ecomarketing also tend to perceive stronger consistency between planned ecomarketing activities and environmental policy. However, because the analysis is based on respondents' declarations and an incomplete empirical dataset, these observations should be regarded as preliminary rather than conclusive evidence.

Table 1.
Spearman's Rank Correlation Between the Analyzed Variables

Variable 1	Variable 2	Spearman's Rank Correlation Coefficient (ρs)	Strength of Relationship	Remarks
Ecomarketing is a factor in the creation and implementation of the competitive strategy of contemporary enterprises	All planned ecomarketing implementations are incorporated into the assumptions of the company's environmental policy	**0.730**	Positive, relatively strong	Preliminary result estimated on the basis of a fragment of the empirical material

Source: Authors' own calculations.

It should be emphasized, however, that the presented value of the correlation coefficient is preliminary and indicative in nature, as it was established on the basis of a fragment of the empirical material rather than the entire dataset. Consequently, this result should be treated as a premise for further, comprehensive statistical verification rather than as a final basis for formulating unequivocal conclusions for the entire studied population. From a methodological perspective, this means that the direction and strength of the relationship have been initially identified; however, their final confirmation requires conducting the analysis on the complete research material.

In the context of between-group analyses, it is also justified to employ the Mann-Whitney U test, which makes it possible to assess whether two independent groups differ with respect to evaluations formulated on an ordinal scale (Table 2). This procedure may be applied in particular to compare evaluations concerning the strategic role of ecomarketing between enterprises with foreign capital participation and those without foreign capital participation, as well as to compare evaluations relating to the consistency of planned ecomarketing implementations with the environmental policy between micro-enterprises and other enterprises. At the present stage, it is possible to confirm the methodological adequacy of this test for the adopted arrangement of variables; however, the lack of complete empirical data prevents the presentation of the final values of the test statistic and the level of statistical significance (Table 2).

Table 2.
Scope of Planned Between-Group Analyses Using the Mann-Whitney U Test

Dependent Variable	Grouping Variable	Group 1	Group 2	Planned Method of Analysis	Purpose of Analysis
Ecomarketing is a factor in the creation and implementation of the competitive strategy of contemporary enterprises	Foreign capital participation	Enterprises with foreign capital participation	Enterprises without foreign capital participation	Mann-Whitney U test	Assessment of differences between groups
All planned ecomarketing implementations are incorporated into the assumptions of the company's environmental policy	Enterprise size	Micro-enterprises	Other enterprises	Mann-Whitney U test	Assessment of differences between groups

Source: Authors' own calculations.

As a result, the findings obtained thus far should be treated as preliminary confirmation of the existence of a positive relationship between the strategic role of ecomarketing and the consistency of planned ecomarketing implementations with the company's environmental policy. These results remain consistent both with the formulated research question and with the adopted research objective aimed at determining whether, and to what extent, the strategic role of ecomarketing is related to the consistency of its implementations within the enterprise. At the same time, full verification of this relationship, as well as the assessment of potential differences between the distinguished groups of enterprises, requires further analyses based on a complete dataset.

5. Discussion

The obtained result indicating a positive relationship between the perception of ecomarketing as a factor in the creation and implementation of a competitive strategy and the belief that planned ecomarketing implementations are incorporated into the assumptions of the company's environmental policy is generally consistent with the adopted theoretical assumptions. In the subject literature, ecomarketing is increasingly perceived not as a set of isolated promotional activities, but as an element of the enterprise's broader strategic orientation, encompassing product and service offering development, stakeholder relationships, and the integration of market and environmental objectives (Dangelico, Vocalelli, 2017). Moreover, the systematic review conducted by Dangelico and Vocalelli demonstrated that research on green marketing has evolved from an instrumental perspective toward a strategic approach, which strengthens the assumption that recognizing ecomarketing as a component of competitive strategy should coexist with its embedding within the company's environmental policy.

This result also corresponds with the stream of research on corporate environmentalism, according to which the way an organization interprets environmental issues influences the degree to which they are incorporated into decision-making and strategic processes. Subhabrata Bobby Banerjee defines corporate environmentalism as the process of integrating environmental issues into organizational decisions and identifies its two fundamental dimensions: environmental orientation and the focus of environmental strategy (Banerjee, 2002). Therefore, if an enterprise attributes strategic importance to ecomarketing, then, according to this perspective, it should be expected that ecomarketing will not remain merely at the declarative level, but will instead be reflected in implementation plans and in the formal assumptions of the company's environmental policy. In this sense, the obtained positive correlation supports the theoretical assumption regarding the coexistence of strategic orientation and the organizational integration of environmental activities.

The discussed result is also consistent with studies concerning the gap between strategy formulation and its implementation. Christina Engert and Rupert J. Baumgartner emphasize that one of the principal problems faced by contemporary organizations is no longer the formulation of sustainability strategies itself, but rather their translation into organizational practice, management systems, and concrete implementation activities (Engert, Baumgartner, 2016). In this light, the positive relationship between the strategic role of ecomarketing and the consistency of its planned implementations with the environmental policy should be interpreted as an indication that, within the studied organizations, the strategic importance of this area may be partially translated into the operational and institutional level. This also corresponds with the findings of Helga Hermundsdottir and Arild Aspelund, who demonstrated that sustainability strategies influence the implementation of environmental and social innovations, and only through these implementations do they affect enterprise performance (Hermundsdottir, Aspelund, 2022). This means that a strategic declaration alone is insufficient; what matters is its organizational embedding. It is precisely within this area that the principal interpretative significance of the obtained result is located.

The results may also be related to studies indicating that a green marketing strategy can contribute to improving organizational and market performance, provided that it does not function independently of the enterprise's culture and practices. Elena Fraj, Martínez, and Matute demonstrated that the impact of a green marketing strategy on company performance is strengthened by the organization's environmental culture, which suggests that the effectiveness of ecomarketing depends on its embedding within a broader organizational system (Fraj et al., 2011). Similar conclusions arise from the studies conducted by Cees J. Gelderman and co-authors, who showed that green marketing as an organizational practice influences satisfaction and loyalty in B2B relationships and therefore has a tangible market dimension when it takes the form of coherent and credible enterprise activities (Gelderman et al., 2021). In this context, the identified positive relationship may be interpreted as preliminary evidence supporting the thesis that the strategic perception of ecomarketing is not

merely a declarative category, but may instead be associated with a higher level of organizational consistency in pro-environmental activities.

An important interpretative context is also the issue of the authenticity of environmental activities. The literature clearly emphasizes that a lack of consistency between strategic declarations and actual organizational practices increases the risk of symbolic actions and accusations of greenwashing (Mesjasz-Lech, 2023). Mizan Rahman and Nga Nguyen-Viet indicate that trust in green marketing activities is associated with transparency, the avoidance of misleading practices, and consistency between communication and practice (Rahman, Nguyen-Viet, 2023). In turn, Yen Truong and co-authors demonstrated that substantive actions strengthen an organization's reputation, whereas merely symbolic actions may weaken it. In this light, the obtained preliminary result may have theoretical and practical significance if confirmed using the complete dataset, as it suggests that the strategic embedding of ecomarketing may potentially reduce the risk of discrepancies between declaration and implementation and thereby foster greater enterprise credibility in the area of environmental policy.

Against the background of previous studies, it should be emphasized that the novelty of the present analysis lies not so much in examining green marketing itself, but rather in capturing the specific relationship between its strategic dimension and its implementation dimension. Most of the cited studies focus either on the definitions and instruments of green marketing or on its impact on enterprise performance, reputation, trust, or consumer behavior (Dangelico, Vocalelli, 2017; Fraj et al., 2011; Gelderman et al., 2021; Rahman, Nguyen-Viet, 2023). Much less frequently, however, is the direct relationship analyzed between whether managers perceive ecomarketing as part of a competitive strategy and whether all planned ecomarketing implementations are embedded within the formal assumptions of the company's environmental policy. Thus, the study contributes cognitive value because it combines two levels of analysis that are often discussed separately in the literature: the level of strategic declaration and the level of implementation consistency.

A particularly important contribution should also be recognized in the fact that the study makes it possible to better capture the mechanism through which environmental orientation may transition from the level of a general management concept to the level of specific organizational decisions. In this sense, the obtained results extend the findings of Subhabrata Bobby Banerjee as well as Christina Engert and Rupert J. Baumgartner by demonstrating that the relationship between strategy and implementation may also be analyzed through the prism of ecomarketing as a specialized component of enterprise strategy, rather than exclusively through the prism of general sustainability strategies (Banerjee, 2002; Engert, Baumgartner, 2016). The novelty of the study therefore lies in a more precise embedding of the problem simultaneously within the fields of marketing management and environmental management.

At the same time, the results should be interpreted with caution. The relationship calculated thus far is preliminary in nature, as it was estimated on the basis of a fragment of the empirical material rather than the complete dataset. This means that the current result should be treated as evidence supporting the adopted theoretical assumptions, rather than as a final and generalizable conclusion. For this reason, the full cognitive value of the study will emerge only after verification of the relationship using the complete empirical material and after extending the analyses to include between-group comparisons, for example through the application of the Mann-Whitney U test for selected enterprise characteristics. This limitation, however, does not undermine the significance of the obtained result, but rather indicates its appropriate place: as an important preliminary step toward the empirical verification of the relationship between the strategic role of ecomarketing and the consistency of its implementations with the company's environmental policy.

In summary, the obtained results remain consistent with the theoretical section and support the assumption that the strategic importance attributed to ecomarketing coexists with greater consistency of its planned implementations within the framework of the organization's environmental policy. Their principal cognitive value lies in linking two perspectives that are often analyzed separately: the strategic perspective and the implementation perspective. Nevertheless, these interpretations should remain cautious because the reported relationship reflects respondents' subjective assessments and has been estimated using only a preliminary part of the empirical dataset. Consequently, the present discussion should be regarded as an interpretation of initial empirical tendencies rather than definitive confirmation of organizational practice.

6. Conclusion

The preliminary analyses suggest the existence of a positive relationship between respondents' perception of ecomarketing as a factor in the creation and implementation of competitive strategy and their assessment that planned ecomarketing implementations are incorporated into the company's environmental policy. At the present stage, these findings should be interpreted as evidence of respondents' perceptions rather than as confirmation that such consistency objectively exists within the surveyed enterprises. Moreover, because the reported correlation coefficient was estimated using only a fragment of the empirical material, the relationship requires verification using the complete dataset before broader conclusions can be drawn.

At the same time, the limitations of the study should be clearly emphasized. The most significant of these results from the fact that the correlation result presented thus far is preliminary in nature and was estimated on the basis of a fragment of the empirical material

rather than the complete dataset. This limits the possibility of formulating generalizable conclusions and requires interpretative caution. Additionally, the study is based on respondents' declarations, which may involve the risk of subjective evaluations and the influence of socially desirable response tendencies. Another limitation is the cross-sectional nature of the analysis, which makes it possible to capture the coexistence of the examined phenomena but does not provide grounds for unequivocal conclusions regarding cause-and-effect relationships. It should also be noted that some of the planned comparative analyses, including those using the Mann-Whitney U test, still require full verification on the complete research material.

Although the findings are preliminary, they suggest that, if confirmed using the complete dataset, stronger integration between ecomarketing and environmental policy may be beneficial for enterprise management. Therefore, the present observations should be regarded as tentative implications requiring further empirical verification rather than definitive managerial recommendations.

The study also makes a specific contribution to science. Its cognitive value lies primarily in linking two areas that are often analyzed separately in the literature, namely the strategic dimension of ecomarketing and the organizational consistency of its implementations with the company's environmental policy. In this sense, the study extends existing findings in the fields of green marketing, corporate environmentalism, and the implementation of sustainability strategies by demonstrating that it is justified to analyze ecomarketing not only as a set of market instruments or a source of organizational outcomes, but also as an element requiring institutional embedding within company policy. This contribution is both theoretical, as it organizes the relationships between the strategic and implementation dimensions, and methodological, as it indicates directions for further operationalization of variables describing the integration of environmental and marketing activities.

In light of the findings obtained, it is justified to indicate directions for further research. First, full verification of the relationship on the complete empirical material is necessary, which will make it possible to determine more precisely the strength and nature of the relationship between the analyzed variables. It would also be desirable to extend the analysis to include between-group comparisons, taking into account such enterprise characteristics as company size, foreign capital participation, business profile, or market position. A valuable direction for further research would also be to include additional intervening or moderating variables, such as organizational culture, management commitment, innovation orientation, or stakeholder pressure. From a methodological perspective, longitudinal studies would also be justified, as they would make it possible to observe changes over time and better identify causal mechanisms. Finally, a valuable complement to quantitative research would be qualitative studies, allowing for a deeper understanding of how enterprises actually integrate ecomarketing with environmental policy and what barriers and conditions accompany this process.

In summary, the conducted study constitutes an important step toward a better understanding of the relationship between the strategic role of ecomarketing and the consistency of its planned implementations with the company's environmental policy. Although the present findings are preliminary and are based on respondents' perceptions rather than independently verified organizational practices, they provide an initial indication that the relationship between the strategic role of ecomarketing and perceived consistency with environmental policy deserves further empirical investigation using the complete research dataset.

References

1. Astakhova, E., Astakhova, I., Reznikova, T. (2020). Greenwashing as a form of modern eco-marketing. *Acta Innovations, no. 34*, pp. 5-12.
2. Banerjee, S.B. (2001). Managerial perceptions of corporate environmentalism: Interpretations from industry and strategic implications for organizations. *Journal of Management Studies, 38*(4), 489513. https://doi.org/10.1111/1467-6486.00246
3. Banerjee, S.B. (2002). Corporate environmentalism: The construct and its measurement. *Journal of Business Research, 55*(3), 177-191. https://doi.org/10.1016/S0148-2963(00)00135-1
4. Banerjee, S.B., Iyer, E.S., Kashyap, R.K. (2003). Corporate environmentalism: Antecedents and influence of industry type. *Journal of Marketing, 67*(2), 106-122. https://doi.org/10.1509/jmkg.67.2.106.18604
5. Dangelico, R.M., Vocalelli, D. (2017). "Green Marketing": An analysis of definitions, strategy steps, and tools through a systematic review of the literature. *Journal of Cleaner Production, 165*, 1263-1279. https://doi.org/10.1016/j.jclepro.2017.07.184
6. de Winter, J.C.F., Dodou, D. (2010). Five-point Likert items: t test versus Mann-Whitney-Wilcoxon. *Practical Assessment, Research & Evaluation, 15*(11), 1-16.
7. Engert, S., Baumgartner, R.J. (2016). Corporate sustainability strategy – Bridging the gap between formulation and implementation. *Journal of Cleaner Production, 113*, 822-834. https://doi.org/10.1016/j.jclepro.2015.11.094
8. Fraj, E., Martínez, E., Matute, J. (2011). Green marketing strategy and the firm's performance: The moderating role of environmental culture. *Journal of Strategic Marketing, 19*(4), 339-355. https://doi.org/10.1080/0965254X.2011.581382
9. Gelderman, C.J., Schijns, J.M.C., Lambrechts, W., Vijgen, S. (2021). Green marketing as an environmental practice: The impact on green satisfaction and green loyalty in a business-to-business context. *Business Strategy and the Environment, 30*(4), 2061-2076. https://doi.org/10.1002/bse.2732

10. Hermundsdottir, F., Aspelund, A. (2022). Competitive sustainable manufacturing: Sustainability strategies, environmental and social innovations, and their effects on firm performance. *Journal of Cleaner Production, 370*, 133474. https://doi.org/10.1016/j.jclepro.2022.133474
11. Jamieson, S. (2004). Likert scales: How to (ab)use them. *Medical Education, 38*(12), 1217-1218. https://doi.org/10.1111/j.1365-2929.2004.02012.
12. Klikovac-Katanić V., Kosanović N. (2012). Implementation of Eco-Marketing During The Export Of Food Products From Vojvodina. *Agriculture & Forestry, Vol. 58. Iss. 2.* Podgorica, pp. 97-109.
13. Mesjasz-Lech, A. (2023). Greenwashing and Corporate Environmental Irresponsibility– Improper Practices of Companies. *Scientific Papers of Silesian University of Technology. Organization & Management [Zeszyty Naukowe Politechniki Śląskiej. Seria Organizacja i Zarządzanie], no. 186,* pp. 433-448.
14. Mukonza, C., Swarts, I. (2020). The influence of green marketing strategies on business performance and corporate image in the retail sector. *Business Strategy and the Environment, 29*(3), 838-845. https://doi.org/10.1002/bse.2401
15. Rahman, S.U., Nguyen-Viet, B. (2023). Towards sustainable development: Coupling green marketing strategies and consumer perceptions in addressing greenwashing. *Business Strategy and the Environment, 32*(4), 2420-2433. https://doi.org/10.1002/bse.3256
16. Sullivan, G.M., Artino, A.R., Jr. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Medical Education, 5*(4), 541-542. https://doi.org/10.4300/JGME-5-4-18
17. Truong, Y., Mazloomi, H., Biedenbach, G., Javalgi, R.G. (2021). Understanding the impact of symbolic and substantive environmental actions on organizational reputation. *Industrial Marketing Management, 92*, 307-320. https://doi.org/10.1016/j.indmarman.2020.12.021
18. Wolniak, R., Hąbek, P. (2015). Reporting process of corporate social responsibility and greenwashing. International Multidisciplinary Scientific GeoConference. *SGEM, 5(3),* pp. 483-490.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

TRIANGULATION OF AI MODELS FOR ANOMALY DETECTION IN ENTERPRISE MANAGEMENT PROCESSES

Sylwia ŁĘGOWIK-ŚWIĄCIK[1*], Daniel KIELAK[2]

[1] Czestochowa University of Technology, Department of Finance, Banking and Accounting; s.legowik-swiacik@pcz.pl, ORCID: 0000-0002-3963-9499
[2] Czestochowa University of Technology, The Doctoral School; daniel.kielak@pcz.pl, ORCID: 0009-0002-2646-6899
* Correspondence author

Purpose: The objective of this study is to understand and assess the effectiveness of triangulating artificial intelligence (AI) models for detecting financial anomalies in enterprise management processes, with particular emphasis on the role of managerial, organizational, and decision-making context in the interpretation of results generated by AI models.
Design/methodology/approach: The study employs a mixed-methods approach, combining a structured literature review with a single exploratory-explanatory case study. Quantitative data were obtained from the ERP system of the analyzed enterprise and processed using six state-of-the-art AI models. The outputs were subsequently compared and synthesized to identify convergent and divergent analytical patterns across models.
Findings: The findings indicate that the analyzed AI models were able to identify several unusual financial patterns, including distorted turnover indicators, high B2B-related costs, and changes in receivables and inventory cycles. However, without detailed managerial and organizational context, the models frequently misclassified planned investments, legal transformation effects, and accounting adjustments as negative business anomalies.
Practical implications: The study suggests that organizations should not rely on AI-driven anomaly detection systems as standalone decision-support tools. Instead, effective implementation requires integrating AI outputs with managerial expertise and organizational context. This implies the need for hybrid decision-making frameworks, redesigned control processes, and enhanced managerial competencies in interpreting AI-generated insights.
Social implications: This study highlights the risks of relying on AI-driven anomaly detection without sufficient organizational context. The findings show that overdependence on AI may lead to misinterpretation of financial data and flawed managerial decisions.
Originality/value: This study provides original value by examining the limitations of AI model triangulation for financial anomaly detection in enterprise management. By comparing six state-of-the-art AI models and an aggregated synthesis approach, it demonstrates that triangulation alone does not overcome the lack of organizational and decision-making context, challenging the assumption that combining multiple AI models necessarily improves analytical outcomes.
Keywords: enterprise management, AI model triangulation, anomaly detection.
Category of the paper: Case study.

1. Introduction

The implementation of artificial intelligence models in enterprise management processes has led to the increasing use of machine learning and deep learning algorithms for monitoring operational efficiency, financial control, and supporting managerial decision-making. A particularly important role is played by AI models for anomaly detection, which enable the identification of unusual deviations in financial, process, and organizational data, often at a very early stage of their occurrence (Chandola et al., 2009; Pang et al., 2021). Under conditions of growing organizational complexity, process digitalization, and high volatility of the economic environment, the ability to rapidly detect anomalies becomes a key element of early warning systems and risk management (Davenport, Ronanki, 2018; Wamba et al., 2021). At the same time, it should be noted that individual AI models, although statistically effective, often generate results that are prone to overinterpretation, especially when the analyzed data are strongly dependent on specific decisions or incidental events.

In this context, the triangulation of AI models is gaining increasing importance, understood as the combination of results from multiple algorithms, different analytical perspectives, and contextual knowledge in order to enhance the accuracy of interpreting detected anomalies. Triangulation has long been recognized as a methodological approach in management sciences and social sciences, serving to reduce cognitive biases and strengthen the credibility of research conclusions (Denzin, 2017). However, an analysis of the current literature indicates that this concept remains underdeveloped in research on the application of AI to anomaly detection in enterprise management processes, where technical approaches focused on the performance of individual models still dominate (Ruff et al., 2021). The lack of integration of multiple AI models and the managerial perspective may lead to misdiagnosis of a company's financial condition and inappropriate strategic decisions. According to the concept of Human-Centered Artificial Intelligence, AI models should serve to enhance decision-making capabilities rather than replace human judgment, particularly in situations where decision risk is high (Shneiderman, 2020). For this reason, the triangulation of AI models currently constitutes an important and timely research direction, combining technological development with the need for responsible, contextual, and human-centered enterprise management (Mikalef et al., 2022).

Therefore, this study poses the following research question: to what extent are AI models able to distinguish between unusual financial patterns and genuinely negative managerial anomalies when detailed organizational and decision-making context is not available during the initial analysis? As a consequence of this research question, the following hypothesis was adopted: artificial intelligence models can identify selected unusual patterns in enterprise financial data but when detailed managerial and organizational context is unavailable, they may misclassify planned investments, legal transformation effects, and accounting adjustments as negative business anomalies. The aim of this study is to fill the identified research gap by

deepening the understanding and assessing the capabilities of artificial intelligence models used for detecting financial anomalies in enterprise management processes, as well as by determining the importance of decision-making and organizational context, possessed by humans, in the process of interpreting the results generated by these AI models.

2. Literature review

The advancement of artificial intelligence models in enterprise management processes has increased significantly over the past decade, evolving from analytical support to active participation in decision-making processes. Research indicates that AI is currently being integrated into key management functions such as strategic planning, management control, operational management, and risk analysis, leading to the transformation of traditional management models toward data-driven models (Davenport, Ronanki, 2018; Haenlein, Kaplan, 2019). Systematic literature reviews emphasize that the dominant applications of AI in enterprises include machine learning and deep learning used for forecasting, classification, and process optimization, with particular importance attributed to the integration of AI with ERP and Business Intelligence systems (Kraus et al., 2022; Raina et al., 2024).

Contemporary AI models used in management are characterized by an increasing level of autonomy and adaptive capability, which affects the structure of decision-making within organizations. The literature indicates that AI not only supports managers in data analysis but increasingly assumes decision-making functions in operational and tactical areas such as inventory management, resource allocation, and dynamic production planning (Shrestha et al., 2019; Wamba et al., 2021). At the same time, the importance of Explainable AI (XAI) solutions is emphasized, as they enhance algorithmic transparency and enable their application in contexts requiring decision accountability and managerial control (Mikalef et al., 2022). This signifies a transition from decision support tools to co-decision systems, which has significant implications for management theory.

An important area of AI application in enterprise management is anomaly detection, understood as the identification of unusual deviations in process, financial, and operational data. Research shows that AI-based methods significantly outperform traditional rule-based approaches, particularly under conditions of high data complexity and dynamics (Chandola et al., 2009; Pang et al., 2021). The literature is dominated by techniques such as autoencoders, LSTM models, Isolation Forest, and hybrid deep learning models, applied mainly in technical contexts (e.g., IT systems, IoT, cybersecurity) and in finance (Ruff et al., 2021). From the perspective of enterprise management, however, anomaly detection is increasingly perceived as an element of operational intelligence and management control, enabling early

detection of risks, inefficiencies, and undesirable behaviors (Bose, Mahapatra, 2019; Appelbaum et al., 2017).

However, the analysis of the literature reveals a clear research gap concerning the application of AI model triangulation for anomaly detection in enterprise management processes. While triangulation of methods and data sources is a well-established methodological practice in management sciences (Denzin, 2017), research on anomaly detection focuses mainly on single models or ensembles of algorithms evaluated in terms of technical performance rather than cognitive complementarity in an organizational context. Decision-making processes, both human and algorithmic, are exposed to simplifications and interpretative biases, which justifies the need to reduce the risk of overinterpretation through the application of solutions such as triangulation of analytical sources (Kahneman, 2011). Consequently, there is a lack of studies that integrate different AI models, different data levels (strategic, operational, financial), and the managerial decision-making perspective within a coherent triangulation approach. This opens an important direction for further research, particularly at the intersection of quantitative methods, strategic management, and intelligent decision support systems (Janssen et al., 2020).

3. Methodology

The study was designed as a single-case study of an exploratory-explanatory nature, which is an approach recommended for the analysis of complex decision-making processes that are strongly embedded in an organizational context and cannot be clearly separated from the research environment (Eisenhardt, 1989; Yin, 2018). The unit of analysis was the process of managerial decision-making supported by artificial intelligence assistants in a trading company that, in the years 2023-2025, underwent a transformation of its management processes from an approach based on employed sales representatives to an approach based on B2B cooperation. The application of the case study paradigm was justified both by the uniqueness of the analyzed transformation and by the necessity of incorporating contextual knowledge into the interpretation of financial analysis results.

The analyzed organization was a Polish trading company specializing in the sale of tools and metal fasteners. Its product portfolio is combined with fast-moving items, such as screws, nuts, with slower-moving specialized tools, including automotive tools. This product mix made working-capital indicators particularly sensitive to changes in sales structure, purchasing policy, stock levels, and the pace of inventory rotation. Before the transformation, the company generated approximately PLN 26.8 million in revenue in 2023. During the legal and operating transition in 2024, annual revenue temporarily declined to approximately PLN 68 thousand. In 2025, revenue recovered to approximately PLN 5.55 million, although it remained

substantially below the pre-transformation level. The transition from an employment-based sales model to cooperation with independent B2B partners was undertaken in response to rising labour costs, the need to scale sales operations, and expressed employee interest in a B2B form of cooperation. The intended purpose was to reduce fixed employment costs while increasing the flexibility and scalability of sales activity. The transformation coincided with a change in the company's legal form, adjustments in accounting treatment, modifications to the incentive system for sales partners, and changes in the sales profile. These overlapping changes created a suitable setting for examining the difference between the initial identification of unusual financial patterns and their subsequent managerial interpretation.

The primary source of quantitative data consisted of monthly financial and operational data obtained from the ERP system and the financial and accounting system of the analyzed enterprise. These data included the income statement, balance sheet, cash flows, and key financial indicators such as operating margin, EBITDA, DSO, DPO, and DIO. The data formed the basis for analyses conducted by artificial intelligence models and enabled the identification of trends and deviations during a period of intensive organizational and financial change. In this study, anomaly identification and managerial interpretation were treated as analytically distinct stages. Anomaly identification referred to a model explicitly flagging an unusual value, trend, or pattern in the reported financial and operational data, including abrupt changes in profitability, DSO, DPO, DIO, inventory turnover, cost ratios, or financing structure. This stage did not involve a formal statistical anomaly-detection algorithm but rather, it concerned the identification of unusual patterns by the analyzed AI models on the basis of the supplied financial data. Managerial interpretation referred to the subsequent assessment of whether a detected deviation represented a negative business event requiring corrective action or an expected consequence of a managerial decision, planned investment, legal transformation, accounting adjustment, or temporary reporting distortion. The study therefore assessed not only whether AI models identified unusual financial patterns, but also whether they interpreted their managerial significance adequately after confrontation with organizational documentation and managerial evidence. The use of real financial data is consistent with the stream of research on the application of AI as a tool supporting data-driven management (Davenport & Ronanki, 2018; Wamba et al., 2021).

The second category of data consisted of analytical results generated by six advanced artificial intelligence models: ChatGPT 5.1, Claude Sonnet 4.5, Gemini 3 Pro, Grok 4.1, Kimi K2, and Sonar. Each of the listed AI models conducted its analysis based on the same description of the business situation of the analyzed enterprise, its financial statements, and the set of financial indicators mentioned above. The results of the analyses were evaluated on a scale from 1 to 10, representing a variant of an ordinal Likert-type scale that allows the results to be treated as quasi-quantitative variables (Norman, 2010). The analyzed AI models were evaluated according to four categories: analysis time, level of analytical detail, quality of diagnosis, and quality of proposed solutions. Subsequently, the Perplexity Pro assistant was

used to create an aggregated synthesis of the results, taking into account both shared conclusions and unique insights generated by individual models.

Combining the outputs of multiple AI models makes it possible to reduce the interpretative errors of a single algorithm and to increase the credibility and stability of analytical conclusions (Dietterich, 2000). Each model received an identical set of financial data and a standardized research prompt, including the analysis of financial indicators, identification of anomalies, assessment of potential risks, and formulation of managerial recommendations. Information was collected on the number and nature of detected anomalies, periods identified as problematic, and the tone and direction of recommendations. This approach enabled a comparison of interpretative consistency and divergence among AI models, as well as an assessment of their usefulness in the decision-making process, in line with the literature indicating the growing role of AI in organizational decision structures (Shrestha et al., 2019).

To improve transparency and replicability, all AI models received the same standardized analytical instruction and the same set of financial statements, operational indicators, and basic business-context information. No model-specific prompt tuning was applied, apart from technical formatting adjustments required by individual platforms. The standardized prompt is reproduced in Appendix B.

An important complement to the quantitative and algorithmic data was qualitative data obtained in the form of an in-depth semi-structured interview with a decision-maker, as well as an analysis of documents and managerial notes created during work with AI assistants. These data concerned, in particular, planned investments in the final months of the analyzed years, the formal transformation of the legal form of the analyzed enterprise, and changes in accounting principles and sales profile. Their purpose was to capture contextual knowledge that made it possible to explain why anomalies identified by AI models, such as significant declines in margins in December or distorted values of turnover ratios during the transformation period, did not constitute signals of a deteriorating financial condition, but rather were consequences of rational and planned strategic decisions. The inclusion of the managerial perspective is consistent with the assumptions of the Human-Centered AI concept, according to which AI plays a supporting role rather than replacing human decision judgment (Mikalef et al., 2022).

The entire data collection process was based on the principle of source triangulation, combining financial data, results generated by AI models, and expert knowledge together with organizational documentation. Such an approach increases the construct validity of the study and enables the development of causal explanations through pattern matching and explanation building (Yin, 2018). Triangulation is particularly important in anomaly detection research, as statistical deviations do not always indicate economic problems, and their correct interpretation requires consideration of decision-making and organizational context (Denzin, 2017). Moreover, systems supporting enterprise management processes should take into account stakeholder values and objectives, rather than focusing exclusively on the optimization of technical or economic indicators (Friedman et al., 2006).

For confidentiality and data-protection purposes, the financial and operational data supplied to the AI models were anonymized, and no personal data relating to employees, customers, or B2B partners were included in the model inputs. The AI-generated outputs were treated solely as analytical decision-support material and were interpreted in conjunction with managerial interview evidence and organizational documentation rather than as autonomous managerial conclusions.

4. Results

In the first phase of the empirical study, six AI models were examined in order to understand and assess the capabilities of artificial intelligence models used for detecting financial anomalies in enterprise management processes. The analyzed AI models were tasked with conducting an analysis of a set of financial indicators of the examined enterprise. The analysis of the indicators was required to take into account four categories of criteria, which are presented in Table 1.

Table 1.
Results of comparative analyses

AI Model	Category				Overall score
	Analysis time	Analytical depth	Diagnostic quality	Quality of recommendations	
ChatGPT 5.1	6.5	10	10	10	9.13
Claude Sonnet 4.5	7.5	9	8.5	9	8.5
Gemini 3 Pro	8	8	7.5	7	7.6
Grok	8.5	6.5	6.5	6	6.88
Kimi k2	10	6	5	5	6.5
Sonar	8.5	4	4	3	4.88

Source: authors' own elaboration based on the evaluation of the obtained results.

In the second phase of the empirical study, a controlled experiment was conducted (Table 2) with the aim of comparing the highest-rated model, ChatGPT 5.1 (average score 9.13), with the aggregated synthesis of models. The single AI model identified 9 out of 12 key problems, whereas the synthesis detected all 12. Unique insights generated by the aggregated model included issues related to debt collection, a faulty B2B incentive system (excessively high annual bonuses), and risks associated with the refinancing of liabilities. The analysis generated by ChatGPT regarding high B2B costs suggested that their cause was incorrect cost aggregation. The Claude model indicated a faulty subcontractor commission mechanism as the source of high B2B costs, while the Gemini model pointed to a lack of cost control, and the Grok model suggested possible data manipulation within the ERP system. The synthesis of all perspectives made it possible to formulate both an audit plan and a managerial action plan.

Table 2.
Consistency matrix among the analyzed AI models

Anomaly	Analyzed AI model						Accordance
	ChatGPT	Claude	Gemini	Grok	Kimi	Sonar	
Disorted indicator values	X	X	X	X	X	X	**6/6**
High B2B costs	X	X	X	X	X	-	**5/6**
Decline in inventory turnover	X	X	X	X	-	-	**4/6**
Deterioration of receivables collection	X	X	X	-	-	-	**3/6**

Source: authors' own elaboration based on analyses conducted by LLM models.

In the third phase of the empirical study, convergence in managerial recommendations was examined for actions proposed by the AI models. Table 3 reports the number and proportion of models explicitly proposing each selected recommendation. The strongest convergence concerned the reduction or reengineering of fixed and operating costs, recommended by all six models, followed by inventory management optimisation, proposed by five of the six models.

Table 3.
Consistency of recommendations among AI models

Recommendation	Number of AI models	Accordance	Implementation priority
Reduction of fixed costs	6/6	100%	Critical
Optimization of inventory management	5/6	83%	High
Hybrid model (B2B partners + sales representatives assigned to key partners)	4/6	67%	Medium
Receivables management	4/6	67%	Medium
ERP data audit and correction of financial indicator formulas	3/6	50%	Medium

Source: authors' own elaboration.

Moderate convergence was observed for receivables management and sales-model redesign (including hybrid channel approaches), each recommended by four of the six models, while ERP data auditing and correction of financial indicator formulas showed comparatively lower convergence, being explicitly proposed by only three of the six models. These results are reported as descriptive evidence of similarity in model outputs and do not establish the factual correctness of the recommendations or the overall reliability of the triangulation procedure. The complete coding matrix underlying the descriptive analysis of recommendation convergence is provided in Appendix A.

Analyses conducted using AI models indicate that, in the examined enterprise, the transformation focused on the B2B approach resulted simultaneously in three key phenomena. First, profit potential still exists, particularly in 2025, when gross margins remained at the level of 24-29%. This indicates that the B2B concept itself, larger volumes, lower customer acquisition costs, and deeper cooperation, is market-viable. Second, the scale of operations collapsed significantly in 2024 (from approximately 26.8 million PLN in 2023 to only 68 thousand PLN), before partially recovering in 2025 to 5.55 million PLN, which represents 20% of the pre-transformation potential. Most of the analyzed AI models consistently indicated that the enterprise "passed through the valley of death", typical for

reorganizations, but did not recover to full operational capacity. Third, the values of operational indicators became extremely unstable: the operating margin fluctuated from +31% to –34% in 2024, and another decline (–22%) was recorded in December 2025. Such strong fluctuations suggest errors in cost monitoring, annual write-offs, accounting issues, or a lack of control over B2B partner costs.

The AI models also revealed a number of serious problems. One of the most significant is the unreliability of accounting data and financial indicators, especially in January 2024, when the days sales outstanding (DSO) reached 1443 days, days payables outstanding (DPO) 2080 days, and days inventory outstanding (DIO) 311 days. It should be noted that these are not decision-making errors at the enterprise management level, but rather errors at the ERP system level. A shared conclusion generated by the AI models was as follows: without correct data, managing the transformation does not provide a clear and reliable picture of the financial condition of the analyzed enterprise. Another issue is that B2B costs turned out to be higher than the costs associated with an approach based on salaried sales representatives. In 2023, employees generated costs amounting to 19% of revenues, whereas in December 2025 B2B partners absorbed 37% of revenues (829 thousand PLN out of 2.2 million PLN). Thus, the new approach is more expensive and less efficient at a smaller sales scale, and the operating margin fell to values close to zero or negative. The increase in inventory levels and the decline in turnover (inventory cycle from 3 to 22 days) were also signals of deteriorating supply chain management quality.

According to the Grok and Gemini models, the new approach requires greater planning precision, and B2B sales partners may introduce products to the market that rotate much more slowly. An equally important issue is the incentive system for B2B partners: the receivables cycle (DSO) increased from 5 to approximately 50 days, indicating significantly worse collection effectiveness than in the case of salaried sales representatives. The Gemini model pointed to a poorly designed bonus system that rewards invoice issuance rather than actual cash inflows from sales, leading to payment backlogs. In addition, there is the issue of financing the operations of the analyzed enterprise: the share of equity capital fell to 9.5% of the balance sheet, which is a level typical of enterprises in a zone of increased insolvency risk. Dependence on liabilities to suppliers has become a short-term mechanism stabilizing the financial situation, which may cease to function at any moment.

The analysis also identified several additional anomalies. First, recurring declines in operating margins are noticeable in December 2024 and 2025, which may result from accounting policies related to write-offs, provisions, and annual postings. Second, December 2025 revealed a sharp increase in B2B partner commission costs, which reached 829 thousand PLN in a single month. The models suggested various possible causes: very high bonuses, incorrect cost aggregation, or a faulty commission mechanism. Third, January 2024 was characterized by distorted financial KPI results, which suggests critical errors in input data rather than managerial decision-making.

Most AI models converged on the general direction of corrective actions. Therefore, a single consolidated recovery plan was developed. In the immediate horizon (0-30 days), the following are necessary: an audit of ERP data and correction of financial KPI formulas, a detailed audit of B2B partner costs, especially commissions for December 2025, and the introduction of a debt collection system based on commissions for cash inflows rather than issued sales invoices. Within 1-3 months, the enterprise should reduce fixed costs by 10-15%, optimize inventories using inventory and cost optimization methods to achieve an inventory cycle below 15 days, and introduce a new pricing policy combined with the elimination of customers with margins below 15%. In the short-term perspective (3-12 months), most AI models recommended considering a hybrid sales model, in which B2B partners serve regular customers, while salaried sales representatives handle key partners. It is also necessary to strengthen equity capital through profit retention, owner contributions, or refinancing of costly short-term liabilities.

Interestingly, the final conclusions of all AI models were characterized by high consistency. The B2B transformation is not a failure, it is incomplete and insufficiently refined. The potential is significant, but the current form generates more risk than value. The strategy is sound, but execution requires substantial improvement. There is potential to increase margin levels. To achieve the increase of margin levels, the scale of operations must increase to at least half of the 2023 level, and the greatest risks are financial liquidity and the level of B2B costs, which are too high relative to the achieved outcomes. If the enterprise implements the recommended changes, the B2B approach may deliver higher profitability, greater operational scale, lower acquisition costs, and more predictable margins. It should be emphasized that the key conclusion of AI models in detecting anomalies in enterprise management processes is that without organized data and properly designed incentive systems, an effective enterprise management process will not function, regardless of whether sales are carried out by salaried sales representatives or B2B partners.

5. Discussion

This study was based on the assumption that artificial intelligence models used to detect anomalies in a company's financial data may misjudge the financial condition of the enterprise if they do not take into account the business context of the conducted activities. The results of the conducted research suggest that the triangulation of AI models for anomaly detection in enterprise management processes made it possible to identify numerous anomalies appearing in the financial statements of the analyzed enterprise. This was particularly evident during the period of annual financial closing, which the AI models described as "December black holes". However, these deviations did not result solely from operational errors but had real business

justifications. Each year, the analyzed enterprise made significant purchases of fixed assets in December, thereby utilizing the financial surplus accumulated in the final months of the year. Nevertheless, economic events related to the acquisition of new equipment generate high costs, which reduce operating margin and EBITDA in December, creating a "collapse" effect that AI models detected as an anomaly. From a managerial perspective, these were planned and controlled investment activities of the analyzed enterprise rather than signals of deteriorating financial condition.

The second category of anomalies identified by all applied AI models consisted of distorted values of the days sales outstanding (DSO), days payables outstanding (DPO), and days inventory outstanding (DIO) indicators, particularly visible in January 2024. The obtained results did not stem from improperly conducted operational activities but were a consequence of the formal transformation of the enterprise. The analyzed company was transformed from a sole proprietorship into a limited liability company, which required the transfer of assets, balance sheet balances, and the redefinition of accounting principles. This means that the transformation period contributed to the distortion of results obtained using financial indicators, especially when initial sales or costs in the new organizational structure were close to zero. In such cases, ratio-based indicators (turnover ratios) react by generating unrealistic values that do not reflect the actual operational situation of the enterprise.

From an analytical perspective, it is worth emphasizing that both identified sets of anomalies, December margin declines and unrealistic financial indicator values during the transformation period, have logical and fully justified origins. Understanding their nature makes it possible to avoid misinterpretation of data and enables a more reliable assessment of the effectiveness of the transformation and the financial condition of the enterprise.

The research results concerning the triangulation of AI models for anomaly detection confirm their usefulness as advanced tools supporting enterprise management processes. The analysis of six AI models demonstrated that artificial intelligence is capable of rapidly identifying not only basic financial trends but also anomalies, deviations, systemic errors, and potential risks, the identification of which in traditional reporting processes often requires significant time and effort.

A clear implication derived from the theoretical assumptions and the conducted research is that the key condition for the effective use of AI in detecting anomalies in enterprise management processes is the quality and completeness of input data. A decision-maker with full access to financial, operational, and system data must ensure the accuracy and consistency of the data that form the foundation of any analysis. Modern ERP systems provide such data directly, however, how these data are utilized depends on decision-makers. In contrast, the conducted research showed that although AI models are capable of indicating problems occurring in enterprise management processes, they cannot replace the contextual knowledge of a manager. The AI models frequently identified unusual financial and operational patterns. However, the adequacy of their interpretation varied across models and required verification against managerial knowledge, organizational documentation, and accounting context.

6. Conclusion

Summarizing the considerations presented in this study, it is worth emphasizing that understanding and assessing the capabilities of artificial intelligence models used for detecting financial anomalies opens the way for enterprises to improve their management processes. The conducted research confirms that the application of AI model triangulation in enterprise management significantly increases the quality and speed of obtained analyses and proposed solutions. The transformation of the enterprise's operational activity from a traditional sales-based approach to the implementation of solutions based on B2B partners proved to be an incomplete process requiring adjustments. Nevertheless, the multi-model analysis conducted using AI models enabled the rapid identification of financial anomalies and the detection of potential risks associated with the conducted business activity.

The main contribution of this article lies in its strong empirical evidence demonstrating that the application of AI model triangulation for anomaly detection shortens the time required to identify threats and formulate recommendations, which is particularly important for enterprises operating in environments characterized by dynamic change. The analyzed AI models were able to perform the analysis within a few minutes, whereas conducting such an analysis in a traditional manner would require many days of work by a financial team. The examined AI models offered different interpretative perspectives, which increased the depth of the analysis. However, caution should be exercised in the assessment of Human-Centered AI, as it does not replace the manager but rather provides diverse interpretations of data, facilitating the selection of appropriate decisions. Moreover, AI models in financial applications do not replace the decision-making process, instead, they radically accelerate its key stages by delivering multi-dimensional diagnoses, detecting anomalies, and proposing corrective actions. The use of AI model triangulation requires decision-making and organizational context, and defining this context necessitates managerial knowledge.

References

1. Appelbaum, D., Kogan, A., Vasarhelyi, M.A., Yan, Z. (2017). Impact of business analytics and enterprise systems on managerial accounting. *International Journal of Accounting Information Systems*, *25*, 29-44. https://doi.org/10.1016/j.accinf.2017.03.003
2. Bose, I., Mahapatra, R.K. (2019). Business data mining—A machine learning perspective. *Information & Management*, *56(3),* 303-323. https://doi.org/10.1016/j.im.2018.09.003

3. Chandola, V., Banerjee, A., Kumar, V. (2009). Anomaly detection: A survey. *ACM Computing Surveys*, *41(3),* 1-58.
4. Davenport, T.H., Ronanki, R. (2018). Artificial intelligence for the real world. *Harvard Business Review*, *96(1),* 108-116.
5. Davenport, T.H., Guha, A., Grewal, D., Bressgott, T. (2020). How artificial intelligence will change the future of marketing. *Journal of the Academy of Marketing Science*, *48(1),* 24-42. https://doi.org/10.1007/s11747-019-00696-0
6. Denzin, N.K. (2017). *The research act: A theoretical introduction to sociological methods* (2nd ed.). Routledge. https://doi.org/10.4324/9781315134543
7. Dietterich, T.G. (2000). Ensemble methods in machine learning. In: Multiple Classifier Systems. MCS 2000. *Lecture Notes in Computer Science, vol. 1857*. Berlin/Heidelberg: Springer. https://doi.org/10.1007/3-540-45014-9_1
8. Eisenhardt, K.M. (1989). Building theories from case study research. *Academy of Management Review*, *14(4),* 532-550. https://doi.org/10.5465/amr.1989.4308385
9. Friedman, B., Kahn, P.H., Borning, A., Huldtgren, A. (2013). Value sensitive design and information systems. In: N. Doorn, D. Schuurbiers, I. van de Poel, M. Gorman (Eds.),
   Early engagement and new technologies: Opening up the laboratory. *Philosophy of Engineering and Technology, vol. 16*. Springer. https://doi.org/10.1007/978-94-007-7844-3_4
10. Haenlein, M., Kaplan, A. (2019). A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California Management Review*, *61(4),* 5-14. https://doi.org/10.1177/0008125619864925
11. Janssen, M., Brous, P., Estevez, E., Barbosa, L.S., Janowski, T. (2020). Data governance: Organizing data for trustworthy artificial intelligence. *Government Information Quarterly*, *37(3),* 101493. https://doi.org/10.1016/j.giq.2020.101493
12. Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.
13. Kraus, S., Feuerriegel, S., Oztekin, A., Benlian, A. (2022). Digital transformation and artificial intelligence: A systematic literature review. *Journal of Business Research*, *142*, 208-224. https://doi.org/10.1016/j.jbusres.2021.12.051
14. Mikalef, P., Conboy, K., Lundström, J.E., Popovič, A. (2022). Thinking responsibly about responsible AI and data governance in business. *Journal of Business Ethics*, *176(2),*
   323-345. https://doi.org/10.1007/s10551-020-04572-5
15. Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances in Health Sciences Education*, *15(5),* 625-632. https://doi.org/10.1007/s10459-010-9222-y
16. Pang, G., Shen, C., Cao, L., Hengel, A. (2021). Deep learning for anomaly detection: A review. *ACM Computing Surveys*, *54(2),* 1-38. https://doi.org/10.1145/3439950

17. Raina, K., Sharma, G.D., Taheri, B., Dev, D. (2024). Artificial intelligence–driven management: Bridging innovation, knowledge creation, and sustainable business practices. *Journal of Innovation & Knowledge*, *9(1),* 100451. https://doi.org/10.1016/j.jik. 2023.100451
18. Ruff, L., Kauffmann, J.R., Vandermeulen, R.A., Montavon, G., Samek, W., Kloft, M., Müller, K.R., Binder, A. (2021). A unifying review of deep and shallow anomaly detection. *Proceedings of the IEEE*, *109(5),* 756-795. https://doi.org/10.1109/JPROC.2021.3052449
19. Shneiderman, B. (2020). Human-centered artificial intelligence: Reliable, safe & trustworthy. *International Journal of Human–Computer Interaction*, *36(6),* 495-504. https://doi.org/10.1080/10447318.2020.1741118
20. Shrestha, Y.R., Ben-Menahem, S.M., von Krogh, G. (2019). Organizational decision-making structures in the age of artificial intelligence. *California Management Review*, *61(4),* 66-83. https://doi.org/10.1177/0008125619862257
21. Wamba, S.F., Bawack, R.E., Guthrie, C., Queiroz, M.M., Carillo, K.D. (2021). Artificial intelligence in practice: Implications for information systems research. *Journal of Information Technology*, *36(1),* 1-24. https://doi.org/10.1177/0268396221989511
22. Yin, R.K. (2018). Case study research and applications: Design and methods (6th ed.). SAGE Publications.

Appendix A

Complete coding matrix of standardized recommendation categories across AI models

Code	Standardized recommendation category	ChatGPT	Claude	Gemini	Grok	Kimi	Sonar	Convergence
R1	Audit ERP data integrity and correct KPI formulas	1	1	0	0	1	0	3/6
R2	Audit the operating-cost structure, including B2B commissions where applicable	0	1	1	1	1	0	4/6
R3	Reduce or reengineer fixed and operating costs	1	1	1	1	1	1	6/6
R4	Review pricing and margin policy	1	1	0	0	1	0	3/6
R5	Analyze customer and product profitability and rationalize the portfolio	1	1	0	0	1	0	3/6
R6	Strengthen receivables management, including payment terms, incentives, or factoring	1	1	1	1	0	0	4/6
R7	Optimize inventory management	1	1	1	1	1	0	5/6
R8	Renegotiate supplier terms and manage payables	1	1	1	0	1	0	4/6
R9	Refinance liabilities or strengthen equity capital	0	0	0	0	0	1	1/6
R10	Introduce KPI monitoring, management reporting, dashboards, or forecasting	1	1	0	1	0	1	4/6
R11	Automate or digitalize B2B, sales, or controlling processes	0	1	0	0	1	0	2/6
R12	Redesign the sales model or diversify sales channels	1	0	1	0	1	1	4/6

Note: Two authors independently coded the recommendation content of each AI output using the predefined coding framework. A recommendation was coded as present only when it was explicitly proposed by a model. Disagreements were resolved through discussion with reference to the original model output. he matrix therefore documents descriptive convergence in recommendation content and does not assess the factual correctness or managerial validity of the recommendations.

Appendix B

Standardized prompt used for all AI models

"Analyze the attached monthly financial and operational data of a trading company for the period 2023-2025.
Identify unusual values, trends, and potential anomalies in:

1. profitability and operating margins,
2. liquidity and financing structure,
3. receivables and DSO,
4. payables and DPO,
5. inventory turnover and DIO,
6. cost structure, including B2B-related costs.

For each identified issue:

a. indicate the relevant period and financial indicator,
b. explain why the issue may be significant,
c. distinguish, where possible, between a potential data-quality problem and a managerial or operational problem,
d. provide possible explanations,
e. propose managerial corrective actions and indicate their priority.

Prepare the response in a structured form, distinguishing: key findings, detected issues, possible causes, and recommended actions".

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

MANAGING AN AGING WORKFORCE: SOME EVIDENCE FROM SILESIA

Izabela MARZEC

University of Economics in Katowice; izabela.marzec@ue.katowice.pl, ORCID: 0000-0002-7149-7566

Purpose: The demographic changes and population ageing have far-reaching consequences for organisations. The growing number of older employees leads to changes in human resource management (HRM). However, in many Polish organisations this problem is marginalised, which may have a negative impact on the work engagement and performance of older employees. Therefore, the aim of this paper is to answer the following question: what is the impact of the organisational equal opportunities climate (EO climate) and age-inclusive HR practices on the work engagement and performance of older employees?
Methodology: This aim is addressed through the analysis of the results of a survey conducted in Silesia involving employees aged 50 and over. The data were analysed using structural equation modelling (SEM).
Findings: The study revealed that the EO climate and age-inclusive HR practices positively influenced the work engagement of older employees, which subsequently affected their work performance, hence it showed that work engagement mediated the relationship between the EO climate, age-inclusive HR practices and work performance.
Research implications: A key contribution of this study is that it provides evidence that age-inclusive HR practices, when implemented within an EO climate significantly enhance older employees' work engagement and performance. This finding implies that initiatives aimed at improving the performance of older employees should focus on increasing their work engagement, as this acts as a mediator in the relationships between organisational factors and employee performance. However, a key limitation of the study, which also points the way for future research, is the relatively small sample size and the fact that it covers only employees from Silesian organisations.
Social implications: The findings are highly significant in the context of ongoing demographic changes and the growing number of older workers in the labour market because they show that, by taking appropriate HRM initiatives within organisations, it is possible to enhance the performance of a growing number of older employees.
Originality/value: Although the topic of age management has gained popularity in the literature on HRM, there is still little research identifying specific actions that should be taken in this area and their impact on older employees' performance.
Keywords: HRM, older employees, age management, work performance.
Category of the paper: Research paper.

1. Introduction

The demographic changes and population ageing that have been underway since the late 1970s have become a key focus of socio-economic policy in economically developed countries. Today, in many countries, the average age of the population is the highest it has ever been (World Population Review, 2026). The ageing of the workforce has become a fact in most EU countries. In Poland, this trend began to become clearly apparent in the early 1990s, particularly following the political transition after 1989 (GUS, 2023). In 2025, population ageing continued in Poland; the old-age index was 148, meaning that for every 100 grandchildren, there were 148 grandparents (GUS, 2026). Life expectancy is still increasing, while the birth rate continues to decrease.

These changes have increasingly far-reaching consequences for many aspects of economic life, including the functioning of organisations. They slow down economic growth and have a negative impact on the labour market, leading to a growing risk of labour and skills shortages. Consequently, for nearly two decades, this issue has also been addressed through employment policy and various EU initiatives aimed at increasing the economic activity of the population and the participation of older employees in the labour market (e.g., Council of the European Union, 2010). One of the key guidelines for the EU Member States set out in the European Employment Strategy, established in 1997 and revised in 2003, was to increase labour supply and promote active ageing (OJEU, 2003). With the launch of the Europe 2020 strategy in 2010, this approach became part of a broader governance framework (e.g., the European Semester) (European Commission, 2010). As part of the employment component of the European Semester, the EU, recognising an ageing population as one of the key challenges facing Europe and pursuing the concept of 'active ageing', promotes the upskilling of older people and their increased participation in the labour market (Zeitlin, Vanhercke, 2018).

In Poland, the 'Act on the Labour Market and Employment Services' (2025), in line with EU objectives, provides for employment subsidies for people aged 50 and above, as well as training and retraining opportunities for older people. As part of the state's social policy, the 'Active Seniors – ASY (2026–2030)' programme is being implemented (Office of the Prime Minister, 2025), focusing not only on the social and educational engagement of older people, but also on their participation in the labour market. Although this programme is not directly an employment programme, its objectives indirectly influence the professional activity of older people, as it aims, among other things, to improve the digital skills of older employees and to promote the idea of lifelong learning. Initiatives such as 'Active 50+' (Ministry of Family and Social Policy, 2021), educational and information programmes implemented by the Social Insurance Institution (ZUS, 2025) are also noteworthy.

There are already mismatches between labour supply and demand, as well as between the supply of and demand for skills, across many sectors and occupations in the Polish labour market. In this situation, many organisations facing staff shortages in certain occupational groups hire employees whose skill sets do not fully match organisational requirements, leading to numerous negative consequences for both organisations and employees, such as lower efficiency, reduced job satisfaction, and decreased employee engagement. Therefore, organisations must address this challenging situation and adapt their HR policies to the age structure of the workforce.

The growing number of older employees should inevitably lead to changes in organisational human resource management practices. However, in many Polish organisations, the extent of these changes still varies greatly. This issue is often marginalised, and initiatives aimed at maintaining and enhancing the employability of older employees are not widely implemented. This approach may have a negative impact on their work performance and work engagement and may, in the long term, lead to serious staff shortages. Therefore, the aim of this article is to answer the following question: What is the impact of the organisational equal opportunities climate and age-inclusive HR practices on the work engagement and performance of older employees? This aim is addressed through an analysis of the results of a survey conducted in Silesia involving employees aged 50 and over.

2. Literature Review

2.1. Work performance

Enhancing employee performance is one of the central concerns of human resource management (HRM), as employee performance is a key determinant of organisational effectiveness (Campbell, Wiernik, 2015). Individual contributions made by employees accumulate at a higher organisational level. However, despite having been studied for more than a century**,** there is no single universally accepted conceptualisation of the notion of work performance, because its understanding has developed over time. It concerns employees' actions, behaviours, and outcomes, which impact the achievement of organisational goals (Alqarni et al., 2023). Consequently, there are no universal measures of work performance, and the methods of its evaluation depend largely on how it is conceptualised. Some researchers focus on the assessment of the quantitative aspects of work performance, whilst others take a broader approach, emphasising its qualitative aspects (Marzec, 2024).

One of the first definitions of work performance was proposed by Burtt (1926), who viewed it in terms of professional proficiency. This understanding of work performance also appeared in later works on the subject, which are now considered classics (e.g., Vroom, 1962).

Later, it came to be associated with an employee's performance of tasks formally defined in the job description (e.g., Borman, Motowidlo, 1993). According to Lee and Jo (2023), work performance concerns the extent to which employees fulfil their roles in achieving organisational goals and completing assigned tasks. Skowron-Mielnik (2016) defines work performance as the ratio of work output (in the sense of direct work results) to work input. In turn, Demerouti and Cropanzano (2010) distinguish two elements of work performance, namely in-role and extra-role performance. In-role performance refers to behaviour that directly supports the formally requested outcomes of an employee's work and contributes to the achievement of organisational goals, while extra-role performance concerns the discretionary behaviour of an employee as a member of an organisation. Another distinction differentiates between task performance, involving specific job-related tasks and behaviours, and contextual performance, encompassing extra-role behaviours (Alqarni et al., 2023). Generally, the proposed approaches can be divided into two main categories of definitions of work performance, i.e. those that focus on the measurable outcomes of work and those that focus on employee behaviour (Grobelny, 2023).

Since the 1980s, there has been an intensive search for clear methods of measuring work performance (Marzec, 2024). However, the variety of its concepts results in numerous measures and criteria for its evaluation. Generally, they can be classified as objective and subjective measures. In the opinion of some researchers, objective measures better reflect the actual level of performance (Du, Choi, 2009). Objective measures of work performance typically include indicators such as absenteeism, work output (e.g., the number of tasks completed, the number of customers served, units produced per hour, or the average time required to complete a task), work quality (e.g., the number of errors, defect rate, or number of complaints), and sales performance (e.g., monthly sales volume, target achievement, revenue contribution, punctuality, and compliance with production standards) (Miraglia et al., 2025; Aarstad, Kvitastein, 2023; Bauer, Omeragic, 2022; Vuong, Nguyen, 2022). Others, however, argue that subjective measures may be better at revealing the relationships between employee performance and other variables; this is particularly justified in the case of employee self-assessments of work performance and their links to employee behaviors and attitudes (Chen et al., 2023). It can therefore be concluded that there is no single best measure of work performance, as its evaluation is relative and depends on the objectives, the specific nature of the tasks and job position, as well as the evaluator and the person being evaluated (Quinn, Rohrbaugha, 1983).

A review of the literature indicates that employee performance is influenced by various individual and organizational factors, both objective and subjective (e.g., Marzec, 2024; Ahmadi, Forouzandeh, Kareh, 2010). Among the organizational conditions identified as influencing employee work performance are leadership style, social support, compensation systems, job characteristics, role ambiguity, employee empowerment, organizational culture and climate, information and communication technology (ICT), and knowledge management,

etc. (Tuffaha, 2020; Ding, Yu, Li, 2023; Chen et al., 2023; Harwiki, 2016; Bakker, Demerouti, 2007; Chen, Chiu, 2009; Yun, Takeuchi, Liu, 2007). The literature also identifies numerous individual factors that may affect work performance. These include motivation, work-family balance, employee well-being, commitment, personality traits, cognitive abilities, organizational citizenship behavior, organizational tenure, job satisfaction, and age (Van Iddekinge et al., 2018; Basu, Pradhan, Tewari, 2017; Ng, Feldman, 2010; Le et al., 2011; Judge et al., 2001; Medina-Garrido, Biedma-Ferrer, Ramos-Rodriguez, 2024).

2.2. Age-inclusive HR practices and Equal Opportunities Climate as a part of Age Management

Due to the growing number of older employees and the wide age diversity of employees in many organisations, where different generations often work side by side, the issue of age management has become an increasingly important topic in HRM. Age management generally refers to HRM activities and practices that take into account the age diversity of the workforce and aim to make effective use of the potential of employees representing different age groups (Liwiński, Sztanderska, 2010).

As populations age, initiatives targeting older employees, aimed at retaining them within organisations, are becoming an increasingly important aspect of age management. Because HRM practices focused on empowering employees across different age groups and on maintaining and enhancing their employability throughout their working lives, regardless of age**,** may help address labour shortages resulting from current demographic trends and the declining number of young workers (OECD, 2025). Such practices are commonly referred to as age-inclusive HR practices. Rudolph and Zacher (2021) define age-inclusive HR practices as practices that benefit the majority of employees throughout their entire working lives (Rudolph, Zacher, 2021). Fan et al. (2023) offer a slightly different conceptualisation, describing age-inclusive HR practices as organisational practices that ensure employees have access to the resources required to successfully perform their work tasks, irrespective of age (Fan et al., 2023). This enables all employees to fully engage in their work, which is reflected in their improved work performance. Furthermore, age-inclusive HR practices positively influence both intrinsic and extrinsic motivation of employees by providing, for example, equal access to promotion opportunities and training regardless of age (Fan et al., 2023).

However, in the context of age management, some researchers focus on older employees. Boehm, Schröder, and Bal (2021, p. 257) emphasise that age-related HR policies and practices ‘allow individuals to extend their working lives’. Such initiatives aimed at older employees enhance their employability and motivation, thereby delaying their decision to retire (Loretto, White, 2006). Moreover, according to Social Exchange Theory, older employees who perceive that they are valued and treated fairly by their organisations are likely to reciprocate through increased work effort and higher levels of work engagement, which may, in turn, lead to enhanced their work performance (Waligóra, 2024). The most frequently mentioned age-

inclusive HR practices include, e.g. age-neutral recruitment and selection, promotion and career development, equal access to training and lifelong learning, flexible working arrangements, health promotion and workplace wellbeing, etc. (e.g. Marques, Nunes, Moreira, 2020; Farr-Wharton et al., 2023; National Academies of Sciences, 2022; Boehm, Schröder, Bal, 2021; Finsel et al., 2025).

Furthermore, researchers highlight the relationship between age-inclusive HR practices and organisational climate. Empirical research conducted by Rudolph and Zacher (2021) suggests that age-diversity climate mediates the relationship between age-inclusive HR practices and employees' work ability. The findings indicate that age-inclusive HR practices foster the development of an age-diversity climate, which, in turn, has a positive impact on employee work ability. Fan et al. (2023) argue that an age-inclusive workplace climate and perceived organisational support mediate the relationship between age-inclusive HR practices and work engagement. These findings show that in contemporary organisations, creating an organisational climate in which all employees, regardless of their age, have equal opportunities for career advancement and professional development is an important aspect of age management.

The concept of 'climate' was introduced into the social sciences by Lewin, Lippitt and White (1939) in reference to the social climate prevailing within groups between the leader and the group members, which arises as a result of the use of different leadership styles. However, the subject of organisational climate gained prominence in management literature in the late 1960s and early 1970s. The literature on the subject offers many definitions of organisational climate. Even in early studies on organisational climate, it was emphasised that it defines the quality of the organisation's internal, social environment as perceived by employees, and that it can be described in terms of values perceived by employees, specific to that organisation (Tagiuri, 1968). Schneider (1990) conceptualizes organizational climate as the perception of events, practices, procedures, and types of behavior that are rewarded, supported, and expected in a given work environment. Grobler and Van Rensburg (2018) describe the organizational climate in a similar way, defining it as the employees' shared perception of organizational policies, practices, and procedures.

One of the first comprehensive studies of the equal opportunity climate (EO climate) was conducted in the U.S. Army in the late 1980s for the Defense Equal Opportunity Management Institute (Dansby, Landis, 1991). This study aimed to develop and validate a scale called the Military Equal Opportunity Climate Survey (MEOCS) to measure the EO climate. It considered the EO climate as a perception of climate in terms of five factors: sexual harassment/ discriminatory behaviors, differential command behaviors, positive command/social behaviors, overt racist/sexist behaviors, and "reverse discrimination" behaviors (Knouse, Landis, Dansby, 1996). This conceptual framework and the EO climate measurement tool have been successfully applied in subsequent studies (e.g. Matthews et al., 2009). Based on this approach, Walsh et al. (2010, p. 192) define the EO climate as "employees' perceptions of the degree to

which discrimination and harassment are likely to occur within their work unit". However, the demographic changes observed over the past decade and the development of the concept of age management have led to definitions of the EO climate increasingly emphasizing the issues of age diversity and equal opportunities in the workplace for employees of different age groups. The term 'age diversity climate' has also been used more frequent use, sometimes replacing the EO climate. It focuses on age and concerns the extent to which organizational policies, practices, and procedures reflect efforts aimed at supporting and valuing age diversity (Bellotti et al., 2022).

Many studies have proved that the organisational climate is a significant factor that affects employees' attitudes and behaviour. Its perception is related to a variety of significant outcomes at the individual, group, and organizational levels (Patterson et al. 2005). Its impact on employee motivation has already been highlighted in classic studies (e.g., Litwin, Stringer, 1968)**.** Research conducted by Grobler and Jansen van Rensburg (2018) at higher education institutions showed that a negative organizational climate significantly influences the intentions of Generation Y and Baby Boomer employees to leave the organization. The results of a study conducted by Zhang and Liu (2010) revealed that the organizational climate influences employees' level of engagement and performance. Similarly, research conducted in Italy has found that age diversity climate not only affects employee work engagement but also their intentions to leave an organization and the job-related well-being (Bellotti et al., 2022).

2.3. Conditions and Outcomes of Work Engagement: Hypotheses Development

The classic definition proposed by Kahn (1990) states that work engagement refers to the "harnessing of organization members' selves to their work roles: in engagement, people employ and express themselves physically, cognitively, emotionally, and mentally during role performances" (Kahn, 1990, p. 694). He claims that an engaged employee is fully engaged physically, emotionally, and cognitively in the performance of his/her work role and that work engagement comprises three elements, namely meaningfulness**,** safety, and availability (Khan, 1990). However, Britt (1999) considers work engagement to be a unidimensional construct. He defines engagement as a sense of responsibility for one's work and a sense of attachment to it (Britt, 1999). According to Bakker (2011), employee engagement constitutes a relatively stable psychological state that depends on environmental factors.

Many researchers emphasise the influence of individual and organisational factors on work engagement (e.g. Bakker, Demerouti, 2008). Individual factors include, for example, an employee's motivation, attitudes, and positive self-evaluations (Schaufeli, 2012; Makowski, 2018). Research presented by Wołpiuk-Ochocińska (2015) indicates a link between work engagement and employees' age, showing that young employees exhibited a lower-than-average level of commitment to their work. Similarly, a study conducted by Böhm et al. (2014) in Germany, involving a sample of 18,269 employees, showed that a perceived climate of age discrimination has a negative influence on employees' collective commitment. A meta-analysis

of studies on the relationship between age and work engagement by Mori et al. (2024) also showed that work engagement increases as employees get older. Therefore, the previously observed relationships between age-inclusive HR practices, the EO climate, and work engagement justify the formulation of the following hypotheses (Fig. 1):

H1: *Age-inclusive HR practices positively influence work engagement of older employees*.

H2: *EO climate positively influences the work engagement of older employees.*

The literature lists various positive effects of work engagement, including, e.g. job satisfaction, organisational citizenship behaviour, personal initiative, a reduced risk of burnout, etc. (Schaufeli, 2012). Many studies indicate that work engagement has a positive impact on work performance (e.g. Bakker, Demerouti, Verbeke, 2004). According to the model proposed by Bakker and Demerouti (2008), organisational factors such as social support, performance feedback, and job characteristics enhance work engagement, which in turn leads to higher work performance. Therefore, employees who are immersed in their work often achieve better performance outcomes.

According to Kruse (2012), the relationship between work engagement and work performance is part of the so-called engagement-profit chain, which begins with strengthening employee engagement, leading to improved work performance, which results in higher customer satisfaction, and this translates into increased sales; higher sales mean greater profits, which translate into higher returns for shareholders (Skowron-Mielnik, 2016). Furthermore, in line with the Social Exchange Theory, when faced with organisational conditions such as an organisational climate that is welcoming to all employees regardless of age, and HRM practices that support older workers, older employees will respond with greater effort and commitment to their work, as well as with greater loyalty to the organisation. Therefore, the following research hypothesis has been formulated (Fig. 1):

H3: *Work engagement of older employees positively influences their work performance.*

It should be noted that hypotheses H1, H2 and H3 are directed toward a mediating role of work engagement in the relationships between the EO climate, age-inclusive HR practices, and work performance. Moreover, this proposition is reinforced by a previous study, which revealed that collective commitment is a mediator of the relationship between perceived age discrimination climate and organisational performance (Böhm et al., 2014). Therefore, it has been proposed:

H4a: *Work engagement is a mediator of the relationship between the EO climate and work performance.*

H4b: *Work engagement is a mediator of the relationship between age-inclusive HR practices and work performance*.

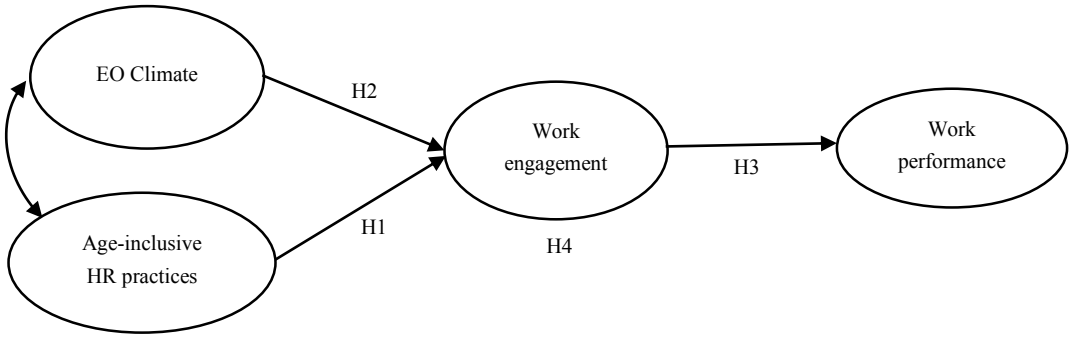


Figure 1. Conceptual model of relationships.

Source: own developed.

Figure 1 presents a conceptual model of the relationships among the constructs under study, namely the organizational predictors examined – the EO climate and age-inclusive HR practices, the mediating variable – work engagement, and the outcome variable – work performance. It is hypothesized that the EO climate and age-inclusive HR practices influence work engagement (H1 and H2), which in turn affects employees' work performance (H3), thereby mediating the relationships between the organizational predictors examined and work performance (H4).

3. Methods

The study was conducted in Silesian organisations in late 2024 as part of an international collaborative network involving researchers from 17 countries, with the aim of developing and validating the long version of the Later Life Workplace Index (LLWI) (Finsel et al., 2025). The study used purposive sampling. The selection criteria were employees' age (50 years or older), tenure with the current employer exceeding one year, organisation size (more than 30 employees), and working at least 20 hours per week. It was assumed that participating organisations should have at least 30 employees, as smaller organisations rarely have specialised HR departments or implement targeted HR policies. Furthermore, respondents employed by temporary work agencies were excluded from the sample.

208 employees took part in the survey in Silesia, of whom 134 were women and 74 were men. The average age of the respondents was 55.3 years (median = 54 years, SD = 4.5 years). Of the respondents, 33.2% held managerial positions and 66.8% held operational positions. In terms of educational attainment, 12% of participants had incomplete secondary education or less, 35.6% had completed secondary education (i.e. high school diploma), 11.1% had completed higher vocational education, 36.1% had a master's studies completed, 4.3% held a doctorate, and 1% reported another form of education.

Regarding organisation size, 36.6% of the respondents worked in medium-sized organisations (50-249 employees), 34.2% were employed in large organisations (250 or more employees), and 28.8% worked in small organisations. The largest groups of respondents were employees of manufacturing companies (18.2%), healthcare organisations (13%), public administration and national defence institutions (10.1%), financial and insurance organisations (9.1%), education (8.2%), retail trade (4.8%), transport and warehousing (4.3%), and IT services (3.8%). Respondents from other sectors accounted for 28.5% of the sample.

The study used previously tested measurement tools, including a scale measuring the EO climate (3 items) (Finsel et al., 2025), the age-inclusive HR practices scale developed by Boehm, Kunze, and Bruch (2014) (5 items), the shortened Utrecht Work Engagement Scale (UWES; 3 items) (Schaufeli et al., 2017), and a scale for self-assessment of work performance (4 items) developed by Eisenberger et al. (2001). The questions were rated on a seven-point Likert scale.

The Cronbach's alpha values for all scales indicated a good level of reliability. Specifically, the Cronbach's alpha coefficient for the scale measuring equal opportunities climate for was 0.86 (AVE = 0.71; CR = 0.88), for the age-inclusive HR practices scale it was 0.77 (AVE = 0.41; CR = 0.77), for work engagement it was 0.82 (AVE = 0.64; CR = 0.84), and for the work performance scale it was 0.89 (AVE = 0.67; CR = 0.89). The obtained Cronbach's alpha, and AVE, CR, demonstrated satisfactory level of reliability and validity for the scales used. The only exception was the age-inclusive HR practices for which the AVE value fell slightly below the recommended threshold. Nevertheless, according to Fornell and Larcker (1981), an AVE below the suggested cutoff may still be considered acceptable when composite reliability exceeds 0.60. In the present study, the CR value for this scale was 0.77, supporting its adequacy.

4. Results

Data were analysed using SPSS 28.0 and Amos 24.0. First, descriptive statistics were calculated for all variables. The overall levels of age-inclusive HR practices, EO climate, work engagement, and work performance were assessed using composite variables computed as the mean scores of the items comprising each scale (Table 1).

The analysis indicated that respondents rated their work performance the highest (M = 6.18 on a seven-point scale), whereas age-inclusive HR practices received the lowest ratings (M = 3.50 on a seven-point scale). Respondents also reported relatively high levels of work engagement (M = 5.04 on a seven-point scale). It should be noted that the greatest variability in ratings was observed for EO climate (SD = 1.60). At the same time, this variable was evaluated relatively positively, with a mean score of 4.64 on a seven-point scale.

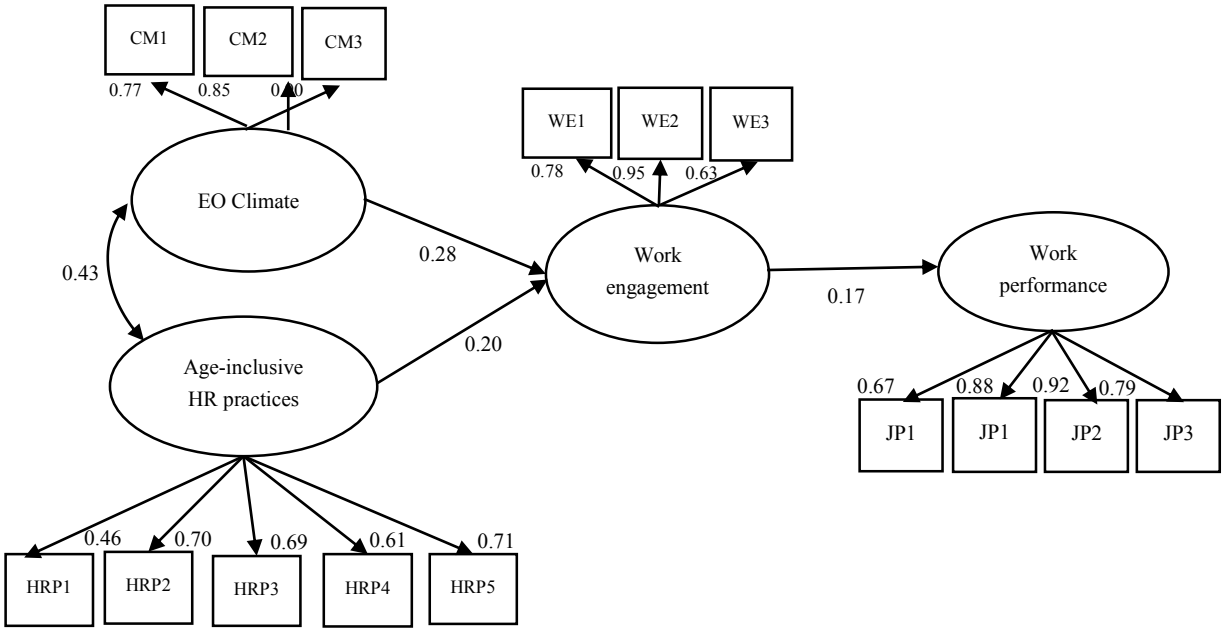
Table 1.

Descriptive statistics of variables examined

Variables	Mean	Median	Std. Deviation	Minim.	Maxim.	Range
EO climate	4.64	5	1.60	1	7	6
Age-inclusive HR practices	3.5	3.6	1.06	1	6	5
Work Engagement	5.04	5	1.09	1.33	7	5.67
Work performance	6.18	6	0.79	2.5	7	4.5

Source: own developed.

Structural equation modelling (SEM) was then used to test the conceptual model of the relationships between the phenomena under study and to analyse the paths among the examined variables. All examined relationships were statistically significant ($p < 0.05$) (Fig. 2). The analysis showed that both the EO climate and age-inclusive HR practices significantly influenced the work engagement of older employees (respectively, $\gamma_1 = 0.28$; $p < 0.05$, $\gamma_2 = 0.20$; $p < 0.05$). Therefore, these results do not provide grounds for rejecting Hypotheses 1 and 2. It was also found that work engagement positively affected the work performance of older employees ($\beta = 0.17$; $p < 0.05$).



Note. The model presents standardised regression weights.

Figure 2. The measurement model of relationships examined

Source: own developed.

The analysis of the model's fit to the empirical data indicates that it fits well; all the fit indices used were within acceptable ranges (Table 2). However, since an acceptable level of model fit does not mean that it is the only or the best possible model of the relationships among the variables, an alternative model was also analysed. This model included the direct effects of the predictors examined - namely, the EO climate and age-inclusive HR practices on work performance (Model 2; Table 2) (Konarski, 2009). However, the model fit measures indicated that this model fit the empirical data slightly less well and, more importantly, the SEM analysis

showed that the direct effects of both the EO climate and age-inclusive HR practices on work performance were statistically insignificant (respectively: $\gamma_3 = 0.09$, $p = 0.32$; $\gamma_4 = -0.07$, $p = 0.47$).

Table 2.

Model fit measures

Models	Chi^2	df	p	Chi^2/df	GFI	CFI	TLI	RMSEA
Model 1	164.89	86	0.00	1.917	0.91	0.95	0.93	0.067
Model 2	163,77	84	0.00	1.950	0.91	0.94	0.93	0.068
Model 0 (lack of relations)	1561.96	105	0.00	14.876	0.44	0	0	0.259

Source: own developed.

The results therefore indicate that work engagement mediates the relationship between the EO climate, age-inclusive HR practices, and work performance, and that this mediation is full. To provide further evidence for the mediating role of work engagement, a Sobel test was conducted. The results confirmed the earlier findings (i.e., $Z_1 = 1.55$, $_{p1} = 0.06$; $Z_2 = 1.84$, $p_2 = 0.03$). The value of p_1 was slightly above the conventional significance threshold, which may be attributable to the relatively small sample size, as the statistical power of the test increases with sample size (Cohen, 1988).

5. Discussion and Conclusions

The results obtained do not provide grounds for rejecting the hypotheses formulated. The analysis showed that both age-inclusive HR practices and the EO climate have a positive impact on work engagement, which in turn has a positive effect on the work performance of older employees. It was also confirmed that work engagement mediates the relationships between age-inclusive HR practices, the EO climate, and work performance, and that this is a case of full mediation, since the direct impact of the organisational factors under investigation on work performance proved to be statistically insignificant.

These findings suggest that in the face of demographic changes and an increase in the number of older employees, organisations should implement management initiatives, especially in the area of HRM, aimed at maintaining and enhancing the work engagement of older employees. This is because the study has shown that age-inclusive HR practices do not directly influence the performance of older employees, but indirectly – by enhancing their work engagement. Moreover, it has also been found that age-inclusive HR practices are linked to the EO climate and both indirectly affect the performance of older employees through their impact on work engagement. This indicates that organisations employing older employees should, above all, strive to strengthen their work engagement in order to improve their work

performance, as a change in objective organisational conditions alone does not guarantee an improvement in performance. Furthermore, the relationship between organisational climate and age-inclusive HR practices suggests that it is not only the organisation's actions that matter, but also how these are perceived by employees.

These results are consistent with some earlier studies which revealed that older employees' work engagement mediates the relationship between age-inclusive human resource practices and an age-diversity climate, on the one hand, and work ability, on the other (Rudolph, Zacher, 2021). Furthermore, they suggest that, in addition to objective HRM initiatives, it is equally important to create an appropriate psychological climate in which employees feel that they are valued by the organisation regardless of their age. Such a climate is conducive to initiatives in the areas of age management and organisational development – it creates the right psychosocial conditions within the organisation for the introduction of age-inclusive HR practices. In line with the assumptions of Social Exchange Theory, older employees who feel supported by the organisation will respond in return with increased work effort and greater engagement in their work, which in turn will lead to an improvement in their performance. A lack of organisational support perceived by older employees, in turn, will lead to a decrease in their work effort and engagement. It will also decrease the perceived costs of leaving the organisation, which will result in leaving the organization and earlier retirement. These observations are supported by the results of an empirical study conducted in Portugal, which showed that work engagement mediates the relationship between age-diversity practices and employees' preference for early or late retirement (Sousa, Ramos, Carvalho, 2019). This study also revealed that age-diversity practices increase the engagement and work capacity of older employees, leading to a preference for a later retirement age (Sousa, Ramos, Carvalho, 2019). In practice, this suggests that the introduction of such initiatives in organisations may help them to mitigate labour shortages caused by demographic changes, as an appropriate HRM policy and organisational climate will encourage many older employees to continue working even after becoming eligible for retirement.

The study also has some other significant practical implications. It clearly demonstrates to management that investing in retaining older employees within an organisation can yield tangible benefits such as improved employee performance, which is a key driver of organisational performance. In many organisations, older employees are marginalised in developmental initiatives, as employers believe that investing in this group of employees is not cost-effective, and that they adapt more slowly to change and learn at a slower pace. However, as many previous studies indicate, this is usually a mistaken and misguided view (Marzec, 2015).

The primary contribution of this study lies in providing empirical evidence that age-inclusive HR practices, together with an organisational climate that promotes equal opportunities regardless of employee age, positively influence work engagement and job performance of older employees. Furthermore, an important insight into the development of

age management theory provided by this research is the finding that age-inclusive human resource management practices and the organisational climate do not directly influence work performance; rather, work engagement is the mediator in these relationships. At the same time, this finding suggests that the effectiveness of age management initiatives should not be assessed solely in terms of employees' performance, but primarily in terms of their impact on employees' attitudes and psychological states, such as engagement, motivation, and identification with the organisation.

The limitations of this study should also be highlighted. Significant limitations include the relatively small sample size and the fact that the research focused solely on employees of organisations located in Silesia. Future research should include a larger sample of employees representing organisations from all regions of Poland. It would also be useful to compare the initiatives aimed at older employees that are implemented in organisations across different sectors and of varying sizes. Furthermore, age-inclusive HR practices were examined only in general terms. It would be worthwhile, however, to specify more precisely which specific practices aimed at older employees are being undertaken within various HR functions. For example, future studies could examine the extent to which the development of older employees' competencies is supported in organisations, what career development opportunities are available to them, whether actions are being taken to manage the health of older employees, whether ergonomic working conditions adapted to their needs are being created and how intergenerational cooperation is promoted within the organisations. Additionally, the study examined only the effects of age-inclusive HR practices and the EO climate on work engagement and performance. It would also be worthwhile to investigate how these factors influence the employability of older workers, their intentions to retire or continue working within the organisation, as well as their proactive and civic behaviours.

To sum up, particularly in the context of an ageing society, efforts to fully utilise the potential of older employees are no longer optional but are increasingly becoming a necessity for organisations facing growing labour shortages. Consequently, age-inclusive policies should constitute an integral component of every organisation's HRM strategy. Such policies can generate substantial benefits for employees of all ages by facilitating knowledge and experience sharing, fostering mutual learning, and promoting effective intergenerational collaboration.

References

1. Aarstad, J., Kvitastein, O.A. (2023). Effect of long-term absenteeism on the operating revenues, productivity, and employment of enterprises. *Administrative Sciences, Vol. 13*, *Iss. 6,* 156, doi: 10.3390/admsci13060156
2. Ahmadi, P., Forouzandeh, S., Kareh, M.S. (2010). The relationship between OCB and social exchange constructs. *European Journal of Economics and Administrative Sciences*, *Vol. 19*, pp. 108-117.
3. Alqarni, S., Hamsan, H., Rasdi, R.M., Abdul Rahman, H. (2023). A systematic literature review on job performance in diverse organizations from 2010 to 2023. *International Journal of Academic Research in Business and Social Sciences*, *Vol. 13*, *Iss. 18*, pp. 203-216, doi: 10.6007/IJARBSS/v13-i18/19960
4. Bakker, A.B. (2011). An Evidence-Based Model of Work Engagement. *Current Directions in Psychological Science*, *Vol. 20, Iss. 4*. Retrieved from: http://cdp.sagepub.com/content/20/4/265, 05.07.2013.
5. Bakker, A.B., Demerouti, E. (2007). The Job Demands–Resources model: State of the art. *Journal of Managerial Psychology*, *Vol. 22, Iss. 3,* pp. 309-328, doi: 10.1108/02683940710733115
6. Bakker, A.B., Demerouti, E. (2008). Towards a model of work engagement. *Career Development International*, *Vol. 13*, pp. 209-223.
7. Bakker, A.B., Demerouti, E., Verbeke, W. (2004). Using the Job Demands - Resources model to predict burnout and performance. *Human Resource Management*, *Vol. 43*, pp. 83-104.
8. Basu, E., Pradhan, R.K., Tewari, H.R. (2017). Impact of organizational citizenship behavior on job performance in Indian healthcare industries: The mediating role of social capital. *International Journal of Productivity and Performance Management, Vol. 66, Iss. 6*, pp. 780-796, doi: 10.1108/IJPPM-02-2016-0048
9. Bauer, A., Omeragic, J. (2022). Volatility in the relative standard deviation of target fulfilment as key performance indicator (KPI). *Academia Revista Latinoamericana de Administracion*. Retrieved from: https://arxiv.org/abs/2201.06373, 12.07.2025.
10. Bellotti, L., Zaniboni, S., Balducci, C., Menghini, L., Cadiz, D.M., Toderi, S. (2022). Age diversity climate affecting individual-level work-related outcomes. *International Journal of Environmental Research and Public Health, Vol. 19*, *Iss. 5*, 3041, doi: 10.3390/ijerph19053041
11. Boehm, S.A., Kunze, F., Bruch, H. (2014). Spotlight on age-diversity climate: The impact of age-inclusive HR practices on firm-level outcomes. *Personnel Psychology, Vol. 67, Iss. 3,* pp. 667-704, doi: 10.1111/peps.12047

12. Boehm, S.A., Schröder, H., Bal, M. (2021). Age-related human resource management policies and practices: Antecedents, outcomes, and conceptualizations. *Work, Aging and Retirement, Vol. 7, Iss. 4*, pp. 257-272, doi: 10.1093/workar/waab024
13. Böhm, S.A., Dwertmann, D.J.G., Kunze, F., Michaelis, B., Parks, K. i McDonald, D. (2014). Expanding Insights on the Diversity Climate-Performance Link: The Role of Work Group Discrimination and Group Size. *Human Resource Management*, *Vol. 53, Iss. 3*, pp. 379-402, doi: 10.1002/hrm.21589
14. Borman, W.C., Motowidlo, S.J. (1993). Expanding the Criterion Domain to Include Elements of Contextual erformance. In: N. Schmitt, W.C. Borman (Eds.), *Personnel Selection in Organizations* (pp. 71-98). San Francisco: Jossey-Bass.
15. Britt, T.W. (1999). Engaging the Self in the Field: Testing the Triangle Model of Responsibility. *Personality and Social Psychology Bulletin*, *Vol. 25,* pp. 696-706, doi: 10.1177/0146167299025006005.
16. Burtt, H.E. (1926). *Principles of employment psychology*. Boston: Houghton-Mifflin.
17. Campbell, J.P., Wiernik, B.M. (2015). The modeling and assessment of work performance. *Annual Review of Organizational Psychology and Organizational Behavior*, *Vol. 2*, pp. 47-74, doi: 10.1146/annurev-orgpsych-032414-111427
18. Chen, Ch., Chiu, S. (2009). The Mediating Role of Job Involvement in the Relationship Between Job Characteristics and Organizational Citizenship Behavior. *Journal of Social Psychology, Vol. 149, Iss. 4*, pp. 474-494.
19. Chen, Y., Zhang, Z., Zhou, J., Liu, C., Zhang, X., Yu, T. (2023). A cognitive evaluation and equity-based perspective of pay for performance on job performance: A meta-analysis and path model. *Frontiers in Psychology, Vol. 13*, 1039375, doi: 10.3389/fpsyg.2022.1039375
20. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates.
21. Council of the European Union (2010). *Council Decision 2010/707/EU on guidelines for the employment policies of the Member States.* Retrieved from: https://eur-lex.europa.eu, 13.05.2026.
22. Dansby, M.R., Landis, D. (1991). Measuring equal opportunity climate in the military environment. *International Journal of Intercultural Relations*, *Vol. 15*, pp. 389-403.
23. Demerouti, E., Cropanzano, R. (2010). From thought to action: Employee engagement and job performance. In A.B. Bakker, M.P. Leiter (Eds.), *Employee engagement: A handbook of essential theory and research* (pp. 147-160). New York, NY: Psychology Press.
24. Ding, H., Yu, E., Li, Y. (2023). Strengths-based leadership and employee work engagement: A multi-source study. *Journal of Vocational Behavior, Vol. 142*, 103859, doi: 10.1016/j.jvb.2023.103859
25. Du, J., Choi, J.N. (2010). Pay for performance in emerging markets: Insights from China. *Journal of International Business Studies*, *Vol. 41*, *Iss. 4*, pp. 671-689, doi: 10.1057/jibs.2009.40

26. Eisenberger, R., Armeli, S., Rexwinkel, B., Lynch, P.D., Rhoades, L. (2001). Reciprocation of perceived organizational support. *Journal of Applied Psychology*, *Vol. 86*, *Iss. 1*, pp. 42-51, doi: 10.1037/0021-9010.86.1.42
27. European Commission (2010). *Europe 2020: A strategy for smart, sustainable and inclusive* growth *(COM(2010) 2020 final)*. Retrieved from: EUR-Lex, 23.02.2024.
28. Fan, P., Song, Y., Fang, M., Chen, X. (2023). Creating an age-inclusive workplace: The impact of HR practices on employee work engagement. *Journal of Management & Organization*, *Vol. 29, Iss. 6*, pp. 1283-1302, doi: 10.1017/jmo.2023.18
29. Farr-Wharton, B., Bentley, T., Onnis, L.-a., Caponecchia, C., Neto, A.D.A., O'Neill, S., Andrew, C. (2023). Older Worker-Orientated Human Resource Practices, Wellbeing and Leave Intentions: A Conservation of Resources Approach for Ageing Workforces. *International Journal of Environmental Research and Public Health*, *Vol. 20, Iss. 3*, 2725, doi: 10.3390/ijerph20032725
30. Finsel, J.S., Axelrad, H., Choi, S.J., Derous, E., Gu, X., Guandalini, P., Ha, J., Kim, E.S., Marzec, I., Mykletun, R.J., Oliveira, E., Pajic, S., Schellaert, M., Van der Heijden, B.I.J.M., Vignoli, M., Wöhrmann, A.M., Deller, J. (2025). Development and validation of the short form of the Later Life Workplace Index (LLWI-SF): A study across ten countries. *Work, Aging and Retirement.* Advance online publication, doi: 10.1093/workar/waaf006
31. Fornell, C., Larcker, D.F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, Vol. 18*, *Iss. 1*, pp. 39-50, doi: 10.1177/002224378101800104
32. Główny Urząd Statystyczny (GUS) (2023). *Sytuacja demograficzna Polski do 2023 roku*. Warszawa: GUS. Retrieved from: https://stat.gov.pl/files/gfx/portalinformacyjny/pl/defaultaktualnosci/5468/40/4/1/sytuacja_demograficzna_polski_do_2023.pdf, 15.05.2026.
33. Główny Urząd Statystyczny (GUS) (2026). *Statistics Poland*. Retrieved from: https://x.com/StatPoland/status/2049480827453538452, 12.05.2026.
34. Grobelny, J. (2023). *Efektywność zawodowa. Problemy definicji i pomiaru*. Poznań: Wydawnictwo Nauk Społecznych i Humanistycznych UAM. doi: 10.14746/9788366983236
35. Grobler, A., Jansen van Rensburg, M. (2018). Organisational climate, person–organisation fit and turn over intention: a generational perspective within a South African Higher Education Institution, *Studies in Higher Education*, *Vol. 44, Iss. 11*, pp. 2053-2065, doi: 10.1080/03075079.2018.1492533
36. Harwiki, W. (2016). The impact of servant leadership on organization culture, organizational commitment, organizational citizenship behaviour (OCB) and employee performance in women cooperatives. *Procedia - Social and Behavioral Sciences*, *Vol. 219*, pp. 283-290, doi: 10.1016/j.sbspro.2016.04.032

37. Judge, T.A., Thoresen, C.J., Bono, J.E., Patton, G.K. (2001). The job satisfaction–job performance relationship: A qualitative and quantitative review. *Psychological Bulletin, Vol. 127*, *Iss. 3*, pp. 376-407, doi: 10.1037/0033-2909.127.3.376
38. Kahn, W.A. (1990). Psychological conditions of personal engagement and disengagement at work. *Academy of Management Journal*, *Vol. 33*, pp. 692-724.
39. Knouse, S.B., Landis, D., Dansby R.M. (1996). *Recent diversity research at the Defense Equal Opportunity Management Institute (DEOMI): 1992-1996* (DEOMI RSP 96-14). Defense Equal Opportunity Management Institute. Retrieved from: https://apps.dtic.mil/sti/tr/pdf/ADA316554.pdf, 22.04.2026.
40. Konarski, R. (2009). *Modele równań strukturalnych. Teoria i praktyka*. Warszawa: PWN.
41. Kruse, K. (2012). What is Employee Engagement. *Forbes*. Retrieved from: http://www.forbes.com/sites/kevinkruse/2012/06/22/employee-engagement-what-and-why, 10.09.2013.
42. Kunze, F., Toader, A.F. (2019). Lifespan perspectives on organizational climate. In: B.B. Baltes, C.W. Rudolph, H. Zacher (Eds.), *Work across the lifespan* (pp. 561-580). San Diego: Elsevier Academic Press, doi: 10.1016/B978-0-12-812756-8.00024-7
43. Le, H., Oh, I.-S., Robbins, S.B., Ilies, R., Holland, E., Westrick, P. (2011). Too much of a good thing: Curvilinear relationships between personality traits and job performance. *Journal of Applied Psychology*, *Vol. 96*, *Iss. 1*, pp. 113-133, doi: 10.1037/a0021016
44. Lee, D.Y., Jo, Y. (2023). The job demands-resource model and performance: The mediating role of employee engagement. *Frontiers in Psychology, Vol. 14*, 1194018. doi: 10.3389/fpsyg.2023.1194018
45. Lewin, K., Lippitt, R., White, R.K. (1939). Patterns of aggressive behavior in experimentally created "social climates". *Journal of Social Psychology*, *Vol. 10*, *Iss. 2*, pp. 269-299, doi: 10.1080/00224545.1939.9713366
46. Litwin, G.H., Stringer, R.A. (1968). *Motivation and organizational climate*. Boston: Harvard University Press.
47. Liwiński, J., Sztanderska, U. (2010). *Zarządzanie wiekiem w przedsiębiorstwie*. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości. Retrieved from: https://www.parp.gov.pl/storage/publications/pdf/19001zarzadzaniewiekiemd.pdf, 21.04.2026.
48. Loretto, W., White, P. (2006). Employers' attitudes, practices and policies towards older workers. *Human Resource Management Journal*, *Vol. 16, Iss. 3*, pp. 313-330, doi: 10.1111/j.1748-8583.2006.00013.x
49. Makowski, M. (2018). Zaangażowanie w pracę w perspektywie psychologii pozytywnej. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, *Vol. 12, Iss. 972*, pp. 85-97, doi: 10.15678/ZNUEK.2017.0972.1206

50. Marques, A.M., Nunes, C., Moreira, S. (2020). Age management practices toward workers aged 45 years or older: An integrative literature review. *Revista Brasileira de Medicina do Trabalho, Vol. 18, Iss. 4*, pp. 423-435, doi: 10.47626/1679-4435-2020-549
51. Marzec, I. (2015). *Uwarunkowania rozwoju zatrudnialności pracowników w organizacji*. Katowice: Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach.
52. Marzec, I. (2024). Employee empowerment as a driver of citizenship behaviour and job performance in the digital age. *Zeszyty Naukowe. Organizacja i Zarządzanie*, *Vol. 203.*, Politechnika Śląska, pp. 313-326, doi: 10.29119/1641-3466.2024.203.18
53. Matthews, R.A., Parks, K.M., Walsh, B.M., Tuller, M.D., McDonald, D.P. (2009). *Deployed Army personnel: The effect of equal opportunity climate perceptions on job satisfaction and organizational commitment*. Paper presented at the Defense Equal Opportunity Management Institute Biennial Symposium, Cocoa Beach, United States. Retrieved from: https://www.researchgate.net/publication/252158323_Deployed_Army_Personnel_The_Affect_of_Equal_Opportunity_Climate_Perceptions_on_Job_Satisfaction_and_Organizational_Commitment, 23.03.2026.
54. Medina-Garrido, J.A., Biedma-Ferrer, J.M., Ramos-Rodriguez, A.R. (2024). Relationship between work-family balance, employee well-being and job performance. *Academia Revista Latinoamericana de Administracion*, *Vol. 30, Iss. 1,* pp. 40-58*,* doi: 10.48550/arXiv.2401.13683
55. Ministry of Family and Social Policy (Ministerstwo Rodziny i Polityki Społecznej) (2021). *Program wieloletni na rzecz Osób Starszych „Aktywni+" na lata 2021-2025*. Retrieved from: https://www.gov.pl, 21.04.2026.
56. Miraglia, M., Dello Russo, S., Bouville, G. (2025). The hazards of performance management: An investigation into its effects on employee absenteeism and presenteeism. *Human Relations, Vol. 78, Iss. 7,* pp. 847-875, doi: 10.1177/00187267241274619
57. Mori, K., Odagami, K., Inagaki, M., Moriya, K., Fujiwara, H., Eguchi, H. (2024). Work engagement among older workers: A systematic review. *Journal of Occupational Health*, *Vol. 66, Iss. 1*, uiad008, doi: 10.1093/joccuh/uiad008
58. National Academies of Sciences, Engineering, and Medicine (2022). *Understanding the aging workforce: Defining a research agenda*. Washington, DC: National Academies Press, doi: 10.17226/26173
59. Ng, T.W.H., Feldman, D.C. (2010). Organizational tenure and job performance. *Journal of Management*, *Vol. 36, Iss. 5*, pp. 1220-1250, doi: 10.1177/0149206309359809
60. OECD (2025). *OECD Employment Outlook 2025: Can We Get Through the Demographic Crunch?* OECD Publishing, Paris. Retrieved from: https://www.oecd.org/en/publications/oecd-employment-outlook-2025_194a947b-en.html, 24.03.2026.
61. Office of the Prime Minister (Kancelaria Prezesa Rady Ministrów) (2025). *Program „Aktywni Seniorzy – ASY" na lata 2026-2030*. Retrieved from: https://www.gov.pl, 22.03.2026, 12.03.2026.

62. Official Journal of the European Union (OJEU) (2003). Council Decision of 22 July 2003 on guidelines for the employment policies of the Member States (2003/578/EC). *Official Journal of the European Union, L 197*, pp. 13-21. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32003D0578&utm_source, 13.05.2026.
63. Patterson, M.G., West, M.A., Shackleton, V.J., Dawson, J.F., Lawthom, R., Maitlis, S., Robinson, D. L., Wallace, A.M. (2005). Validating the organizational climate measure: Links to managerial practices, productivity and innovation. *Journal of Organizational Behavior*, *Vol. 26, Iss. 4,* pp. 379-408, doi: 10.1002/job.312
64. Quinn, R.E., Rohrbaugh, J. (1983). A spatial model of effectiveness criteria: Towards a competing values approach to organizational analysis. *Management Science*, *Vol. 29*, *Iss. 3*, pp. 363-377, doi: 10.1287/mnsc.29.3.363
65. Rudolph, C.W., Zacher, H. (2021). Age inclusive human resource practices, age diversity climate, and work ability: Exploring between- and within-person indirect effects. *Work, Aging and Retirement, Vol. 7, Iss. 4*, pp. 387-403, doi: 0.1093/workar/waaa008
66. Schaufeli, W.B. (2012). Work engagement: What do we know and where do we go? *Romanian Journal of Applied Psychology*, *Vol. 14, Iss. 1,* pp. 3-10.
67. Schaufeli, W.B., Shimazu, A., Hakanen, J., Salanova, M., De Witte, H. (2019). An ultra-short measure for work engagement: The UWES-3 validation across five countries. *European Journal of Psychological Assessment*, *Vol. 35, Iss. 4*, pp. 577-591, doi: 10.1027/1015-5759/a000430
68. Schneider, B. (1990). The climate for service: An application of the climate construct. In: B. Schneider (Ed.), *Organizational climate and culture* (pp. 383-412). San Francisco, CA: Jossey-Bass.
69. Skowron-Mielnik, B. (2016). *Paradoks efektywności pracy – między budowaniem zaangażowania a wypaleniem zawodowym*. *Nauki o Zarządzaniu [Management Sciences], Vol. 2, Iss. 27*, pp. 151-163, doi: 10.15611/noz.2016.2.13
70. Sousa, I.C., Ramos, S., Carvalho, H. (2019). Age-Diversity Practices and Retirement Preferences Among Older Workers: A Moderated Mediation Model of Work Engagement and Work Ability. *Frontiers in Psychology, Vol. 10*, 1937, doi: 10.3389/fpsyg.2019.01937
71. Tagiuri, R. (1968). The concept of organizational climate. In: R. Tagiuri, G.H. Litwin (Eds.), *Organizational climate: Explorations of a concept* (pp. 11-32). Boston: Harvard University, Graduate School of Business Administration.
72. Tuffaha, M. (2020). The determinants of employee's performance: A literature review. *Journal of Economics and Management Sciences*, *Vol. 3*, *Iss. 3*, pp. 14-24. doi: 10.30560/jems.v3n3p14
73. Ustawa z dnia 20 marca 2025 r. o rynku pracy i służbach zatrudnienia. *Dz.U. 2025, poz. 620*.

74. Van Iddekinge, C.H., Aguinis, H., Mackey, J. D., DeOrtentiis, P.S. (2018). A meta-analysis of the interactive, additive, and relative effects of cognitive ability and motivation on performance. *Journal of Management, Vol. 44*, *Iss. 1*, pp. 249-279, doi: 10.1177/0149206317702220
75. Vroom, V.H. (1962). Ego-involvement, job satisfaction, and job performance. *Personnel Psychology*, *Vol. 15*, *Iss. 2*, pp. 159-177, doi: 10.1111/J.1744-6570.1962.TB01858.X
76. Vuong, T.D.N., Nguyen, L.T. (2022). The key strategies for measuring employee performance in companies: A systematic review. *Sustainability, Vol. 14*, *Iss. 21*, 14017, doi: 10.3390/su142114017
77. Waligóra, L. (2024). Exploring the impact of age diversity on organizational identification: A study of HR practices and perceived age discrimination climate. *Administrative Sciences*, *Vol. 14, Iss. 10*, 243, doi: 10.3390/admsci14100243
78. Walsh, B.M., Matthews, R.A., Tuller, M.D., Parks, K.M., McDonald, D.P. (2010). A multilevel model of the effects of equal opportunity climate on job satisfaction in the military. *Journal of Occupational Health Psychology, Vol. 15*, *Iss. 2*, pp. 191-207, doi: 10.1037/a0018756
79. Wołpiuk-Ochocińska, A. (2015). Motywacje do pracy i zaangażowanie w nią młodych pracowników na rynku pracy. *Zeszyty Naukowe Wyższej Szkoły Zarządzania Ochroną Pracy w Katowicach*, *Vol. 1, Iss. 11*, pp. 72-84.
80. World Population Review (2026). *Median Age by Country 2026*. Retrieved from: https://worldpopulationreview.com/country-rankings/median-age, 02.04.2026.
81. Yun, S., Takeuchi, R., Liu, W. (2007). Employee self-enhancement motives and job performance behaviors: Investigating the moderating effects of employee role ambiguity and managerial perceptions of employee commitment. *Journal of Applied Psychology, Vol. 92, Iss. 3*, pp. 45-756, doi: 10.1037/0021-9010.92.3.745
82. Zakład Ubezpieczeń Społecznych (ZUS) (2025). *Co robi Europa w zakresie aktywizacji*. Retrieved from: https://www.zus.pl/en/aktywni-50-plus/co-robi-europa? 15.04.2026.
83. Zeitlin, J., Vanhercke, B. (2018). Socializing the European Semester: EU social and economic policy co-ordination in crisis and beyond. Swedish Institute for European Policy Studies. *European Policy Analysis, Iss. 1,* pp. 34-51, doi: 10.1002/epa2.1022
84. Zhang, J., Liu, Y. (2010). Organizational climate and its effects on organizational variables: An empirical study. *International Journal of Psychological Studies*, *Vol. 2*, *Iss. 2*, pp. 189-195, doi: 10.5539/ijps.v2n2p189

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

BUSINESS INTELLIGENCE ADOPTION IN LOGISTICS: AN EMPIRICAL SWOT/TOWS-BASED STRATEGIC ANALYSIS

Mateusz MAŚLANKA[1*], Łukasz HADAŚ[2]

[1] Łukasiewicz Research Network – Poznań Institute of Technology; mateusz.maslanka@pit.lukasiewicz.gov.pl, ORCID: 0009-0006-3481-7707
[2] Poznań University of Technology, Faculty of Engineering Management; lukasz.hadas@put.poznan.pl, ORCID: 0000-0001-9271-8738
*Correspondence author

Purpose: This study examines the adoption of Business Intelligence (BI) in logistics enterprises and aims to identify internal and external determinants of BI adoption using a SWOT framework and to assess how BI supports digital transformation in logistics.
Design/methodology/approach: A qualitative research design was applied, combining a literature review with empirical data from 30 logistics professionals. Responses were analyzed using thematic analysis with hybrid inductive/deductive approach. A weighted SWOT matrix was developed to assess strengths, weaknesses, opportunities, and threats, and to derive strategic implications for BI adoption.
Findings: Key internal and external factors influencing the effective implementation of Business Intelligence (BI) tools in logistics operations were identified. Inter-action analysis between these factors showed that defensive strategy is recommended for the logistics sector regarding the adaptation of BI solutions.
Research limitations/implications: The study is limited by its qualitative scope and geographically concentrated sample. Further quantitative and cross-country research is recommended to validate the relationship between BI maturity and logistics performance.
Practical implications: Organizations should invest in analytical capability development training programs to bridge the gap in analytical competencies among staff, integrated data infrastructures, and coherent BI strategies to strengthen competitiveness and long-term resilience.
Social implications: Enhanced BI-driven efficiency contributes to reduced resource waste, improved supply chain reliability, and more sustainable logistics operations.
Originality/value: The study provides a weighted SWOT/TOWS empirical assessment of BI adoption in logistics, offering strategic insights grounded in expert evidence.
Keywords: Business Intelligence (BI), Logistics Management, Digital Transformation, Technology Adoption.
Category of the paper: Research Paper.

1. Introduction

In recent years, digital transformation has become a strategic priority for logistics enterprises, which face mounting pressure for speed, accuracy, and adaptability driven by more demanding customer expectations and increasingly complex supply chain structures. Within this context, Business Intelligence (BI) is increasingly recognized as a capability that allows logistics organizations to convert operational data into timely, actionable knowledge. Despite the growing interest in BI adoption, the internal and external factors that determine its successful implementation, particularly within a logistics-specific setting, remain insufficiently understood, which constitutes the rationale for the present study.

This study aims to identify and assess the internal and external factors influencing the adoption of BI in the logistics sector, and to determine the strategic direction indicated by their interaction, using a weighted SWOT/TOWS methodology. The qualitative research design combining a literature review with an empirical survey among 30 logistics professionals was applied, with results processed through a weighted SWOT/TOWS analysis. Compared with existing, largely descriptive studies on BI adoption, the present analysis introduces a quantified weighting mechanism into the SWOT/TOWS framework applied specifically to a Logistics 4.0 context, which underlines the novelty of the results presented. The following section reviews the current state of the research field concerning BI adoption in logistics and positions this study within it.

1.1. Selected issues of BI adoption

In recent years, the logistics sector has undergone a profound transformation driven by rapid technological development (Vicente et al., 2024). The globalization of supply chains combined with rising customer expectations influence overall design of those (Golabek et al., 2021). The era of linear, stable logistics operations has given way to highly dynamic, data-intensive networks, where timely, accurate, and informed decision making has become a key factor in determining the competitive advantage (Kozhamkulova et al., 2024). Research conducted by Kozhamkulova et al. (2024) reveals that advanced decision-making processes within logistics supply chains can be supported by Intellectual Decision-Making System (IDMS). Such approach can be incorporated within existing Logistic Business Process Management System (LBPSMS). Research emphasizes profound impact of IDMS on decision making process within supply chains. In this context, Business Intelligence (BI) solutions are becoming strategic tools that enable logistics organizations not only to monitor and control operational processes, but also to predict, optimize, and automate them in increasingly complex environments (Iliashenko et al., 2022). Research conducted by Pancić et al. (2023) presents that the Business Intelligence has a direct and major influence on firm performance. Moreover, research by (Pancić et al., 2023) proved that the adoption of big data analytics and blockchain

technology signified and positively mediated the relationship between business intelligence and firm performance.

The role of Business Intelligence (BI) is to fill the gap between raw data and decision-making process (Bolsunovskaya et al., 2023). BI tools enable organizations to transform data into structured knowledge through KPI dashboards, visualizations, data modelling, predictive forecasting, and prescriptive optimization. Their application is no longer limited to the highest management level. According to research conducted by Srikanth research (Srikanth Yerra, 2025) one from the BI solutions which is Microsoft Power BI connects with databases such as SQL Server and cloud platforms like Microsoft Azure, allowing businesses to track inventory levels, predict demand, and streamline warehouse operations using interactive BI dashboards. These technologies are increasingly being implemented in everyday logistics processes, providing planners, dispatchers, warehouse managers, and transport coordinator with real time and accurate information (Srikanth Yerra, 2025).

BI tools are conditioned by logistics process data availability. The quality of data provided for creation of BI dashboards and further analysis is also essential fac-tor (Sorour, Atkins, 2024). The inclusion of BI tools in the decision-making process requires continuous efforts to increase the degree of digitization of processes within the supply chain (Mesa et al., 2022). The study of low-code and no-code platforms has shown that there are many tools on the market that allow users to quickly create applications without using code or with its minimal use. Thanks to this, users without programming skills can create their own solutions and streamline their business processes (Domański et al., 2023). The digitization of supply chains has a positive impact on decision-making based on iterative simulations. Optimization of liquid transport services using ArcGIS tools has shown that data availability and appropriate aggregation is an essential condition (Dubisz et al., 2025). Research conducted by Adamczak et al. (2025) indicates that improvement of process parameterization and inclusion of data exploited within the Internet of Things (IoT) network allows not only for better decision-making, but also for the mitigation of the carbon footprint of logistics processes. Structured and aggregated data can feed dashboards of KPIs supported by BI tools.

Current research trends emphasize the significant role of BI tools in the decision-making process. Continuous improvement of the degree of digitization of logistics processes is important to enable the adoption of advanced BI solutions. Therefore, it allows for visualization and dynamic determination of KPIs that are crucial from perspective of decision-making process.

However, the adoption of Business Intelligence solutions is not just a technological process. It is a profound, organizational transformation that affects data management, employee competencies, operational culture, and strategic planning. It requires organizations to rethink how they collect, store, share, and interpret information. Effective BI adoption requires not only technical infrastructure, but also the development of analytical maturity which is a transition from descriptive reporting to diagnostic, predictive, and prescriptive functions.

The analysis of research data confirms that Business Intelligence systems are becoming a critical element of digital transformation in transport and logistics enterprises. Drawing on the case study by (Vicente et al., 2024) and the qualitative findings presented in this research, the results consistently demonstrate that BI tools significantly influence operational efficiency, strategic decision-making, and competitive advantage within Logistics 4.0 environments.

In the Portuguese logistics operator examined by (Vicente et al., 2024), sixty-one experts from five departments, including logistics, transport, finance, innovation, and central services, participated in two Delphi rounds. The consensus results revealed that BI is perceived as a key strategic asset when aligned with the company's goals and management priorities. Top management support and employee engagement were identified as decisive factors for successful BI adoption. Respondents emphasized the need for investment in data infrastructure and user training to optimize BI use. BI adoption has led to improved data transparency, process monitoring, and decision speed, particularly in logistics operations such as transport scheduling and warehouse control. Leadership commitment to innovation was found essential for sustaining BI-driven competitiveness. The findings confirm that BI contributes to more accurate performance tracking, cost reduction, and greater operational agility.

At the operational level, BI tools facilitate real-time visibility across supply chain processes, optimization of route planning and resource allocation, reduction of delays, stockouts, and excess inventory, as well as improved coordination with suppliers and customers through shared analytics platforms (Jafari et al., 2023). At the strategic level, BI enables scenario modelling and risk forecasting, data-driven decision-making that reduces uncertainty, integration of performance information into long-term planning, and support for innovation and strategic agility (Jafari et al., 2023). Respondents also reported faster decision cycles and higher confidence in analytical outcomes, echoing (Jafari et al., 2023), who found that BI has the greatest positive impact on supply chain integration and agility.

Despite these benefits, several limitations were observed. Among the most significant challenges observed by Iliashenko et al. (2022) were technological barriers, including data fragmentation and incompatibility among legacy systems; financial constraints, as BI adoption often requires significant investment; hu-man and organizational challenges, such as lack of analytical skills and cultural resistance to data-driven practices; and security and privacy concerns, particularly regarding sensitive logistics and customer data. These challenges are consistent with the barriers noted by Iliashenko et al. (2022) and the SWOT analysis within this research, which underlines that cultural adaptation and continuous user training are as critical as the technology itself.

1.2. Research Gap and Research Questions

Research conducted by (Muniswamaiah et al., 2019) proves that data analytics and Business Intelligence (BI) are essential components of decision support technologies that gather and analyze data for faster and better strategic and operational decision making in an organization.

Organizations with low BI integration reported a Supply Chain Agility Score (SCAS) of 58. This figure increased to 73 at medium BI maturity and peaked at 88 for high integration (Usman, Moinuddin, 2025). This trend aligns with the findings of (Wamba et al., 2017), suggesting that real-time data visibility and advanced forecasting tools significantly enhance supply chain responsiveness and resource reallocation. Despite the increasing usage of BI solutions in logistics, there is still limited insight into how these systems are adopted and used within logistics-specific operational and decision-making context. Existing studies rarely address the distinctive characteristics of logistics operations such as time-critical decisions, complex supply chain coordination, and high process interdependence. Empirical evidence documenting practical experiences with BI adoption in logistics remains partial, especially regarding identifying strengths, weaknesses, opportunities, and threats related to BI adoption in this sector. As a result, there is insufficient understanding of the internal and external factors that influence the effective adoption of BI solutions in logistics companies.

Based on conducted literature research following Research Questions has been outlined:

RQ1: What internal and external factors influence the successful adoption and integration of Business Intelligence tools in logistics operations?

RQ2: What is the recommended strategy for adapting BI solutions in the logistics sector?

2. Methods

2.1. Research Design

The research process initiates with the clarification of the scope, establishing the boundaries of the investigation. This foundational phase operationalizes the study's objectives into two distinct Research Questions (RQs) tailored to the logistics sector:

RQ1 – Identifies the strengths, weaknesses, opportunities, and threats of BI implementation, and explores mitigation strategies for the identified risks.

RQ2 – Determines the most effective strategic approach for adaptation of BI solutions within the logistics sector.

Following the formulation of research questions, the methodology focuses on two concurrent data collection streams which are literature review and qualitative research. The review of existing academic and industry literature was conducted to identify current practices and examples of Business Intelligence (BI) usage and adaptation processes within logistics companies. Additionally, primary data was collected through a dedicated online survey consisting of both closed-ended and open-ended questions, allowing participants to provide structured responses as well as more detailed qualitative insights.

Furthermore, the findings from the primary qualitative research are analyzed and then compared with the findings from the literature review. This step in-volves triangulating empirical data with established theoretical frameworks to validate results and identify gaps or consistencies.

Based on the synthesized results from qualitative research and literature comparison, an analysis is conducted with usage of SWOT. This framework is used to categorize findings into Strengths, Weaknesses, Opportunities and Threats. This analysis supports providing a structured assessment of BI adaptation in the target sector.

The final stage involves definitive conclusions from the SWOT/TOWS analysis and prior findings. These conclusions form the basis for practical recommendations for logistics companies, regarding the adoption and usage of BI solutions. To visualize the logic behind this research, Figure 1 presents further research steps covered within this paper.

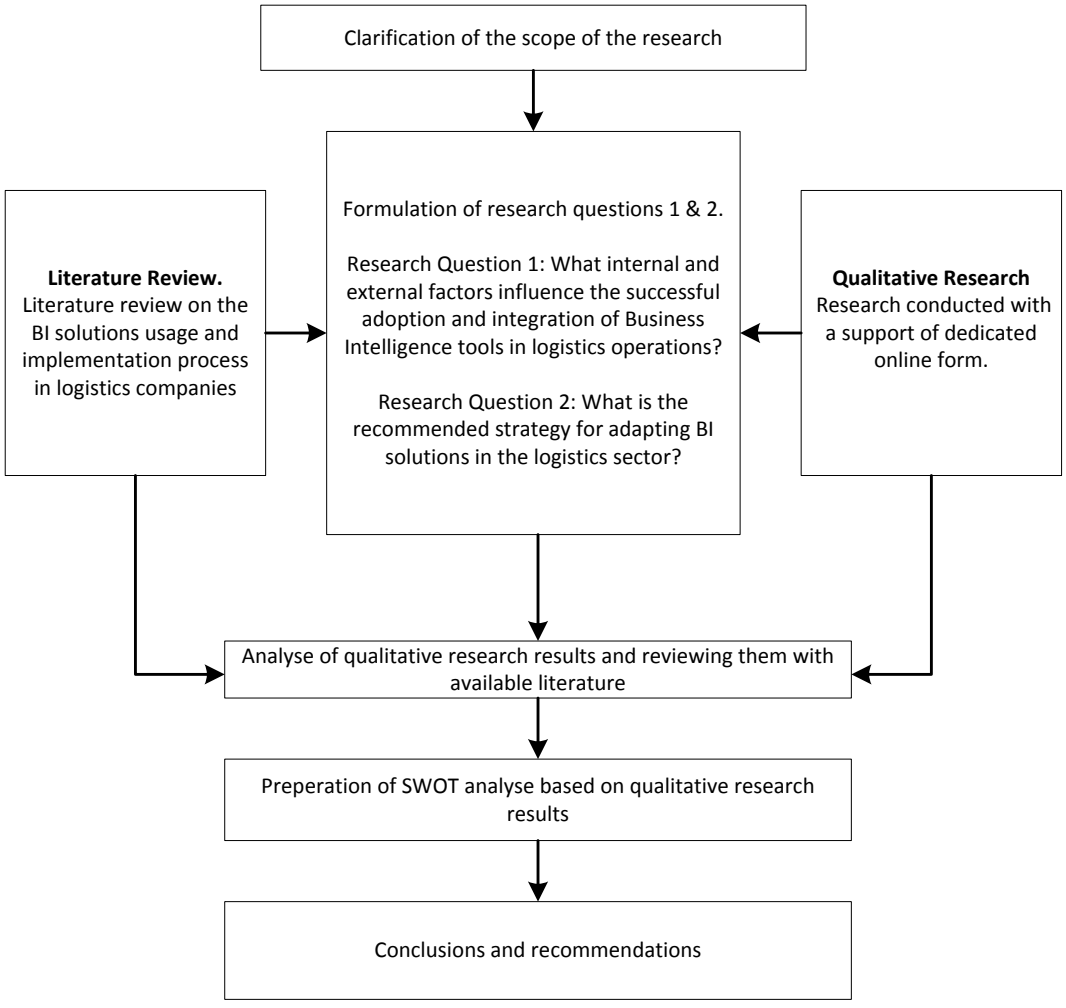


Figure 1. Research methodology.

Source: own elaboration.

The methodological steps presented in Figure 1 were systematically applied throughout the empirical phase of the study. After formulating the research questions and reviewing the relevant literature, the empirical study began with the development of a qualitative questionnaire designed to collect primary data consistent with the study's objectives. The questionnaire was then distributed to selected participants, and the collected responses formed the basis for subsequent stages of data analysis and interpretation, as described in the following sections.

2.2. Data Collection and Data Analysis

As stated in Research Methodology section, this study employed a qualitative research approach to explore the adoption, usage, and impact of Business Intelligence (BI) solutions in logistics companies. Qualitative research was selected as the most appropriate approach due to the exploratory nature of the study and the need to obtain in-depth insights into complex organizational processes, operational challenges, and decision-making practices. The analysis has been further parameterized to determine the significance of the responses obtained. Therefore, a Likert scale has been employed in the evaluation of the results. Research conducted by Tu (2018) indicates a high degree of applicability of the Likert scale in analyzing quantitative research results in the field of Internet of Things (IoT) adaptability within supply chains. The extensive application of this scale in research validates the results obtained.

This approach allowed respondents to participate at their convenience and provide thoughtful, reflective answers (Chambers, 1997). Electronic interviews produced rich textual data suitable for rigorous qualitative analysis and enabled inclusion of geographically dispersed professionals from multiple logistics companies. The qualitative design captured participants' responses while accounting for geography, group structure, and economic sector.

The research was conducted among 30 representatives of various logistics companies. Table 1 shows the size of the companies from which the experts came. Approximately 43% of the experts came from large enterprises with more than 250 employees.

Table 1.
Distribution of responses categorized by size of the company

Size of the company	Number of survey participants
Micro enterprise (less than 10 employees)	0
Small enterprise (from 10 to 49 employees)	10
Medium enterprise (from 50 to 249 employees)	7
Large enterprise (more than 250 employees)	13

Source: Authors' own work.

The research covered employees of companies whose activities are based on logistics operations. These were companies involved in warehousing, goods transport, and e-commerce. Research participants represented logistic oriented companies of various scopes of operation. Summary of the expert's logistics company types were transportation companies, warehousing oriented companies, supply replenishment companies. All of those operate as Third Party Logistics (3PL) services suppliers.

The data collection tool used in this study allowed research participants to choose one of four preset answers and add free-text explanations, which encouraged elaboration on individual experiences, operational examples. To ensure a structured and systematic analysis, participants were categorized according to their level of knowledge and experience with BI solutions. This categorization was designed to provide context for interpreting responses and to allow comparison of perspectives across all levels of experts. Definition of each expert group is presented in Table 2.

Table 2.
Explanation of the participants' process awareness

Process awareness of participants involved in research	Description
No knowledge of BI solutions	Respondents with no prior exposure to or familiarity with BI tools or concepts. Answers and comments of participants from this group were not included in further analyses.
Incomplete knowledge	Individuals with fragmentary or superficial understanding of BI, often informed by general impressions or indirect experiences. Answers and comments of participants from this group were not included in further analyses.
Basic knowledge	Participants familiar with fundamental BI functions and capabilities but lacking extensive experience in practical application. Answers and comments of participants from this group were not included in further analyses.
Extended knowledge and skills	Respondents with comprehensive understanding and hands-on experience using BI solutions. Insights from this group illuminated advanced operational applications, process optimizations, and organizational impacts.
Expert level knowledge and skills	Specialists proficient in BI tools, methodologies, and adoption strategies, capable of providing deep technical insights and strategic perspectives. This group's responses were particularly valuable in identifying advanced analytics opportunities, integration strategies, and organizational best practices.

Source: Authors' own work.

The purpose of conducting the categorization was to identify the most experienced participants, whose responses possess the highest substantive value. Additionally, the categorization aimed to distinguish less experienced experts, to as-sign lower analytical significance to their responses in the SWOT analysis. The process also enabled the determination of the structure of the group participating in the study and provided insights into the overall level of familiarity with Busi-ness Intelligence (BI) tools among employees of the enterprises. Figure 2 represents the structure of experts involved in this qualitative research. Breakdown of expert's structure refers to their knowledge level.

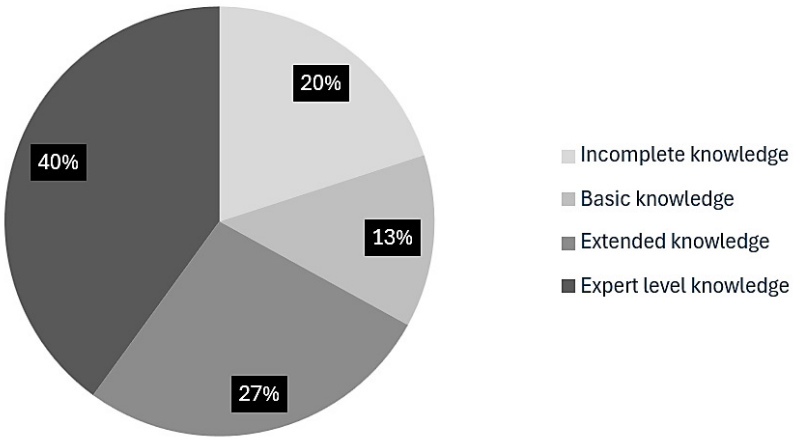


Figure 2. Respondents' level of knowledge about Business Intelligence solutions.

Source: Authors' own work.

20 respondents, representing 67% of qualitive research participants, had expert or advanced knowledge of BI. Their responses were considered in further conclusions and in the preparation of the SWOT analysis. A total of 30 respondents from companies operating in the logistics industry with varying levels of BI solution utilization took part in the survey. Table 3 presents the numerical distribution of participants' knowledge in the field of BI.

Table 3.
Distribution of responses categorized by level knowledge

BI knowledge level	Number of survey participants
No knowledge	0
Incomplete knowledge	6
Basic knowledge	4
Extended knowledge	8
Expert level knowledge	12

Source: Authors' own work.

The study involved a series of steps. A preliminary set of questions was created and adapted for further qualitative research. A crucial element was the selection of study participants. It was important that their responses reflected their aware-ness, knowledge, and use of BI tools in logistics. The data from the responses was then collected and subjected to thorough analysis. The results were used in the section containing the conclusions. Figure 3 presents detailed framework of the research below.

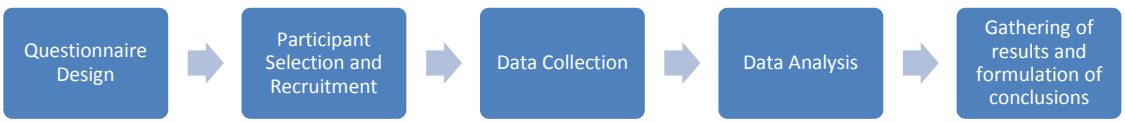


Figure 3. Qualitative research framework.

Source: Authors' own work.

Questionnaire Design – The questionnaire was developed based on a thorough review of the literature on BI in logistics and preliminary consultations with subject-matter experts. Questions were designed to explore three key dimensions: operational usage, decision-making impacts, and barriers/challenges to adoption.

Participant Selection and Recruitment – Respondents were recruited from large logistics companies known to implement or explore BI solutions. Selection criteria emphasized diversity in organizational size, operational scope, and respondent roles to capture a broad range of experiences.

Data Collection – Participants were invited to complete the electronically assisted questionnaire at their convenience, allowing ample time for reflection. Responses were collected in textual form, enabling detailed qualitative coding and thematic analysis.

Data Analysis – Responses were analyzed using thematic analysis, a systematic approach to identifying, analyzing, and reporting patterns within qualitative data. The analysis involved coding textual data, grouping codes into categories, and synthesizing them into broader themes related to BI usage, benefits, challenges, and best practices. Special attention was given to cross-group comparisons to explore how perceptions and experiences varied by respondent expertise.

To ensure methodological transparency and analytical consistency, the qualitative responses collected from selected participants of the interview were analyzed using a structured thematic approach. The coding process was designed to identify patterns in expert opinions regarding the adoption, impact, and challenges of BI solutions within logistics organizations.

The coding framework was developed through a hybrid inductive/deductive approach described in more detail by (Naeem et al., 2023). First of all, broad analytical categories were derived from the research questions, literature review, and open-ended answers of interview participants. These predefined categories served as a basis for structuring the qualitative data. Afterwards, during the analysis of the experts' responses, additional themes and subcategories emerged from the data and were incorporated into the coding structure to better reflect the respondents' perspectives.

The final coding scheme consists of three hierarchical analytical levels:

- Primary analytical dimensions (Level 1) – statements and opinions of experts from categories:
  - General knowledge about BI.
  - User Experience.
  - Benefits and Opportunities.
  - Challenges and Barriers.
  - Future Perspectives.
- Thematic categories (Level 2) – selection of keywords based on statements and opinions of experts' analysis.
- Operational codes and indicators (Level 3) – conversion of keywords into the codes which allowed to assign the results to SWOT matrix.

Table 4 presents a structured coding procedure based on statements and expert quotations, keywords, a summarized code, and the corresponding SWOT category.

Strengths (S) highlighted the benefits and internal capabilities of BI adoption, s uch as improved decision making (S1), operational efficiency (S2), wide BI applications (S3), high employee BI knowledge (S4), and improved internal data quality (S5).

Weaknesses (W) identified internal challenges and limitations, including uneven BI expertise across departments (W1), operational efficiency (W2), data sharing barriers due to system fragmentation (W3), limited use of advanced analytics (W4), and the lack of a consistent BI strategy (W5).

Opportunities (O) focus on potential areas for growth and enhancement, such as integrating BI with automation technologies to streamline logistics operations (O1), gaining competitive advantage through effective BI use (O2), establishing an integrated data environment (O3), developing predictive analytics and AI capabilities (O4), and strengthening employee BI skills through training pro-grams (O5).

Threats (T) address external risks and organizational constraints, including technology volatility requiring continuous system updates (T1), cultural resistance to data-driven decision-making (T2), high implementation costs (T3), the risk of incorrect decision-making from data misinterpretation (T4), and data security concerns arising from increased reliance on analytics (T5).

Table 4.
Structure coding procedure

Statement/Expert quotation	Keywords	Code	SWOT category
"Thanks to BI dashboards we can monitor logistics performance almost in real time, which improves strategic planning and operational decision-making"	BI dashboards, real time, strategic planning, operational decision-making	Improved decision-making	S1
"Using BI reports helped us identify bottlenecks in transport planning and warehouse operations"	BI reports, identify bottlenecks, transport planning, warehouse operations	Operational efficiency	S2
"BI tools support many logistics activities, including demand forecasting, route optimization and warehouse analysis"	BI tools, demand forecasting, route optimization, warehouse analysis	Wide BI applications	S3
"Many employees are familiar with BI platforms and can independently analyze operational data"	employees, BI platforms, independently analyze, operational data	High BI knowledge	S4
"The availability and quality of internal logistics data has improved in recent years"	availability, quality, internal logistics data	Improved internal data quality	S5
"The level of BI knowledge varies across departments (some teams use it actively while others struggle with dashboards)"	BI knowledge, varies across departments, struggle with dashboards	Uneven BI expertise	W1
"BI tools are implemented only in selected areas of the organization, which limits the overall benefits"	BI tools, selected areas of the organization, limits the overall benefits	Incomplete BI adoption	W2

Cont. table 4.

"Data sharing between logistics units is sometimes problematic due to system fragmentation"	Data sharing, logistics units, system fragmentation	Data sharing barriers	W3
"Most analyses focus on basic reporting rather than predictive or advanced analytics"	basic reporting, predictive, advanced analytics	Limited advanced analytics	W4
"Different departments implement BI solutions independently because of not consistent BI strategy"	departments, independently, lack of a consistent BI strategy	Lack of BI implementation strategy	W5
"Combining BI with automation technologies could improve logistics operations"	BI, automation technologies, improve logistics operations	Logistics process automation	O1
"Organizations that effectively use BI gain a clear competitive advantage in the logistics market"	use BI, competitive advantage, logistics market	Increased competitiveness	O2
"Integrating data from multiple systems and external sources would improve logistics analytics"	Integrating data, multiple systems, external sources	Integrated data environment	O3
"Predictive analytics and AI could support demand forecasting and improve logistics planning"	Predictive analytics, AI, demand forecasting, logistics planning	Development of predictive analytics	O4
"Training programs could improve employees' ability to use BI tools effectively"	Training programs, employees, BI tools	BI skills development	O5
"The rapid pace of technological change means BI systems must be continuously updated"	technological change, BI systems, continuously updated	Technology volatility	T1
"Some employees resist shifting toward a data-driven decision-making culture"	employees, resist, data-driven decision-making culture	Cultural resistance	T2
"Adaptation of BI solution requires financial resources"	Adaptation, BI solution, financial resources	High BI adaptation cost	T3
"If users misinterpret the data, BI reports may lead to incorrect managerial decisions"	misinterpret the data, BI reports, incorrect managerial decisions	Risk of incorrect interpretation	T4
"Increasing reliance on data analytics also increases concerns related to cybersecurity and data protection"	data analytics, cybersecurity, data protection	Data security risks	T5

Source: Authors' own work.

Results of the response analysis were incorporated into SWOT matrix. Below Table 5 shows experts' answers categorization for each category. It was further supplemented with the actual weight of each parameter decided by answers from experts in the survey. The weight assigned to each parameter within a given SWOT category was calculated as the relative share of expert responses coded to that specific factor, expressed as the number of responses assigned to the factor divided by the total number of responses classified within the same category. This normalization procedure ensured that the weights within each category summed to 1.00 and reflected the relative importance experts attributed to each identified strength, weakness, opportunity, and threat.

Table 5.
SWOT matrix of BI adoption in logistics based on expert responses

	Strengths	Weight		Weaknesses	Weight
S1	Improvement of strategic and operational decision-making processes	0.30	**W1**	Uneven level of BI expertise	0.45
S2	Increased operational efficiency	0.20	**W2**	Partial/incomplete adoptions within the organization	0.10
S3	Wide range of BI applications in logistics	0.10	**W3**	Potential data sharing issues	0.10
S4	High level of BI knowledge among logistics company employees	0.30	**W4**	Limited use of advanced analytics	0.10
S5	Enhanced quality and availability of internal data	0.10	**W5**	Lack of a consistent strategy for implementing BI across the organization	0.25
	Sum	1.00		Sum	1.00
	Opportunities	**weight**		**Threats**	**Weight**
O1	Automation of logistics processes	0.30	**T1**	Technology volatility	0.20
O2	Increased competitiveness using BI	0.35	**T2**	Organizational resistance to changing work culture	0.30
O3	Integration of data from multiple sources	0.10	**T3**	Costs of implementing comprehensive BI solutions	0.15
O4	Development of predictive analytics and AI	0.10	**T4**	Risk of misinterpreting data	0.15
O5	Education and development of employee competencies	0.15	**T5**	Data security	0.20
	Sum	1.00		Sum	1.00

Source: Authors' own work.

The following research involved a thorough analysis of the experts' responses. Table 6 analyzes interactions connected to strengths and opportunities. For each parameter indicated by the experts, a value of '1' was assigned to indicate mutual interdependences. In the case of no interdependence identified, a value of '0' was selected. For each parameter, the number of interactions was calculated, and their number was referred to the defined weights. As a result, the coefficient of weight and interaction was determined for the expert's parameters identified as strengths and opportunities.

Table 6.
Strengths and Opportunities parameter coefficient of weight and interaction calculation

Strengths / Opportunities	O1	O2	O3	O4	O5	Weight	Number of interactions	Weight and interaction product	Rank
S1	1	1	1	1	1	0,30	5	1,50	1
S2	1	1	0	1	0	0,20	3	0,60	3
S3	1	1	1	1	1	0,10	5	0,50	4
S4	0	1	1	1	1	0,30	4	1,20	2
S5	1	1	1	1	1	0,10	5	0,50	4
Weight	0,30	0,35	0,10	0,10	0,15				
Number of interactions	4	5	4	5	4				
Weight and interaction product	1,20	1,75	0,40	0,50	0,60				

Cont. table 6.

Rank	2	1	5	4	3				
Total interactions							**22**		
Sum of products								**4,30**	

Source: Authors' own work.

Subsequent calculation was made for Strengths and Threats parameters identified during the research. Detailed information has been presented in the following Table 7. It has been observed that coefficient shows a higher value compared with S/O parameters comparison.

Table 7.
Strengths and Threats parameter coefficient of weight and interaction calculation

Strengths / Threats	T1	T2	T3	T4	T5	Weight	Number of interactions	Weight and interaction product	Rank
S1	1	1	0	1	1	0,30	4	1,20	2
S2	0	1	1	1	1	0,20	4	0,80	3
S3	1	1	1	1	1	0,10	5	0,50	4
S4	1	1	1	1	1	0,30	5	1,50	1
S5	1	1	1	1	1	0,10	5	0,50	4
Weight	0,20	0,30	0,15	0,15	0,20				
Number of interactions	4	5	4	5	5				
Weight and interaction product	0,80	1,50	0,60	0,75	1,00				
Rank	3	1	5	4	2				
Total interactions							**23**		
Sum of products								**4,50**	

Source: Authors' own work.

Table 8 presents the results of the comparison between weaknesses and opportunities identified in the research. The calculated coefficients made it possible to rank the weaknesses according to how strongly they interact with the opportunities.

This ranking shows which weaknesses have the greatest impact with the identified opportunities. The total number of interactions shown in the table is higher than in previous comparisons which shows stronger correlation between the analysed parameters.

Table 8.
Weaknesses and Opportunities parameter coefficient of weight and interaction calculation

Weaknesses / Opportunities	O1	O2	O3	O4	O5	Weight	Number of interactions	Weight and interaction product	Rank
W1	1	0	0	1	1	0,45	3	1,35	1
W2	1	1	1	1	1	0,10	5	0,50	3
W3	0	1	1	1	0	0,10	3	0,30	5
W4	0	1	1	1	1	0,10	4	0,40	4
W5	1	1	1	1	1	0,25	5	1,25	2
Weight	0,30	0,35	0,10	0,10	0,15				
Number of interactions	3	4	4	5	4				

Cont. table 8.

Weight and interaction product	0,90	1,40	0,40	0,50	0,60				
Rank	2	1	5	4	3				
Total interactions							**20**		
Sum of products								**3,80**	

Source: Authors' own work.

Table 9 presents the comparison between weakness and threats identified during the research. The obtained results made it possible to rank the weaknesses according to their level of interaction with the threats. This ranking shows which weaknesses have the strongest influence in relation to the identified threats. The overall number of interactions is the higher compared to previous comparisons, which suggests a strong level of interdependence between the analyzed parameters.

Table 9.
Weaknesses and Threats parameter coefficient of weight and interaction calculation

Weaknesses / Threats	**T1**	**T2**	**T3**	**T4**	**T5**	**Weight**	**Number of interactions**	**Weight and interaction product**	**Rank**
W1	1	1	1	1	1	0,45	5	2,25	1
W2	1	1	1	1	1	0,10	5	0,50	3
W3	1	1	1	1	1	0,10	5	0,50	3
W4	0	1	1	1	1	0,10	4	0,40	4
W5	1	1	1	1	1	0,25	5	1,25	2
Weight	0,20	0,30	0,15	0,15	0,20				
Number of interactions	4	5	5	5	5				
Weight and interaction product	0,80	1,50	0,75	0,75	1,00				
Rank	3	1	4	4	2				
Total interactions							**24**		
Sum of products								**4,90**	

Source: Authors' own work.

In order to ensure analytical consistency, the interactions identified within the TOWS framework were examined using a methodological approach analogous to that applied in the SWOT analysis. Specifically, pairwise relationships between internal and external factors were systematically evaluated to determine both the frequency and the weighted significance of their interactions. The resulting syn-thesis, presented in Table 10, provides a structured comparison across four strategic archetypes: aggressive (SO), competitive (WO), conservative (ST), and defensive (WT).

Table 10.
Selecting a strategy based on the analysis results

	Opportunities (O)	**Threats (T)**
Strengths (S)	Aggressive Strategy	Conservative Strategy
Total interactions	38	37
Sum of products	8,00	7,30
Weaknesses (W)	Competitive Strategy	**Defensive Strategy**
Total interactions	32	**43**
Sum of products	6,30	**8,60**

Source: Authors' own work.

The collected information was analyzed in the subsequent part of the study. Further conclusions were drawn based on SWOT/TOWS analysis. The coefficient of weight and interaction calculated for each category of parameters allowed for the identification of the conditions for the use of BI tools. Capturing the practical perspective of experts from logistics sector is essential to ensure the relevance and usability of the research results.

3. Results and Discussion

The defensive strategy received the highest score, showing that most logistics companies currently operate in an environment with many external threats and internal challenges. This means that companies are focused on stability, reducing risks and improving efficiency rather than seeking aggressive strategy of implementation.

Experts pointed out that defensive strategy reflects the current stage of BI development in logistics. Many organizations use BI mostly for monitoring, reporting, and improving internal visibility rather than for advanced predictive analytics. Despite this cautious approach, the results show that the use of Power BI tools already helps companies make better decisions, improve process transparency, and reduce errors in daily basic operations.

Across all participating companies, BI was identified as a standard component of management and operational practice. However, the depth of BI integration varied: most organizations used descriptive and diagnostic analytics, such as standard dashboards and key performance indicators, while only a limited number implemented predictive and prescriptive analytics powered by artificial intelligence or machine learning.

The dominance of the defensive approach suggests an important level of adaptation of BI solutions in supply chains that value stability and control. It also shows that companies are preparing solid analytical foundations for future growth when market conditions become more favorable.

Results of the research confirm that Business Intelligence provides tangible operational and strategic benefits, while it is full potential, will be realized through deeper digital integration, enhanced analytical maturity, and sustained organizational commitment to data-driven transformation.

These results directly address the research questions. The set of strength, weakness, opportunity, and threat factors identified and weighted in Table 5 answers RQ1, providing a structured picture of the internal and external factors that influence BI adoption in logistics operations. The clear dominance of the defensive strategy in the SWOT/TOWS analysis answers RQ2, indicating that a cautious, stability-oriented approach is the strategy currently recommended for BI adoption in the logistics sector.

4. Summary

The research confirms that the defensive approach is the primary strategic recommendation for the sector regarding the implementation and use of BI solutions. While this strategy also focuses on caution and stability, it also creates real potential for building a new form of competitive advantage in the future.

Results of qualitative research show that BI tools play a key role by allowing organizations to visualize data, monitor logistics processes in real time and make faster operational and strategic decisions. The research also identified that the main barriers to BI adoption are uneven knowledge levels, excessive costs, and challenges in data integration. These barriers can be overcome through systematic training and consistent digital strategies.

In the long term, defensive orientation can be transformed into a strategic advantage. By continuously improving their analytical proficiency and digital tools, logistics companies can turn operational stability into a strong and lasting competitive advantage.

In addition to the strategic conclusions presented above, several limitations of this study should be acknowledged. The most significant limitations of the research conducted include the territorial coverage of the experts. Nevertheless, increasing the number of experts participating in the research might increase the overall quality of the results and have a positive impact on the conclusions.

Because of the reason that data is sourced from experts representing different logistics companies, the results reflect a variety of organizational realities. Some of the assumptions might appear to contradict one another, however they highlight two different sides of same case, and their coexistence is a direct result of the diverse panel of experts consulted for analysis prepared in this study.

This study was conducted among experts from the logistics industry in Poland. However, identifying a broader European perspective and conducting the survey among experts from Western Europe is also essential for further research. Appropriately conducted research will allow to cover not only the local Polish context, but the entire European context, which will increase the value of the obtained results. It could also be relevant to assess the perspective of experts from other sectors of the economy.

Acknowledgements

This work was supported by the Poznan University of Technology, Faculty of Engineering Management, under project No. 0812/SBAD/4237.

References

1. Adamczak, M., Toboła-Walaszczyk, A., Cyplik, P. (2025). Using IoT Solutions in Car Sharing to Reduce CO2 Emissions. *IFAC-PapersOnLine, 59(10),* 1361-1365. https://doi.org/10.1016/j.ifacol.2025.09.229
2. Bolsunovskaya, M., Shirokova, S., Budkin, A., Leksashov, A., Shirokova, A. (2023). BI Application Development and Their Use for Logistics, Transport and Service Companies. In: A. Guda (Ed.), *Networked Control Systems for Connected and Automated Vehicles, Vol. 509* (pp. 1395-1405). Springer International Publishing. https://doi.org/10.1007/978-3-031-11058-0_141
3. Domański, R., Wojciechowski, H., Lewandowicz, J., Hadaś, Ł. (2023). Digitalization of Management Processes in Small and Medium-Sized Enterprises—An Overview of Low-Code and No-Code Platforms. *Applied Sciences, 13(24),* 13078. https://doi.org/10.3390/app132413078
4. Dubisz, D., Boonmee, C., Rokicki, R., Golińska-Dawson, P. (2025). Iterative Simulations Supported by GIS-Class Tools Based on a Supply Chain for Liquid Products. In: A. Kolinski, M. Adamczak (Eds.), *Digitalisation of the Greening Supply Chain* (pp. 97-116). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-88918-9_5
5. Golabek, L., Stokłosa, J., Dziwulski, J., & Wyrwisz, J. (2021). Optimization of Logistics and Distribution of the Supply Chain, Taking into Account Transport Costs, In-ventory and Customer Demand. *European Research Studies Journal, XXIV(Special Issue 2),* 545-556. https://doi.org/10.35808/ersj/2284

6. Iliashenko, V., Ilin, I., Schuur, P., Gerrits, B., Kalyazina, S., Esser, M. (2022). Business Intelligence Systems Application in Transport and Logistics Companies. In: A. Beskopylny, M. Shamtsyan (Eds.), *XIV International Scientific Conference "INTERAGROMASH 2021", Vol. 246* (pp. 457-465). Springer International Publishing. https://doi.org/10.1007/978-3-030-81619-3_52
7. Kozhamkulova, Z., Kuntunova, L., Amanzholova, S., Bizhanova, A., Vorogushina, M., Kuparova, A., Maikotov, M., Nurlybayeva, E. (2024). Development of Intellectual Decision Making System for Logistic Business Process Management. *International Journal of Advanced Computer Science and Applications, 15(1).* https://doi.org/10.14569/IJACSA.2024.0150186
8. Mesa, D., Renda, G., Iii, R.G., Kuys, B., Cook, S.M. (2022). Implementing a Design Thinking Approach to De-Risk the Digitalisation of Manufacturing SMEs. *Sustainability, 14(21)*, 14358. https://doi.org/10.3390/su142114358
9. Muniswamaiah, M., Agerwala, T., Tappert, C. (2019). Data Virtualization for Decision Making in Big Data. *International Journal of Software Engineering & Applications, 10(5),* 45-53. https://doi.org/10.5121/ijsea.2019.10503
10. Naeem, M., Ozuem, W., Howell, K., Ranfagni, S. (2023). A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research. *International Journal of Qualitative Methods, 22,* 16094069231205789. https://doi.org/10.1177/16094069231205789
11. Pancić, M., Ćućić, D., Serdarušić, H. (2023). Business Intelligence (BI) in Firm Performance: Role of Big Data Analytics and Blockchain Technology. *Economies, 11(3),* 99. https://doi.org/10.3390/economies11030099
12. Sorour, A., Atkins, A.S. (2024). Big data challenge for monitoring quality in higher education institutions using business intelligence dashboards. *Journal of Electronic Science and Technology, 22(1),* 100233. https://doi.org/10.1016/j.jnlest.2024.100233
13. Srikanth Yerra. (2025). Enhancing Inventory Management through Real-Time Power BI Dashboards and KPI Tracking. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 11(2),* 944-951. https://doi.org/10.32628/CSEIT25112458
14. Usman, M., Moinuddin, M. (2025). From Data to Decisions: Leveraging Business Intelligence for Supply Chain and Marketing Success. *American Journal of Business, Commerce and Economics, 6(4),* 15-34. https://doi.org/10.71465/ajbce2907
15. Vicente, J.J., Neves, L., Bernardo, I. (2024). The potential of Logistics 4.0 technologies: A case study through business intelligence framing by applying the Delphi meth-od. *Frontiers in Artificial Intelligence, 7*, 1469958. https://doi.org/10.3389/frai.2024.1469958
16. Wamba, S.F., Gunasekaran, A., Akter, S., Ren, S.J., Dubey, R., Childe, S.J. (2017). Big data analytics and firm performance: Effects of dynamic capabilities. *Journal of Business Research, 70*, 356-365. https://doi.org/10.1016/j.jbusres.2016.08.009

SILESIAN UNIVERSITY OF TECHNOLOGYPUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIESNO. 253

HYBRID AESTHETICS IN CONTEMPORARY CRAFTS – CULTURAL NARRATIVE IN SUSTAINABLE DEVELOPMENT

Katarzyna MAZUR-WŁODARCZYK[1*], Katarzyna ŁUKANISZYN-DOMASZEWSKA[2]

[1] Opole University of Technology; k.mazur-wlodarczyk@po.edu.pl, ORCID: 0000-0002-4822-9328
[2] Opole University of Technology; k.lukaniszyn-domaszewska@po.edu.pl, ORCID: 0000-0002-2165-5095
* Correspondence author

Purpose: Traditional crafts have long served as an essential foundation for social capital, economic resilience, and local identity; however, the ongoing transformation of craft processes necessitates a re-evaluation of their aesthetic and functional boundaries. This article explores the phenomenon of hybrid aesthetics in contemporary craftsmanship and its role in fostering cultural narratives within the framework of sustainable development. The research aims to demonstrate how hybridization acts as a bridge between heritage and innovation, reinforcing the strategic role of craftsmanship in building a sustainable, culturally rich economic future.
Design/methodology/approach: This study is based on a non-systematic literature review on hybridization and its aesthetics, with a particular focus on cultural and ethnic aspects. The review includes publications in English and Polish available until 2026.
Findings: The hybridization of crafts represents not only a technological shift but also a profound aesthetic and social transformation, combining tradition with innovation in the spirit of sustainable development. Cultural and ethnic components play a key role, strengthening identity and enabling intergenerational transmission of heritage, as do economic strategies based on high value, "slow production", and greater market appeal. At the same time, the development of hybrid crafts requires preserving cultural authenticity to ensure a lasting synergy between technology and tradition.
Originality/value: The authors define "hybridity" in this context as the integration of seemingly disparate elements, including the merging of traditional techniques with modern technologies, the use of renewable raw materials, and the blending of diverse ethnic motifs. By analyzing the shift from purely utilitarian manual labor to a sophisticated fusion of art and industry, the study investigates how these hybrid objects create new sensory experiences.
Keywords: hybrid craft, new technology, hybrid aesthetics, craft heritage, sustainable development, economic culture.
Category of the paper: Research paper.

1. Introduction

Crafts serve many functions in society. They enable interactions between those involved in crafts and those connected to their surroundings. They offer the opportunity to build social capital through collaboration, which in turn builds trust—the foundation of lasting social relationships. Research conducted by Brännkärr et al. (2025) indicates that handicraft classes and the possibility of moving around while working in the studio create conditions for broader discussions, encouraging participants to spend time together outside of classes and thus positively influencing interpersonal interactions. Crafts also fulfill important educational and cultural roles, including sharing knowledge and skills and organizing cultural events. They also create jobs and support local economies. As Kolek notes (2026), crafts also contribute to building economic resilience – the ability to adapt and cope with crisis in technical, social, and economic terms. Crafts are a pillar of economic security, supporting basic production functions in times of global disruption, while craftsmanship constitutes an important strategic resource (Kolek, 2026). In addition to the above, crafts serve both utilitarian and aesthetic purposes. Lufiani et al. (2017) emphasize that crafts can enhance the aesthetics of settlement units and strengthen their identity, and that their presence in public spaces can impact the community. In an environment saturated with art, residents are subject to the process of civilization, and their emotional and spiritual spheres gain subtlety, sensitivity, and the ability to selectively perceive aesthetic values and filter what is good for them (Lufiani et al., 2017).

The aesthetic qualities of artisans' work are linked to contemporary craftsmanship and, therefore, to the transformation that has occurred within the craft process and product. As Ukim (2021) notes, this can be illustrated by the changing perception of craftsmanship relative to art. He details several phases of craftsmanship's development, each related to its intended purpose. Initially, there was no distinction between craftsmanship and art. Creation was aimed at satisfying basic human needs, including solving emerging problems. It required physical skills and involved manual labor. Later, craftsmanship focused on utilitarian purposes, served domestic functions, and was practiced by women. Art, on the other hand, was associated with aesthetic goals. Painters and sculptors (formerly craftsmen) became artists, while other craftsmen and their work were perceived as creative activities of a lower rank than art. In the next stage, following the industrial revolutions (which introduced machines and led to the invention of new tools) and the possibility of training craftsmen in schools, craftsmen in the production sphere began to function as artists, taking aesthetic aspects into account in design and production. Furthermore, they no longer focused solely on implementing local ideas but also opened up to influences and ideas from abroad. Craftsmanship began to be associated with the creation of aesthetic values, and its goals came to be defined as utilitarian and aesthetic, or aesthetic regardless of utilitarian considerations. Despite this, the social perception of craftsmanship as having lower status than art has not yet changed (Ukim, 2021).

In this text, the authors will mainly refer to artistic crafts (including everyday objects with artistic value) produced in craft studios and workshops, in accordance with craftsmen's designs (ZPE, n.d.). The categories i) 'hybrids' and ii) 'hybrid aesthetics' appearing in the title are interpreted as: i) a combination of different, even incompatible elements, e.g., from at least two different languages, genres (Wielki Słownik Języka Polskiego, n.d. a, b), varieties, breeds, or parts (Słownik Języka Polskiego, n.d.); ii) the sensual experience associated with contact with hybrid craft, as well as considering the aesthetic values of hybrid objects created by craftsmen. These objects combine elements of traditional crafts with new solutions, including the materials selected by artisans (e.g., renewable raw materials), the technologies used, and the combination of various cultural elements—e.g., ethnic patterns.

The chosen goal of the research is to analyze hybridization and its aesthetics by focusing on cultural and ethnic narratives in the context of sustainable craft development.

2. Methods

The study is based on a non-systematic literature review that examines hybridization and its aesthetics, with attention to cultural and ethnic aspects. The research stages include outlining the background of issues related to the introduction of new technologies into crafts and the specificity of hybrid crafts, specifying the aesthetic elements of this craft, distinguishing cultural components in the context of sustainable craft development, and specifying conclusions. The literature review includes publications available until 2026, in English and Polish, using the following keywords in the abstracts: craft AND “hybrid aesthetics”. Initially, it was planned to use only the Web of Science and Scopus databases, but only one text met these criteria and was indexed in both. However, this text indirectly alluded to the adopted craft perspective, combining fashion design and experimental cinema (see: D’Souza, 2024). Due to the above, it was also decided to search for texts outside of them using the Google web browser. After selecting the articles, their abstracts were first reviewed, and the next stage included those that discussed aspects of hybrid aesthetics and craft in the broadly understood sense, without regard to the meaning of the word "craft" as applied to aircraft, spacecraft, statecraft, and hovercraft. Two research questions were formulated:

Q1: What cultural and ethnic components in hybrid crafts support sustainable craft development?

Q2: What economic strategies result from the hybridization of crafts in terms of aesthetics and sustainability?

The sources analyzed came from scientific journals and conference monographs, both of which were available as open-access publications. Articles were selected primarily for their relevance to the research questions. The texts were analyzed independently by two researchers, and the resulting findings were synthesized in a descriptive form.

The results section is organized into four parts; however, due to the specificity of the research problem under analysis, the boundaries between them are not always clearly delineated. Consequently, this division should be understood primarily as a structural device intended to facilitate the presentation of the analyzed content.

3. Results

3.1. Outlining the background - craft and new technologies

The relationship between craft and new technologies is sometimes described as both paradoxical—craft presented as the opposite of technology—and stimulating innovation in science, technology, and engineering—craft as an element compatible with technology (Tan et al., 2018). Castelblanco-Pérez (2025) notes that the hybridity of craft carries risks, including appropriation, idealization, and the erasure of original creators. On the other hand, it offers the possibility of reconstructing dispersed cultural heritage, initiating the exchange of ideas, and protecting vanishing knowledge (Castelblanco-Pérez, 2025). Hybridization is a regenerative practice—revitalizing traditional crafts, supporting their continuity and further development through the introduction of new tools, changing contexts, and shifting cultural values. Furthermore, craftsmanship and new technology can also work together to shape form, structure, and aesthetics (Gupta, Shende, 2025). Soledad Duarte Poblete et al. (2024) note that the hybrid approach results from a positive tension between craft and design processes and new technologies, and that experimenting with them favors the development of local, traditional crafts (Soledad Duarte Poblete et al., 2024). Kale et al. (2026) point out that even a well-planned use of new technologies (e.g., artificial intelligence [AI]) In crafts, opportunities exist to bridge the "gap" between tradition and introduced technology, as well as to help preserve cultural values. According to the researchers, the main challenges of its implementation are not technological, but rather management and corporate governance. Especially in small, decentralized craft businesses, new technologies should be introduced in a structured manner to avoid losing cultural values and existing craft values (Kale et al., 2026). Outlining the background – hybrid craft

Hybrid crafts are a relatively new type of craft that combines traditional crafts with elements of applied science. In this case, the result of artisanal work is not always perceived as handmade (Dolabella, Pagnan, 2025). Most often, it is a hybrid of traditional craftsmanship and new technologies. Examples of hybrid crafts include:

- Combining Indian bamboo weaving techniques with 3D-printed PLA mesh, which involves weaving bamboo strips around the shape created by the mesh, bypassing complex assembly processes (Gupta, Shende, 2025).
- Hybrid basketry using 3D printing enables the creation of repeatable products (Zoran, 2013).
- Digital production with ceramic craftsmanship, enabling the restoration of previous works, including connecting damaged elements with a printed grid (Zoran, Leah, 2013).
- 3D-printed ceramics enabling the creation of complex geometries and intricate patterns (including fine details) (Mehrotra, 2025).
- Hybrid ceramics produced traditionally and using digital 3D printing technology (De Castro Lima Dolabella, Salvan Pagnan, 2025).
- Creating smart materials and clothing tailored to changing consumer needs, including aesthetic preferences (Tan et al., 2018).
- 3D printing in jewelry and metalwork for faster prototyping and personalization (Singh et al., 2025).
- Laser cutting in wood carving, enabling the creation of complex and precise patterns (Singh et al., 2025).
- Goldsmithing practices using conductive metals, including the creation of near-skin sensors (Tsaknaki et al., 2015; 2017).
- The use of computational design tools, CNC milling, 3D printing technology, and electronic interaction in works exhibited at the SIGGRAPH 2015 Hybrid Craft exhibition (Zoran, 2015).
- Handcrafted bag production using recycled materials and cross-cultural collaboration (Castelblanco-Pérez, 2025).

The above examples demonstrate the combination of traditional craft techniques with 3D printing (as an extension of craftsmanship), the enhancement of craftsmanship with digital technologies, the possibility of personalization, and material and cultural hybridization.

3.2. Aspects directly related to aesthetics

A hybrid aesthetic approach results from the integration of various techniques, materials, and disciplines, enabling the creation of innovative/artistic works (Aracı, 2025). Aesthetics influences numerous scientific and artistic disciplines; however, digital production practices in engineering are fundamentally different from those used in art, for example, they may focus on a pre-defined goal or be oriented towards exploitation (Torres, 2019).

The analysis identified three aesthetically related categories: ‘digital aesthetics’, ‘virtual aesthetics’, and ‘illumination aesthetics’. Digital aesthetics is evolving as machine learning advances and is applied to the production, evaluation, development, and interpretation of creative works. Data-driven models used in digital creativity enable the learning of visual image patterns, stylistic norms, and aesthetic predispositions. It broadens the scope of aesthetic diversity and accelerates creative exploration. Still, it can also result in the merging and unification of different artistic styles, leading to the homogenization of creativity (Upadhyay et al., 2025). The main characteristic of virtual aesthetics is its current rapid growth. This aesthetic was most visible during the Covid-19 pandemic, when lifestyle and fashion-related aesthetic communities (such as Dark Academia, Cottagecore, Fairycore, Royalcore, and Light Academia) adapted to participants' needs and capabilities (López Millán, 2024). Illumination aesthetics, on the other hand, is an aesthetic based on computer-aided techniques, design, and fabrication that enables manipulation of light properties (Torres, 2018).

The texts examined address aesthetics in a multifaceted yet fragmented manner. Among other things, the opportunities and threats associated with the use of new technologies are in crafts. The hybridization opens new markets for artisans and adds a contemporary dimension. This integration increases production efficiency and fosters innovation. It enables new ways to preserve crafts, including through digital archives, immersive experiences with crafts via augmented and virtual reality, and the implementation of practices consistent with sustainable development principles (e.g., renewable energy sources in craft workshops and environmentally friendly production processes) (Singh et al., 2025). Another advantage noted by Torres (2018) is that hybrid crafts offer the opportunity to expand existing aesthetic repertoires. Challenges associated with integrating new technologies with crafts include: i) insufficient financial resources and skills necessary to implement new technologies, ii) the risk of undermining the authenticity of crafts (Singh et al., 2025), and iii) the threat to the integrity and security of the original aesthetics of crafts associated with streaming data that is easily modified and reproduced (Shan, 2023). According to Aracı (2025), hybrid aesthetics results from the transmission and interaction of cultural values. This researcher emphasizes that the culture being described is not something constant today, but has a hybridizing structure. It is fostered by modernization and globalization (Aracı, 2025).

3.3. Aspects related to the cultural narrative

Across regions and traditions, research shows that crafts link people to place, ancestors, and each other, while also facing strong pressures from modernization and globalization.

Crafts embody local stories, symbols, and pride, conveying narratives through forms, designs, and motifs that express regional culture and cultural identity (Li et al., 2025; Bell et al., 2021; Lyu et al., 2024; Härkönen et al., 2018; Partarakis et al., 2020). Many studies stress crafts as visible expressions of cultural heritage, turning utilitarian objects into emotional expressions of history and worldview (Yang et al., 2018; Bell et al., 2021; Lyu et al., 2024).

In fashion and design, traditional craft processes preserve symbolic meanings and "embedded codes" tied to place and belief, and help avoid superficial cultural appropriation (Brown, Vacca, 2022).

Table 1 presents the diverse cultural roles of craft practices, detailing how these activities function as active mechanisms for social and individual expression. The data synthesized below illustrates that craftsmanship is not merely a technical pursuit but a complex social performance that affirms and reclaims identities, encodes collective memory, and anchors individuals within stable social structures, while bridging traditional heritage with modern innovation and spiritual continuity.

Table 1.
Main cultural roles that crafts play across studies

Cultural role	How crafts enact it	Sources
Identity & pride	They serve as a tangible medium for affirming and reclaiming Indigenous, ethnic, or regional identities, allowing artisans and communities to express their unique heritage and maintain a sense of distinctiveness.	Li et al. (2025), Sydora et al. (2023), Lyu et al. (2024), Härkönen et al. (2018), Yadav, Gopinath (2025)
Storytelling & memory	Craft objects act as physical archives that encode ancestral stories, myths, and oral histories; they also facilitate the processing of collective trauma and the celebration of healing.	Li et al. (2025), Sydora et al. (2023), Härkönen et al. (2018), Liaqat et al. (2023)
Community & belonging	Crafting practices provide a social anchor, integrating individuals into stable networks such as families, professional guilds, and local workshops, fostering mutual support.	Sydora et al. (2023), Ionică (2022), Dhar et al. (2024), Partarakis et al. (2020), Rubin et al. (2024)
Intergenerational transmission	They function as a living classroom where technical mastery is inseparable from the transfer of life lessons, ethical values, and cultural wisdom from elders to youth.	Yang et al. (2018), Sydora et al. (2023), Lyu et al. (2024), Härkönen et al. (2018), Zhang, Sirisuk (2025)
Spiritual connection	The process of making often maintains vital links to the sacred, involving rituals in the harvest of natural materials and objects that bridge the material and spiritual realms.	Yang et al. (2018), Wang et al. (2024), Zhang, Sirisuk (2025)
Hybrid innovation	By merging traditional motifs with contemporary digital tools or sustainable materials, crafts allow communities to adapt their cultural narrative to reflect modern lived realities.	Liaqat et al. (2023), Partarakis et al.(2020), Ukim (2021), Kolek (2026)

Source: own study.

The social dimension of craftsmanship is manifested through intergenerational transmission and community practices. Craft-making is a key conduit for passing knowledge, values, and life lessons between elders and youth, often in family or community settings (Yang et al., 2018; Sydora et al., 2023; Lyu et al., 2024; Härkönen et al., 2018; Zhang, Sirisuk, 2025; Rubin et al., 2024; Wang et al., 2024). Activities like weaving, beading, pottery, song, dance, and storytelling are taught together, linking skills with cultural teachings, identity, and wellness (Sydora et al., 2023; Rubin et al., 2024). Master–apprentice and family systems, often supported by museums, schools, or camps, structure the evolution of intangible cultural heritage across generations (Härkönen et al., 2018; Zhang, Sirisuk, 2025; Rubin et al., 2024; Wang et al., 2024). Another aspect to consider is crafts from the perspective of well-being and social connection.

Participating in traditional crafts builds intergenerational cohesion, cultural connectedness, and healing, especially in Indigenous and Arctic contexts (Sydora et al., 2023; Härkönen et al., 2018; Rubin et al., 2024). Collaborative (including digital) crafting supports social bonding, narrative sharing, and cross-cultural understanding in immigrant and mixed communities (Härkönen et al., 2018; Liaqat et al., 2023). However, it should be noted that industrialization, mass production, modernization, and weakened interest among youth threaten the continuity and authenticity of traditional crafts (Yang et al., 2018; Lyu et al., 2024; Ionică, 2022; Härkönen et al., 2018; Partarakis et al., 2020; Yadav, Gopinath, 2025; Liu, Xu, 2024; Wang et al., 2024). Community-based, educational, and digital strategies (schools, museums, digital representation) are seen as crucial to preserve skills, meanings, and community ties (Yang et al., 2018; Lyu et al., 2024; Ionică, 2022; Dhar et al., 2024; Partarakis et al., 2020; Zabulis et al., 2020). Across regions and traditions, crafts function as dense cultural "texts" that hold identity, memory, spirituality, and social relations. They are central to intergenerational knowledge transfer and community cohesion, while also contributing to wellbeing and sustainable local economies.

4. Summary

The analysis presented in this article underscores that the hybridization of crafts is not merely a technological shift but a profound aesthetic and social evolution. By merging traditional heritage with modern innovations, contemporary craftsmanship establishes a new paradigm for sustainable development that balances innovation with cultural integrity. Based on the investigated research questions, the cultural and ethnic components (Q1) serve as the bedrock for sustainable development, ensuring that hybrid objects remain rooted in their origins and provide a sense of identity and pride (Li et al., 2025; Sydora et al., 2023). Furthermore, the use of craft as a medium for intergenerational transmission allows these cultural narratives to remain dynamic, evolving across contemporary digital and analog forms while preserving the intangible heritage that defines them (Yang et al., 2018; Härkönen et al., 2018).

On the other hand, the strategic economic choices (Q2) shift the sector toward high-value, culturally significant "slow" production (Kolek, 2026; Ukim, 2021).

While these findings offer valuable insights, this study faces certain limitations that must be critically acknowledged. First, the rapid pace of technological integration may outpace the adaptive capacity of smaller, traditional artisan communities, potentially creating a digital divide within the craft sector. Second, because hybridization relies heavily on localized case studies, the economic and cultural frameworks proposed here may not be uniformly applicable across different geopolitical regions or varied levels of market infrastructure. Finally, balancing

commercial viability with cultural authenticity remains a fragile process, as excessive commercialization threatens to erode the intangible heritage this study aims to protect.

The core lesson learned from this study is that technology and tradition do not exist in a zero-sum relationship. The hybridization process demonstrate that digital innovation can serve as a protective shell for cultural narratives rather than a force of erasure. This research introduces new knowledge by demonstrating how intergenerational transmission can be successfully digitized, transforming ancestral storytelling into dynamic, interactive analog-digital forms (Yang et al., 2018). Furthermore, it redefines "slow production" not as an obsolete economic model, but as a highly competitive strategy tailored for the modern, eco-conscious consumer.

The importance of this research lies in its ability to bridge the gap between cultural anthropology, design studies, and sustainable economics. For the wider field, it shifts the academic dialogue from merely documenting dying traditions to actively engineering their survival through hybrid systems.

In summary, while the hybridization of crafts offers vast potential to enrich aesthetics and create new forms of engagement, it also requires careful attention to cultural authenticity. Cultural elements, such as local ethnic patterns and traditions, are essential to the sustainable advancement of crafts. By prioritizing the preservation of ethnic narratives and fostering community-based practices, hybrid crafts contribute to a sustainable future where technology and tradition coexist in productive synergy.

Acknowledgements

This research was developed with support from the Opole University of Technology as part of the DELTA project no. 297/25.

References

1. Aracı, A. (2025). Hybrid Aesthetics and Cultural Sustainability in the Context of Glocalization: Reshaping Strategies in Art. In: Aydoğan D. (Ed.), *Art Management: Selected Topics*. Özgür Yayınları. https://doi.org/10.58830/ozgur.pub904.c3739
2. Bell, E., Dacin, M., Toraldo, M. (2021). Craft Imaginaries – Past, Present and Future. *Organization Theory, 2*. https://doi.org/10.1177/2631787721991141

3. Brännkärr, P., Porko-Hudd, M., Hartvik, J. (2025). Students' experiences of interaction in a multicultural university-level craft course, *International Journal of Technology and Design Education.* https://doi.org/10.1007/s10798-025-10035-w
4. Brown, S., Vacca, F. (2022). Cultural sustainability in fashion: reflections on craft and sustainable development models. *Sustainability: Science, Practice and Policy, 18*, pp. 590-600. https://doi.org/10.1080/15487733.2022.2100102
5. Castelblanco-Pérez, S. (2025). *Hybrid Bags: Identity, ecology, and heritage*. An Autoethnographic Journey in Traditional Craftsmanship Exhibition, Biennial International Conference for the Craft Sciences - Mariestad, 22-24th of October 2025.
6. D'Souza, R.E. (2024). Fashioning identity and resistance: Shilpa Chavan's HUM (we/us). *Journal of Visual Art Practice*, *23(3),* pp. 213-243. https://doi.org/10.1080/14702029.2024.2394751
7. De Castro Lima Dolabella, F., Salvan Pagnan, C. (2025). Hybrid ceramic crafts: users' perception of traditional and digital technologies for production. Estudosem Design. Revista (online). *Rio de Janeiro, 33(2),* pp. 97-115.
8. Dhar, B., Chawla, U., Mulchandani, D. (2024). Sustainable Craft Culture: Socio-Cultural Drivers and Economic Impact on Sustainable Development. *Sustainable Development*. https://doi.org/10.1002/sd.3282
9. Dolabella, F.de C.L., Pagnan, S.C. (2025). Hybrid ceramic crafts: users' perception of traditional and digital technologies for production. *Estudosem Design, Revista* (online), *33*(2), pp. 97-115.
10. Gupta, S., Shende, A. (2025). Crafting the In-Between: Weaving with Hybrid Bamboo and 3D Printed Mesh as Regenerative Practice. In: Chang C.-Y., Hsu, Y. (Eds.), *IASDR 2025: Design Next, 02-05 December*, Taiwan. https://doi.org/10.21606/iasdr.2025.1135
11. Härkönen, E., Huhmarniemi, M., Jokela, T. (2018). Crafting Sustainability: Handcraft in Contemporary Art and Cultural Sustainability in the Finnish Lapland. *Sustainability*. https://doi.org/10.3390/su10061907
12. Ionică, P. (2022). Traditional Crafts. What About? *Culture. Society. Economy. Politics, 2*, pp. 51-59. https://doi.org/10.2478/csep-2022-0005
13. Kale, C.D., Kaur, G., Sule, B., Jarad, R.S. Prabha, D., Bawa, D.S., Priyadharshini, K. (2026). Management strategies for AI-integrated craft industries, *ShodhKosh: Journal of Visual and Performing Arts Special Issue on Digital Preservation and Intelligent Innovation in Traditional and Modern Arts, 7(1s)*, pp. 305-314. https://doi.org/10.29121/shodhkosh.v7.i1s.2026.7086
14. Kolek, A. (2026). *The role of crafts in building the state's resilience [Rola rzemiosła w budowaniu odporności państwa]*. Związek Rzemiosła Polskiego. Retrieved from: https://zrp.pl/rola-rzemiosla-w-budowaniu-odpornosci-panstwa/, 31.03.2026.

15. Li, H., Xue, T., Zheng, Z., Luo, X., Huang, G. (2025). The innovation of traditional handicrafts and cultural identity: A multidimensional value analysis using the DEMATEL-ISM method. *PLOS One, 20*. https://doi.org/10.1371/journal.pone.0322893
16. Liaqat, A., Epp, C., Cai, M., Munteanu, C. (2023). Exploring Collaborative Culture Sharing Dynamics in Immigrant Families through Digital Crafting and Storytelling. *Proceedings of the ACM on Human-Computer Interaction, 7*, pp. 1-29. https://doi.org/10.1145/3610098
17. Liu, F., Xu, H. (2024). Craft making: Traditional and creative trajectories in Jingdezhen, China. *Asia Pacific Viewpoint*. https://doi.org/10.1111/apv.12407
18. López Millán, L. (2024). Virtual aesthetics as knowledge environments. In: Musicoguia (Ed.). *Conference Proceedings CIVAE 2024*. Madrid, Spain: Adaya Press. https://doi.org/10.58909/adc24571456
19. Lufiani, A., Sabana, S., Haldani, A. (2017). Aesthetics and functions of craft art in public art space. *HARMONIA: Journal of Arts Research and Education, 17(1),* pp. 41-47. https://doi.org/10.15294/harmonia.v17i1.7469
20. Lyu, J., Alli, H., Yusoff, I., Lyu, L. (2024). From Handicraft to Cultural Heritage: Redefining the Role of Traditional Handicraft in Shanxi's Cultural Expression. *International Journal of Academic Research in Business and Social Sciences*. https://doi.org/10.6007/ijarbss/v14-i7/21953
21. Mehrotra, M.S. (2025). *Interplay between traditional and modern 3D printing: a new perspective in future craft.* International Conference on Future Craft: Digital Innovation in Art, Fashion, 28.03.2025, pp. 150-159.
22. Partarakis, N., Zabulis, X., Antona, M., Stephanidis, C. (2020). Transforming Heritage Crafts to Engaging Digital Experiences, In: Liarokapis F., Voulodimos A., Doulamis N., Doulamis A. (Eds.), *Visual Computing for Cultural Heritage* (pp. 245-262). https://doi.org/10.1007/978-3-030-37191-3_13
23. Rubin, S., Mørch, I., Olsen, N., Nørtoft, K. (2024). Important intergenerational transmission of knowledge in promotion of well-being and cultural identity in Greenland. *International Journal of Circumpolar Health, 83*. https://doi.org/10.1080/22423982.2024.2420479
24. Shan, L. (2023). Preserving the Integrity of Li Yu's Craft Aesthetics Using the Digital Information Technology. *International Journal of Communication Networks and Information Security, 15(4)*.
25. Singh, A., Misra, S., Mishra, A. (2025). The future of Indian craftsmanship: integrating traditional artistry with modern technology. *International Conference on Future Craft: Digital Innovation in Art, Fashion*, *28.03.2025*, pp. 24-31.
26. Soledad Duarte Poblete, S., Lin, Y.S., Romania, A., Lid, J.-Y., Rognolia, V. (2024). A materials design practice between craft, creativity and technology. *Design Across*

Borders - United in Creativity, No. 13. Cumulus Conference Proceedings Series. Monterrey: Cumulus Association, pp. 2074-2096.

27. Sydora, B., Listener, L., Kung, J., Ross, S., Voyageur, C. (2023). Traditional crafting as a catalyst for Indigenous women's intergenerational cohesion and wellness: a Canadian perspective. *International Journal of Circumpolar Health, 82*. https://doi.org/10.1080/22423982.2023.2175763
28. Tan, J., Toomey, A., Warburton, A. (2018). CraftTech: hybrid frameworks for textile-based practice. *Journal of Textile Engineering & Fashion Technology, 4(2),* pp. 165-169.
29. Torres, C. (2018). *Hybrid Aesthetics: Design of New Media Practices within Digital Fabrication.* IS '18 Companion: Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems (May 2018). https://doi.org/10.1145/3197391.3205381
30. Torres, C. (2019). *Hybrid Aesthetics: Bridging Material Practices and Digital Fabrication through Computational Crafting Proxies*. Technical Report No. UCB/EECS-2019-109, July 19, 2019.
31. Tsaknaki, M., Fernaeus, V., Jonsson, Y. (2015). Precious Materials of Interaction - Exploring Interactive Accessories as Jewellery Items. *Nordes'15: Design Ecologies*, *6*, pp. 1-10.
32. Tsaknaki, V., Fernaeus, Y., Rapp, E., Solsona, J. (2017). *Articulating Challenges of Hybrid Crafting for the Case of Interactive Silversmith Practice.* DIS '17: Proceedings of the 2017 Conference on Designing Interactive Systems, pp. 1187-1200. https://doi.org/10.1145/3064663.3064718
33. Ukim, I. (2021). Discourse on similitude between craft and art. *The Artist Journal (Taj), 5(2),* pp. 138-144.
34. Upadhyay, J., Nanda, S., Nayak, G., Sindha, Y., Malik, M., Jackulin, T., Khemnar, V.R. (2025). Digital Aesthetics in the Age of Machine Learning. *ShodhKosh: Journal of Visual and Performing Arts, 6(5s),* pp. 56-65. https://doi.org/10.29121/shodhkosh.v6.i5s.2025.6892
35. Wang, J., Su, M., Wall, G., Dong, H., Zhang, H. (2024). Intergenerational evolution of intangible cultural heritage through tourism development: perspectives of practitioners in Hangzhou China. *International Journal of Heritage Studies, 30*, pp. 968-991. https://doi.org/10.1080/13527258.2024.2363793
36. Yadav, U., Gopinath, S. (2025). The Last Artisans: Indigenous Craftsmanship Across Generations in Zanskar Valley. *Research Review Journal of Indian Knowledge Systems*. https://doi.org/10.31305/rrjiks.2025.v2.n1.001
37. Yang, Y., Shafi, M., Song, X., Yang, R. (2018). Preservation of Cultural Heritage Embodied in Traditional Crafts in the Developing Countries. A Case Study of Pakistani Handicraft Industry. *Sustainability, 10*, *1336*. https://doi.org/10.3390/su10051336

38. Zabulis, X., Meghini, C., Partarakis, N., Beisswenger, C., Dubois, A., Fasoula, M., Nitti, V., Ntoa, S., Adami, I., Chatziantoniou, A., Bartalesi, V., Metilli, D., Stivaktakis, N., Patsiouras, N., Doulgeraki, P., Karuzaki, E., Stefanidi, E., Qammaz, A., Kaplanidi, D., Neumann-Janßen, I., Denter, U., Hauser, H., Petraki, A., Stivaktakis, I., Mantinaki, E., Rigaki, A., Galanakis, G. (2020). Representation and Preservation of Heritage Crafts. *Sustainability*. https://doi.org/10.3390/su12041461
39. Zhang, T., Sirisuk, M. (2025). The Development and Educational Inheritance of Li Pottery as a Carrier of Local Wisdom in the Context of Modernity. *Journal of Practical Studies in Education*. https://doi.org/10.46809/jpse.v6i3.107
40. Zoran, A. (2013). Hybrid Basketry: Interweaving Digital Practice within Contemporary Craft. *Leonardo, 46(4),* pp. 324–331.
41. Zoran, A. (2015). Hybrid Craft: Showcase of Physical and Digital Integration of Design and Craft Skills. *Leonardo, 48(4)*, pp. 384-398. https://doi.org/10.1162/LEON_a_01093
42. Zoran, A., Leah B. (2013). Hybrid reAssemblage: An Exploration of Craft. *Digital Fabrication and Artifact Uniqueness, Leonardo, 46(1)*, pp. 5-10.
43. ZPE (n.d.). *Artisticcrafts [Rzemiosło artystyczne]*. Zintegrowana Platforma Edukacyjna. Retrieved from: https://zpe.gov.pl/watek/LP6WO6jnLj/1/a/rzemioslo-artystyczne/DC16eegiE, 31.03.2026.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

CROSS-SUBSIDISATION AND PERCEIVED FAIRNESS AMONG YOUNG DRIVERS IN POLAND'S MOTOR INSURANCE

Beata NOWOTARSKA-ROMANIAK[1*], Sonia SZCZEPANIK[2]

[1] Katowice University of Economics; beata.nowotarska-romaniak@uekat.pl, ORCID: 0000-0003-3563-2596
[2] Katowice University of Economics; sonia.szczepanik@edu.uekat.pl, ORCID: 0000-0002-4275-3700
*Correspondence author

Purpose: The purpose of this paper is to examine young drivers' perceptions of the fairness of third-party liability insurance pricing in Poland, particularly regarding age-based premium differentiation, perceived unequal treatment, and the relationship between insurance premiums and actual accident risk.
Design/methodology/approach: The study combines statistical analysis of road accident data published by the National Police Headquarters with a survey conducted among drivers aged 18-24 in the Silesian Voivodeship. Data were collected using an anonymous questionnaire distributed near major universities. A total of 128 correctly completed questionnaires were obtained.
Findings: The results indicate that young drivers perceive the current insurance pricing system as excessively generalised and strongly dependent on age-based classifications. Most respondents assessed third-party liability insurance premiums as excessively high and believed that insurers insufficiently considered individual driving behaviour, accident-free history, and driving experience. Respondents also reported perceptions of unequal treatment, including higher premiums and limited access to discounts. At the same time, the findings suggest that young drivers generally accept differentiated pricing because it reflects observable behavioural factors rather than solely demographic characteristics.
Research limitations/implications: The study is limited by a relatively small, regionally concentrated sample, which may reduce the generalisability of the findings. Future research could incorporate larger, more geographically diverse samples, as well as insurer-side actuarial data.
Practical implications: The findings suggest that insurers could improve perceptions of fairness by implementing more individualised pricing mechanisms based on driving behaviour, claim-free history, and telematics-based solutions.
Originality/value: The paper contributes to the limited literature concerning young drivers' perceptions of fairness within the Polish motor insurance market and connects theoretical debates on actuarial fairness with empirical evidence collected directly from young drivers.
Keywords: motor insurance; young drivers; actuarial fairness; third-party liability insurance; cross-subsidisation.
Category of the paper: Research paper.

1. Introduction

Poland remains one of the most motorised countries in Europe, with private vehicles remaining a dominant means of everyday transport. According to Statistics Poland (GUS), by the end of 2024, there were approximately 22.9 million registered passenger vehicles in the country, corresponding to 612 vehicles per 1000 inhabitants (GUS, 2024). Even when considering only vehicles up to 30 years old, the motorisation rate remained exceptionally high. The widespread use of private automobiles underscores the growing significance of road safety issues and reinforces the importance of mechanisms that provide financial protection for road users. Consequently, motor insurance constitutes one of the most important segments of the Polish insurance market, performing both protective and compensatory functions within the broader transport and legal system.

Among the various forms of motor insurance operating in Poland, compulsory third-party liability insurance (pol. odpowiedzialność cywilna, OC) holds a particularly significant position. Under Polish law, every registered vehicle owner is obliged to maintain valid OC coverage, which provides compensation for damage caused to third parties in connection with the operation of a motor vehicle (Ustawa z dnia 22 maja 2003 r. o ubezpieczeniach obowiązkowych, Ubezpieczeniowym Funduszu Gwarancyjnym i Polskim Biurze Ubezpieczycieli Komunikacyjnych). The compulsory nature of this insurance reflects the social importance of guaranteeing compensation for victims of road traffic accidents and of ensuring the financial stability of the compensation system. In practice, the motor insurance market also includes motor own damage insurance (pol. Autocasco, AC), assistance insurance, and accident insurance products; however, OC insurance remains the most universal and socially significant form of coverage (Handschke, Monkiewicz, 2010, pp. 87-88).

The motor insurance market operates on risk assessment and premium differentiation. Insurers set premiums using numerous variables that reflect the likelihood of accidents and expected claim costs. Across the literature, young-driver insurance premiums are usually higher than those for older motorists, but the premium gap is not uniform across countries. European Commission road-safety syntheses show that 16 to 24 year old drivers are heavily over-represented in crash and fatality statistics, with risks about 2 to 3 times higher than those of more experienced drivers, and that young-driver crashes are more often linked to night driving, speeding, single-vehicle loss-of-control events, alcohol, distraction, and peer passengers (Euopean Comission 2026a, 2026b) Because insurers price for expected claims, age is widely used as a rating factor: the ABI notes that age materially affects both the likelihood and cost of claims and that premiums rise for younger drivers, while Confused.com likewise states that drivers aged 17 to 25 typically face the highest prices (ABI 2026; Rahou 2026). Consequently, drivers entering the insurance market often face substantially higher premiums than older, more experienced policyholders.

The relationship between young drivers and road accident risk is well documented in European and international literature. Reports published by the European Commission indicate that drivers aged 18-24 remain significantly overrepresented in road accident statistics and face accident risks approximately two to three times higher than those of more experienced drivers (European Commission, 2021). Young drivers are particularly associated with single-vehicle crashes, loss-of-control accidents, speeding, night-time driving, and risky driving behaviour linked to distraction, fatigue, alcohol consumption, and peer influence. Similar patterns are evident globally. According to the World Health Organisation (WHO, 2026), road traffic injuries remain the leading cause of death among individuals aged 5-29 worldwide, with young male drivers especially likely to engage in high-risk driving behaviour.

Similar trends are evident in the Polish context as well. Data published annually by the National Police Headquarters indicate that young drivers continue to represent one of the highest-risk categories within road traffic statistics, particularly when measured by the accident rate per 10,000 population. Although the overall number of road accidents in Poland has gradually declined in recent years, young drivers remain disproportionately represented in accident statistics relative to their share of the population (The National Police Headquarters Road Traffic Office, 2025). According to the National Police Headquarters Road Traffic Office (2025), 2941 road accidents involving drivers aged 18-24 were recorded in Poland in 2025. While this age category did not constitute the largest absolute group of accident perpetrators, young drivers ranked among the highest-risk categories when accident frequency was analysed relative to population size. The report also indicates that drivers aged 18-24 ranked fourth in both fatalities and injuries in road accidents. The statistical profile of young drivers presented in police reports remains relatively limited and primarily descriptive. The reports do not provide a broader sociological or behavioural characterisation of this age group, nor do they explain the rationale behind the adopted age classifications.

Nevertheless, the reports consistently associate young drivers with increased risk-taking behaviour, insufficient driving experience, and a lower ability to assess road conditions properly. A particularly significant factor concerns driving speed. According to police statistics, the most common cause of accidents involving young drivers was failure to adjust speed to prevailing traffic conditions, accounting for 35.5% of accidents among drivers aged 18-24. Excessive speed, combined with limited driving experience and behavioural risk factors, contributes to the persistent classification of young drivers as a high-risk category within the motor insurance market.

At the same time, the relationship between accident statistics and insurance pricing remains socially controversial. Although insurers justify higher premiums for young drivers through actuarial risk assessment, public debate increasingly questions whether age-based pricing accurately reflects individual accident risk and driving behaviour. Consequently, the case of young drivers represents a particularly visible example of the broader tension between actuarial fairness and perceived fairness within contemporary motor insurance systems.

From an insurance economics perspective, higher premiums for young drivers are generally justified by actuarial principles and risk-based pricing. According to the classical actuarial approach, insurance premiums should closely match the expected loss for a given insured individual or risk group. More precise risk classification improves market efficiency, reduces adverse selection, and enables insurers to align premiums with anticipated claim costs (Crocker, Snow, 1986; Dionne, Rothschild, 2014). Within this framework, age and driving experience are treated as actuarially relevant predictors of accident probability and therefore constitute legitimate variables in insurance pricing models.

At the same time, the use of demographic variables in insurance pricing raises significant ethical, social, and economic debates. Young drivers often view current premium structures as unfair, overly generalised, or insufficiently linked to their actual driving behaviour and individual accident history. The issue, therefore reflects a broader tension within insurance systems between actuarial fairness and social perceptions of equal treatment. On the one hand, insurers seek to improve pricing accuracy and reduce market inefficiencies through increasingly detailed risk segmentation. On the other hand, excessive reliance on demographic characteristics may fuel perceptions of discrimination and undermine the solidarity-based function traditionally associated with insurance systems (Landes, 2015).

This debate has intensified in recent years as telematics and behavioural pricing systems have become more prominent in motor insurance markets. Contemporary usage-based insurance models increasingly enable insurers to assess policyholders based on actual driving behaviour, rather than relying solely on demographic proxies such as age or gender. Studies by Usman et al. (2024) suggest that telematics-based pricing may reduce cross-subsidisation between low- and high-risk drivers by improving the precision of risk assessment. However, other researchers argue that highly individualised pricing models may weaken the redistributive and solidarity functions of insurance by fragmenting risk pools into increasingly narrow categories (Cevolini, Esposito, 2022; Xin, Huang, 2023). As a result, the development of behavioural insurance technologies raises new questions about the balance between efficient actuarial pricing and socially acceptable forms of risk redistribution.

Despite the growing body of literature on actuarial fairness, risk classification, and technological transformations in the insurance sector, relatively little attention has been devoted to how young drivers perceive these mechanisms. Existing research primarily focuses on the economic efficiency of insurance pricing systems and regulatory frameworks, as well as the technical aspects of telematics-based insurance models. Relatively little research examines the subjective experiences of young drivers, particularly their perceptions of fairness, discrimination, affordability, and the adequacy of age-based premium differentiation.

This research gap is particularly evident in the Polish context. Although industry reports and market surveys indicate growing dissatisfaction among young drivers with third-party liability insurance premiums, academic studies examining young drivers' attitudes to insurance pricing remain limited. Existing Polish studies largely focus on general insurance consumer

behaviour or broader transformations within the insurance sector, while the perspectives of young drivers themselves remain underexplored.

Accordingly, this study aims to examine young drivers' perceptions of the fairness of third-party liability insurance pricing in Poland, with particular emphasis on age-based premium differentiation, perceived unequal treatment by insurers, and attitudes towards the relationship between insurance premiums and actual accident risk. The study also seeks to identify the strategies young drivers use to reduce insurance costs and to assess how factors such as driving experience, vehicle ownership status, and financial responsibility for insurance premiums influence these perceptions. By combining theoretical discussions of actuarial fairness and redistributive pricing mechanisms with empirical evidence collected directly from young drivers, the study contributes to the broader debate over the balance between efficient risk classification and perceived fairness in contemporary motor insurance systems.

2. Theoretical Background and Literature Review

Motor insurance constitutes one of the most significant segments of the Polish property insurance market and encompasses both vehicle protection and the civil liability of vehicle owners and users. The functioning of the motor insurance system is regulated primarily by the Act on Compulsory Insurance (Ustawa z dnia 22 maja 2003 r. o ubezpieczeniach obowiązkowych, Ubezpieczeniowym Funduszu Gwarancyjnym i Polskim Biurze Ubezpieczycieli Komunikacyjnych). The Polish market includes several principal forms of motor insurance, including motor own damage insurance (Autocasco, AC), compulsory third-party liability insurance (odpowiedzialność cywilna, OC), and assistance insurance covering various forms of roadside and post-accident support (Handschke, Monkiewicz, 2010). Among these products, compulsory third-party liability insurance occupies a particularly important position due to its universal and legally mandatory character.

Motor insurance in Poland operates under the bonus–malus principle, in which insurance premiums are adjusted based on a driver's claims history. Claim-free driving generally results in premium reductions, whereas accidents and insurance claims lead to increased premiums (Rogowski, ed., 2016). Premium levels are additionally influenced by factors such as age, driving experience, vehicle type, insurance history, and place of residence. Consequently, motor insurance performs not only a protective and compensatory role but also a preventive and redistributive function within the broader compensation system (Witkowska, 2020).

In the context of motor insurance for young drivers, particular importance is attached to the redistributive dimension of insurance pricing, especially in relation to cross-subsidisation. Cross-subsidisation occurs when insurance premiums diverge from strictly individualised actuarial pricing and instead incorporate a degree of risk pooling between different categories

of policyholders. Under perfect risk classification, each insured individual would pay a premium equal to their expected loss, thereby eliminating implicit financial transfers between groups (Landes, 2015). In practice, however, insurers rarely achieve complete pricing granularity due to regulatory limitations, market structures, and broader social considerations. As a result, motor insurance systems frequently contain implicit redistributive mechanisms through which certain policyholder groups partially subsidise the risks generated by others.

This issue is particularly relevant for young drivers, who are commonly classified as a high-risk category in insurance pricing systems due to their elevated accident risk and limited driving experience. Consequently, the relationship between actuarial fairness, risk classification, and redistributive pricing mechanisms constitutes a central theoretical problem in contemporary motor insurance markets. The theoretical foundations of this issue were established by Crocker and Snow (1985, 1986), who demonstrated that risk classification involves an inherent trade-off between efficiency and redistribution. More precise risk classification reduces adverse selection and improves allocative efficiency; however, it simultaneously eliminates cross-subsidies that may benefit higher-risk groups within pooled insurance arrangements (Crocker, Snow, 1986). Dionne and Rothschild (2014), in a comprehensive review of the literature, further formalised this trade-off by identifying three possible regulatory scenarios. In the first scenario, prohibiting risk classification has no observable effect because there is no meaningful cross-subsidisation in the market. In the second scenario, restrictions on risk classification generate only efficiency losses without producing redistributive benefits. In the third scenario, prohibiting detailed risk classification creates cross-subsidies from low-risk to high-risk policyholders. Although such redistribution may be regarded as socially desirable, it inevitably reduces market efficiency (Dionne Rothschild, 2014).

This theoretical framework is particularly relevant in the context of motor insurance, where young drivers are often classified as high risk due to their elevated accident risk and limited driving experience. Consequently, less differentiated pricing systems may contain implicit redistributive mechanisms through which lower-risk policyholders partially subsidise higher-risk groups, including young drivers. At the same time, highly individualised pricing structures may substantially increase insurance costs for novice drivers, raising broader questions concerning fairness, affordability, and the social function of insurance systems.

Empirical research demonstrates that restrictions on risk classification can generate measurable redistributive effects within insurance markets. Schmeiser, Störmer, and Wagner (2013) examined the consequences of the European Union's 2012 prohibition on gender-based pricing and identified the emergence of cross-subsidisation between male and female policyholders across motor, health, and annuity insurance markets. Their findings indicate that lower-risk groups effectively subsidised higher-risk policyholders under unisex pricing regulations, while individuals facing increased premiums expressed lower acceptance of the revised pricing system. Similar redistributive mechanisms were identified by Finkelstein, Poterba, and Rothschild (2009) in the United Kingdom annuity market, where the magnitude

of cross-subsidisation depended substantially on contractual structures and insurers' ability to differentiate policyholders through alternative mechanisms.

The relationship between compulsory insurance systems and redistributive pricing has also been examined in the context of motor insurance markets. Schwarze and Wein (2005) demonstrate that mandatory third-party motor insurance in Germany required a degree of pooling among heterogeneous policyholders, thereby limiting the efficiency gains associated with increasingly detailed risk classification. Likewise, Tennyson (2010), analysing community-rated automobile insurance in Massachusetts, shows that restricting premium differentiation may produce measurable behavioural effects, as drivers classified as higher risk exhibit weaker incentives to reduce loss exposure when premiums do not accurately reflect individual claims history.

In the literature, particular importance is attributed to bonus–malus systems, which constitute a structural element of most European motor insurance markets. Lemaire and Zi (1994), comparing bonus–malus systems across 22 countries, demonstrate that young and inexperienced drivers frequently pay premiums exceeding their expected losses during the early years of driving, thereby contributing to an intertemporal redistribution mechanism that benefits older, claim-free policyholders later in the insurance cycle. This form of redistribution is rarely explicit yet remains embedded within merit-rated insurance systems. de Jong and Ferris (2006) further argue that excessive restrictions on risk classification may intensify adverse selection if cross-subsidies benefiting higher-risk groups become too substantial relative to the informational advantages available to those policyholders.

Beyond efficiency considerations, the literature increasingly addresses the ethical and normative dimensions of actuarial pricing. Landes (2015) argues that strict actuarial fairness, understood as assigning each policyholder a premium precisely corresponding to individual risk, may undermine the social purpose of insurance by weakening the redistributive and risk-pooling mechanisms inherent within insurance systems. From this perspective, the central issue is not whether redistribution exists within insurance markets, but rather what degree of cross-subsidisation may be considered socially acceptable. Similar concerns are raised by Xin and Huang (2023), who demonstrate that increasingly precise algorithmic pricing models may reduce cross-subsidisation while simultaneously fragmenting the insurance pool and reducing affordability for higher-risk groups, including young novice drivers.

Collectively, these studies demonstrate that motor insurance pricing involves a persistent tension between actuarial efficiency and broader social expectations concerning fairness and solidarity. This tension becomes particularly visible in relation to young drivers, whose elevated premiums are statistically justified yet frequently perceived as excessive or insufficiently individualised.

Recent technological developments are significantly transforming contemporary motor insurance markets. In particular, telematics- and usage-based insurance models increasingly enable insurers to assess policyholders based on actual driving behaviour rather than relying

primarily on demographic indicators such as age or gender. As a result, these technologies are frequently presented as a mechanism capable of reducing redistributive distortions embedded within traditional pricing systems.

Usman et al. (2024) demonstrate that telematics-based pricing models may reduce cross-subsidisation among higher-risk drivers by adjusting premiums according to real-time driving behaviour and behavioural risk indicators. From this perspective, personalised pricing systems may improve actuarial accuracy and reduce the reliance on demographic proxies that frequently disadvantage young drivers. However, the literature also indicates that increasingly individualised pricing mechanisms may generate new forms of inequality and intensify market segmentation.

Gemmo, Browne, and Grundl (2025), analysing a theoretical market characterised by cross-subsidisation under the Wilson-Miyazaki-Spence framework, demonstrate that the introduction of screening technologies such as telematics improves welfare primarily for low-risk individuals willing to disclose behavioural information. At the same time, policyholders unwilling or unable to participate in such systems may experience deteriorating market conditions and intensified adverse selection effects. Consequently, the transition from pooled pricing structures toward highly individualised behavioural pricing does not necessarily produce universally beneficial outcomes.

These developments are particularly relevant in the Polish motor insurance market, where drivers under 25 frequently face premiums substantially above market averages despite the broader downward trend in road accident statistics observed recently. The Polish case therefore illustrates the broader tension identified within the literature between actuarial differentiation, redistributive pricing mechanisms, and perceptions of fairness within compulsory insurance systems. Whether current premium structures primarily reflect objective actuarial risk, implicit cross-subsidisation embedded within bonus–malus systems, or excessive reliance on demographic proxies remains both an empirical and normative question.

Research concerning Polish young drivers' attitudes toward motor insurance pricing and cross-subsidisation mechanisms remains limited. The most directly relevant evidence originates primarily from industry reports rather than academic studies. A 2025 survey conducted by Rankomat found that 55% of respondents believed young drivers pay excessively high third-party liability insurance premiums, while only 23% considered the current pricing system justified (Rankomat.pl, 2025). Among respondents supporting lower premiums for young drivers, the most frequently identified reasons included the general unaffordability of insurance, the financial barriers young people face when seeking independence, and the perception that premium levels do not accurately reflect actual accident risk. These findings suggest a widespread perception that the burden imposed on young drivers within the insurance system may be disproportionate.

At the same time, existing evidence indicates that Polish drivers broadly accept the principle of risk-differentiated pricing itself. According to a study conducted by the Polish Insurance Association (Polska Izba Ubezpieczeń, 2022), 83% of respondents agreed that drivers regularly accumulating penalty points should pay higher insurance premiums. This suggests that dissatisfaction among young drivers may not stem from opposition to actuarial differentiation as such, but rather from perceptions that current pricing systems rely excessively on demographic categories instead of individual driving behaviour.

Academic research addressing these issues within the Polish context remains scarce. Borda and Jędrzechowska (2012) examined consumer attitudes and decision-making processes within the Polish motor insurance market; however, their study preceded the substantial premium increases and market transformations observed during the 2020s and did not specifically address redistributive pricing mechanisms or perceptions of age-based discrimination. Consequently, there remains a lack of empirical research examining how young Polish drivers themselves perceive the fairness of motor insurance pricing systems and whether they consider existing premium differentiation mechanisms justified.

Discussions of telematics and behavioural pricing systems similarly dominate the literature concerning cost-reduction strategies for young drivers. Usman et al. (2024) demonstrate that telematics-based pricing can reduce cross-subsidisation by adjusting premiums based on actual driving behaviour rather than demographic proxies. Cevolini and Esposito (2022; 2025) further argue that behavioural insurance models increasingly individualise risk assessment, potentially improving pricing precision while simultaneously weakening the solidarity and risk-pooling functions traditionally associated with insurance systems. Additional studies also identify practical limitations associated with telematics-based insurance, including privacy concerns, technological costs, cyber risks, and implementation challenges (Cimbru et al., 2025; Qi et al., 2025).

Within the Polish grey literature, several practical strategies for reducing insurance costs are frequently identified, including registering an experienced driver as a co-owner of the vehicle, selecting lower-powered vehicles, comparing offers across insurers, and building a claim-free driving history (Rankomat.pl, 2025; Klaro.pl, 2026; Przewodnik Ubezpieczeniowy, 2026). However, these recommendations remain largely absent from peer-reviewed academic literature. The only recent academic contribution indirectly related to this issue is the study by Śliwiński, Kuryłowicz, and Pajewska-Kwasny (2025), which discusses digital transformation and the growing role of telematics and artificial intelligence in the Polish insurance sector, although it does not directly analyse cost-minimisation strategies among young drivers.

Despite the growing body of literature concerning actuarial fairness, risk classification, and cross-subsidisation in motor insurance, considerably less attention has been devoted to how young drivers themselves interpret and evaluate these mechanisms. Existing studies primarily focus on pricing efficiency, the regulatory consequences of risk classification,

and technological transformations in insurance markets, while the subjective experiences of young drivers remain comparatively underexplored.

This research gap is particularly visible in Poland, where no dedicated academic study has directly examined whether young drivers perceive age-based premium differentiation as fair, whether they believe insurance premiums accurately reflect actual accident risk, or which aspects of the insurance system they consider most discriminatory. Furthermore, limited research has examined how young drivers attempt to reduce insurance costs or how factors such as driving experience, vehicle ownership, and financial responsibility for premiums influence these perceptions.

Accordingly, the purpose of this study is to examine young drivers' perceptions of the fairness of third-party liability insurance pricing in Poland, with particular emphasis on age-based premium differentiation, perceived unequal treatment by insurers, and attitudes toward the relationship between insurance premiums and actual accident risk. The study also seeks to identify the strategies young drivers use to reduce insurance costs and to assess how factors such as driving experience, vehicle ownership status, and financial responsibility for insurance premiums influence these perceptions. To achieve these objectives, the study addresses the following research questions:

RQ1: How do young drivers assess the fairness of third-party liability insurance pricing in Poland?

RQ2: Do young drivers perceive age-based premium differentiation as justified by actual accident risk?

RQ3: Which forms of unequal treatment by insurers are most frequently identified by young drivers?

RQ4: What strategies are most commonly used by young drivers to reduce motor insurance costs?

RQ5: How do factors such as driving experience, vehicle ownership status, and responsibility for paying insurance premiums influence young drivers' perceptions of fairness within the motor insurance market?

By combining theoretical considerations of actuarial fairness and redistributive pricing mechanisms with empirical data collected directly from young drivers, the study contributes to the broader discussion of the balance between efficient risk classification and perceived fairness in contemporary motor insurance systems.

3. Research methodology

For the purposes of this study, a survey was conducted among young drivers participating in the Polish motor insurance market. The study employed the field survey method to collect empirical data. Data collection was carried out between April 2024 and March 2025 in the vicinity of the largest universities located in the Silesian Voivodeship, including the University of Silesia in Katowice, the Silesian University of Technology, the Medical University of Silesia in Katowice, and the University of Economics in Katowice.

Participation in the study was voluntary and anonymous. Before completing the questionnaire, respondents were informed about the purpose of the study and assured that all responses would remain confidential and analysed exclusively in aggregate form. The age range of young drivers was defined as 18–24 years, in accordance with the classification adopted in the annual reports of the National Police Headquarters. Consequently, the inclusion criteria for participation were: (1) being between 18 and 24 years of age and (2) holding a valid driving licence and consenting to participate in the survey.

The study employed a non-probability purposive sampling approach, targeting young drivers within the selected academic environments.

The questionnaire was developed specifically for the purposes of this study following a review of the literature concerning actuarial fairness, motor insurance pricing, cross-subsidisation, and young drivers' perceptions of insurance markets. The instrument consisted predominantly of closed-ended questions designed to measure respondents' perceptions of premium fairness, experiences of unequal treatment by insurers, insurance purchasing behaviour, and opinions regarding the relationship between insurance premiums and accident risk. In addition, one open-ended question enabled respondents to express their own views on changes that could improve the situation of young drivers in the Polish motor insurance market. The questionnaire was therefore designed to address the research objectives and research questions formulated in the preceding section. Prior to data collection, the questionnaire underwent an internal review to ensure clarity, logical sequence, and consistency with the study objectives.

Data were collected using an anonymous questionnaire consisting of 12 substantive questions and four demographic (metric) questions. A total of 128 correctly completed questionnaires were obtained and qualified for further analysis (see Table 1). Given the exploratory nature of the study, the primary objective was not to estimate population parameters but to identify dominant attitudes and perceptions regarding the fairness of motor insurance pricing among young drivers. Consequently, a purposive sample of 128 respondents was considered sufficient to identify the principal patterns and relationships within the analysed population. Nevertheless, the relatively limited sample size may restrict the generalisability of the findings, an issue discussed in the limitations section.

Respondents were recruited in the vicinity of the largest universities in the Silesian Voivodeship because these institutions provided efficient access to individuals belonging to the target population of the study, namely drivers aged 18-24 years. The selection of academic settings was therefore based on practical considerations associated with reaching respondents who met the inclusion criteria rather than on an intention to investigate university students as a distinct social group. Although many participants were students, the study focused on young drivers irrespective of their educational status.

Table 1.
Socio-demographic characteristics of respondents (N = 128) in %

Sex			
Men		Women	
49.2		50.8	
Driving experience			
Less than 1 year	1-2 years	3-5 years	More than 5 years
12.5	53.1	32.8	1.6
Status regarding the vehicle covered by third-party liability insurance			
User without ownership rights	Co-owner of the vehicle	I use the car but I am not its owner or co-owner	
15.6	32.8	51.6	
Responsibility for the payment of the third-party liability insurance premium			
Full self-payment	Partial self-payment	Paid by another person	
58.6	18.0	23.4	

Source: Authors' own calculations based on survey data.

Table 1 presents the socio-demographic characteristics of the respondents participating in the study. The gender distribution of the sample was relatively balanced, with women accounting for 50.8% and men for 49.2%. Concerning driving experience, the largest group of respondents had held a driving licence for between one and two years (53.1%). Respondents with driving experience of three to five years represented 32.8% of the sample, whereas individuals with less than one year of driving experience accounted for 12.5%. Only 1.6% of respondents had possessed a driving licence for more than five years. The analysis of vehicle ownership status indicates that the majority of respondents used a vehicle without being its owner or co-owner (51.6%). Co-owners of vehicles constituted 32.8% of the sample, while sole vehicle owners represented 15.6% of respondents. The findings further demonstrate that most respondents covered the costs of third-party liability insurance premiums independently. 58.6% of respondents reported full self-payment of the insurance premium, whereas 18.0% reported partial contribution to the premium. In contrast, 23.4% of respondents indicated that the insurance premium was paid entirely by another person, such as a parent or guardian.

4. Results

The first two survey questions enabled the researchers to identify the motor insurance products most commonly used by young drivers, as well as their preferences for the insurance companies with which they currently hold policies.

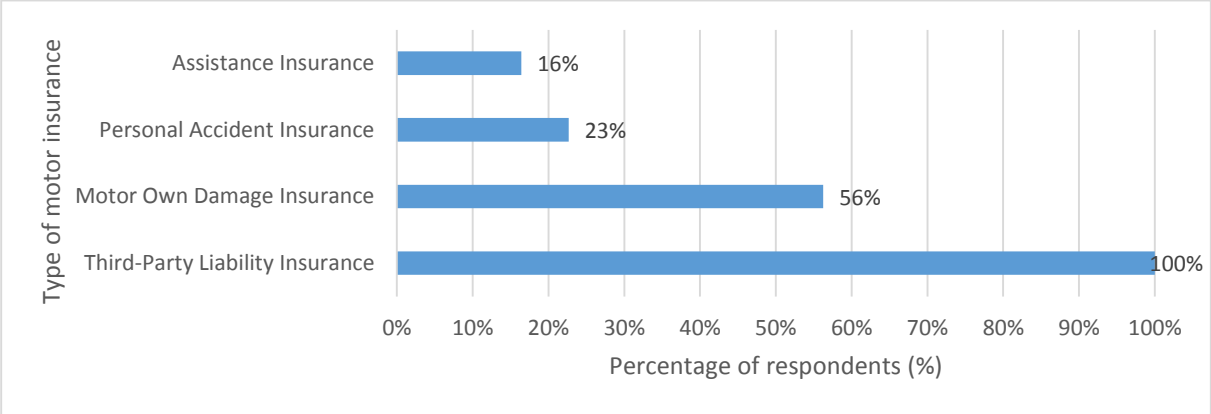


Figure 1. Types of motor insurance held by young drivers.

Source: Authors' own calculations based on survey data.

Figure 1 presents the types of motor insurance policies held by young drivers participating in the study. All respondents reported having compulsory third-party liability insurance (100%), reflecting the mandatory nature of this coverage in Poland. More than half of the respondents additionally reported possessing their own motor damage insurance (56%), indicating a relatively high level of interest in voluntary vehicle protection among young drivers. Participation levels were considerably lower for personal accident insurance (23%) and assistance insurance (16%). These findings suggest that young drivers primarily prioritise mandatory insurance coverage and protection against vehicle damage, while supplementary insurance products remain less common among this demographic.

The distribution of insurance providers selected by young drivers shows a clear dominance of PZU, chosen by 41% of respondents (see Figure 2). The second-most-frequently chosen insurer was Warta, selected by 23% of respondents.

Considerably lower percentages were observed for the remaining insurance companies. ERGO Hestia and Allianz Polska were each indicated by 9% of respondents, while UNIQA accounted for 8%. Link4 was selected by 5% of respondents, whereas Compensa, Generali, Aviva, and HDI Ubezpieczenia each represented 2% of responses. The findings suggest a strong concentration of young drivers within the largest and most recognisable insurance providers operating in the Polish market. This pattern may reflect factors such as brand recognition, perceived reliability, pricing policies, market availability, or the influence of family purchasing decisions in the selection of motor insurance providers.

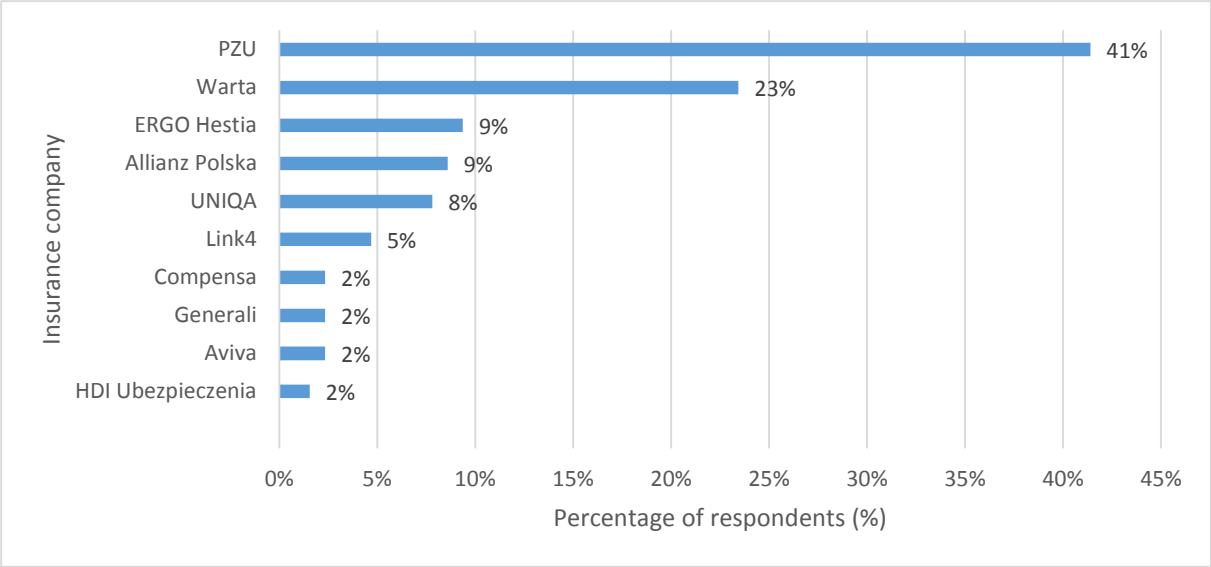


Figure 2. Motor insurance companies selected by young drivers.

Source: Authors' own calculations based on survey data.

The survey also examined the factors influencing young drivers' selection of motor insurance companies (see Figure 3). The findings indicate that insurance price was the most significant determinant in the decision-making process. A substantial proportion of respondents agreed or strongly agreed that insurance cost influenced their choice of insurer, confirming the high price sensitivity characteristic of younger consumers.

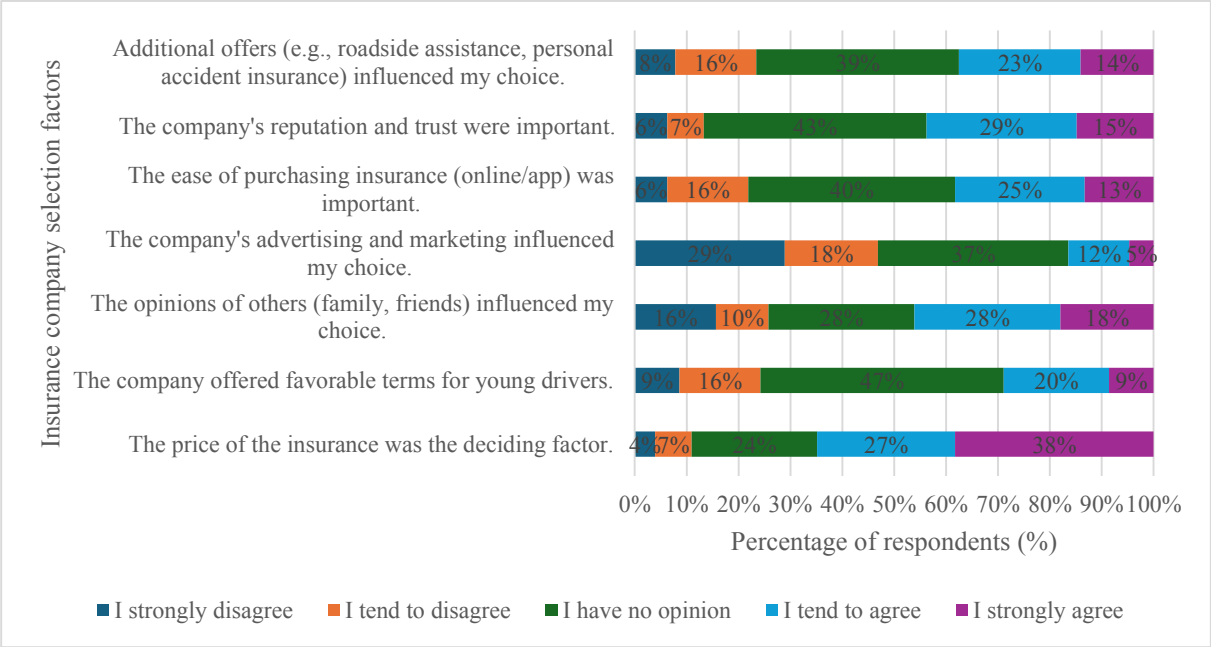


Figure 3. Factors influencing young drivers' choice of an insurance company.

Source: Authors' own calculations based on survey data.

Another important factor was the availability of favourable insurance terms specifically for young drivers. Nearly half of the respondents expressed neutral opinions in this regard; however, a considerable share indicated that preferential terms influenced their purchasing

decisions. Similar tendencies were observed for the reputation and trustworthiness of the insurance company, as well as for the ease of purchasing insurance through online platforms or mobile applications. These results suggest that both economic and convenience factors play an important role in young drivers' insurance preferences.

Additional insurance benefits, such as roadside assistance or personal accident insurance, were also identified as factors influencing insurer selection, although respondents' opinions were more diversified in this category. By contrast, advertising and marketing activities appeared to exert only a limited influence on respondents' decisions, with a substantial proportion expressing disagreement or neutral attitudes toward this factor.

The opinions of family members and friends also demonstrated moderate importance in the insurer selection process. This finding may indicate that young drivers partially rely on informal recommendations and social environment when making insurance-related decisions, particularly during the early stages of participation in the motor insurance market.

The respondents were also asked to evaluate the level of the third-party liability insurance premium offered by their current insurance company (see Table 2). Assessments were made using a five-point Likert scale ranging from "definitely too high" to "definitely too low". Notably, none of the respondents evaluated the premium as either "rather low" or "definitely low", indicating a generally negative perception of insurance pricing among young drivers.

Table 2.
Rating the third-party liability insurance premium offered to the young driver by their current insurance company (N = 128)

		Definitely too high	Rather too high	Adequate
Overall		28%	41%	31%
Sex	Women	23%	45%	32%
	Men	38%	38%	24%
Driving experience	Less than 1 year	25%	44%	31%
	1-2 years	25%	44%	31%
	3-5 years	40%	38%	21%
	More than 5 years	50%	0%	50%
Status regarding the vehicle covered by third-party liability insurance	User without ownership rights	60%	25%	15%
	Co-owner of the vehicle	26%	50%	24%
	I use the car, but I am not its owner or co-owner	24%	41%	35%
Responsibility for payment of the third-party liability insurance premium	Full self-payment	43%	40%	17%
	Partial self-payment	39%	35%	26%
	Paid by another person	23%	44%	33%

Source: Authors' own calculations based on survey data.

Overall, the majority of respondents considered the insurance premium to be excessively high. Specifically, 41% of participants described the premium as "rather too high", while 28% regarded it as "definitely too high". Only 31% assessed the premium level as adequate.

Differences were also observed between male and female respondents. Men demonstrated a more critical assessment of insurance prices, with 38% indicating that premiums were "definitely too high", compared with 23% of women. Female respondents were more likely to select the response "rather too high" (45%) than male respondents (38%).

Substantial differences were also observed regarding vehicle ownership status. Respondents using vehicles without ownership rights expressed the most negative evaluations, with 60% indicating that premiums were "definitely too high" and only 15% considering them adequate. By contrast, co-owners of vehicles demonstrated comparatively less critical attitudes, with half of the respondents evaluating premiums as "rather too high" and 24% considering them adequate. Respondents who used a vehicle without being its owner or co-owner provided relatively more balanced assessments, although negative evaluations continued to predominate.

Perceptions of insurance pricing also varied by driving experience. Respondents with less than three years of driving experience most frequently assessed premiums as "rather too high" (44%). Among drivers with three to five years of experience, 40% considered the premiums "definitely too high". The most experienced respondents, with more than 5 years of driving experience, showed a more divided assessment: half rated premiums as "definitely too high". while the other half considered them adequate.

A similar relationship was identified regarding responsibility for the insurance premium. Respondents who independently covered the full insurance cost expressed the most critical evaluations, with 43% describing premiums as "definitely too high." By contrast, individuals whose insurance premiums were paid by another person assessed pricing less negatively, with 33% considering the premium level adequate.

The survey additionally examined the strategies employed by young drivers to reduce the cost of third-party liability insurance premiums (Figure 4). The findings indicate that the most common method was the use of multi-insurance packages offered by a single insurer, which was declared by 46% of respondents. Another frequently reported strategy was building a claim-free driving history to obtain future discounts, as reported by 43% of participants.

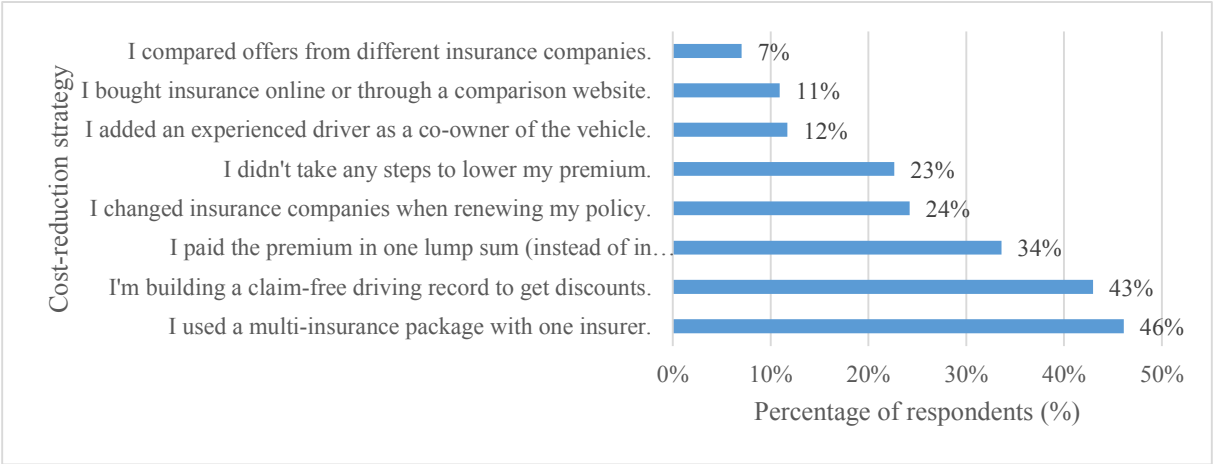


Figure 4. Strategies used by young drivers to reduce third-party liability insurance premiums.

Source: Authors' own calculations based on survey data.

A considerable proportion of respondents also declared paying the insurance premium as a single lump-sum payment rather than in instalments (34%). Less frequently, respondents reported changing insurance companies during policy renewal periods (24%) or taking no action to reduce the premium (23%). Other strategies were relatively uncommon among the surveyed young drivers. Adding a more experienced driver as a co-owner of the vehicle was indicated by 12% of respondents, while 11% reported purchasing insurance online or through comparison websites. Only 7% declared actively comparing offers from different insurance companies before purchasing a policy. The results suggest that young drivers primarily rely on long-term discount mechanisms and insurer package offers rather than active market comparisons when attempting to reduce insurance costs. This may indicate limited market knowledge, low engagement in comparative analysis, or a preference for simplified purchasing decisions within this demographic group.

The subsequent survey question examined whether young drivers believed they were treated less favourably by insurers than older drivers (see Table 3).

Table 3.
Young drivers' perceptions of insurer treatment relative to older drivers (N = 128)

		Yes	No	it's hard to say
Overall		78%	4%	18%
Sex	Women	80%	2%	18%
	Men	76%	6%	17%
Driving experience	Less than 1 year	69%	6%	25%
	1-2 years	81%	1%	18%
	3-5 years	79%	7%	14%
	More than 5 years	50%	0%	50%
Status regarding the vehicle covered by third-party liability insurance	User without ownership rights	85%	5%	10%
	Co-owner of the vehicle	81%	5%	14%
	I use the car, but I am not its owner or co-owner	74%	3%	23%
Responsibility for payment of the third-party liability insurance premium	Full self-payment	85%	5%	10%
	Partial self-payment	81%	5%	14%
	Paid by another person	74%	3%	23%

Source: Authors' own calculations based on survey data.

The results indicate that the majority of respondents perceived age-based unequal treatment by insurance companies. Overall, 78% of respondents answered affirmatively, while only 4% rejected this opinion. The remaining 18% indicated uncertainty.

Differences between male and female respondents were relatively limited. Women more frequently perceived unequal treatment by insurers (80%) compared with men (76%), whereas male respondents slightly more often rejected this opinion.

The perception of unequal treatment was also associated with driving experience. Respondents with one to two years of driving experience most frequently declared that young drivers were treated worse by insurers (81%). A similarly high proportion was observed among drivers with three to five years of experience (79%). By contrast, respondents with more

than 5 years of driving experience showed more divided opinions, though this result should be interpreted cautiously given the limited number of individuals in this category.

Substantial differences were also observed regarding vehicle ownership status and responsibility for insurance payments. Respondents without ownership rights to the insured vehicle most frequently perceived unequal treatment by insurers (85%). An identical percentage was recorded among respondents who fully financed their insurance premiums. In contrast, respondents whose premiums were paid by another person reported less frequent discriminatory treatment, although affirmative responses continued to predominate in this group.

The findings suggest that young drivers are highly aware of age-based differentiation in the motor insurance market and commonly perceive insurance pricing practices as unfavourable toward their demographic.

Young drivers were also asked whether they had ever encountered insurer treatment they perceived as unequal or discriminatory (see Figure 5). The results indicate that the most commonly identified issue was the imposition of very high third-party liability insurance premiums, which was reported by 71% of respondents. This finding confirms that insurance pricing is the primary area in which young drivers perceive unfavourable treatment in the motor insurance market.

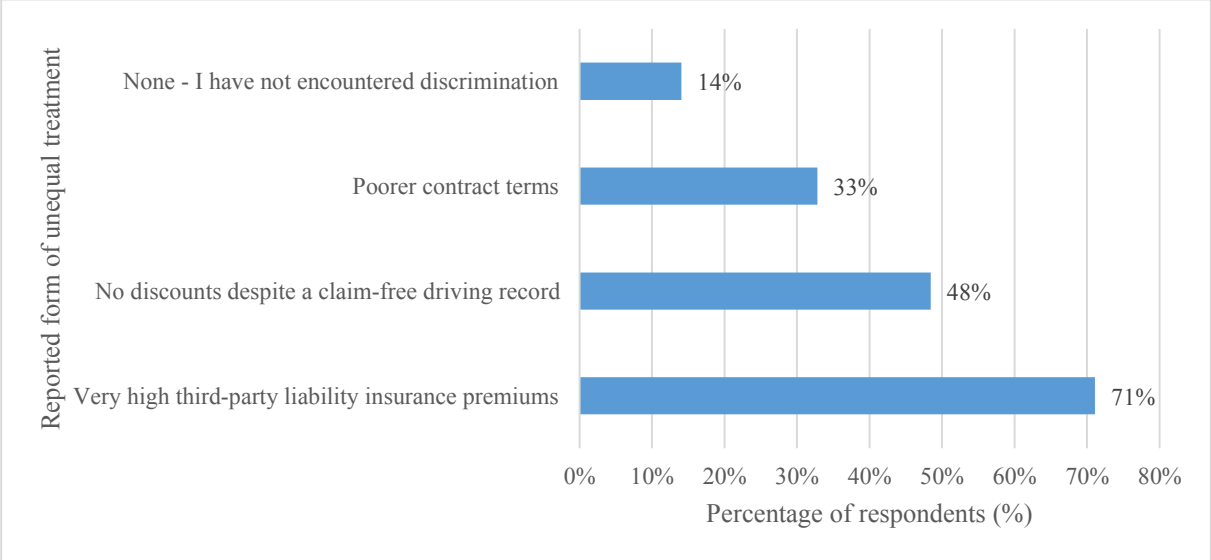


Figure 5. Forms of unequal treatment perceived by young drivers.

Source: Authors' own calculations based on survey data.

Another frequently indicated problem concerned the lack of discounts despite maintaining a claim-free driving record, as reported by 48% of respondents. This suggests that many young drivers perceive limited opportunities to benefit from standard bonus mechanisms commonly available to more experienced drivers. Additionally, 33% of respondents reported encountering less favourable contract conditions specifically offered to young drivers. These responses may reflect perceptions of restricted coverage, less advantageous policy terms, or higher contractual requirements imposed on younger policyholders. Only 14% of respondents reported not

experiencing any form of unequal treatment by insurers. Overall, the findings suggest that the vast majority of surveyed young drivers perceive age-based disparities in the insurance market, particularly in pricing and access to preferential conditions.

Given the context of the preceding survey questions concerning insurance pricing and perceived unequal treatment, respondents were additionally asked whether, in their opinion, the level of third-party liability insurance premiums accurately reflects the actual risk of causing road accidents (see Table 4).

The results demonstrate a predominantly sceptical attitude toward the fairness of insurance pricing mechanisms among young drivers. Overall, 59% of respondents stated that insurance premiums do not adequately reflect the actual risk of causing accidents, whereas only 8% disagreed. One-third of respondents (33%) indicated uncertainty regarding this issue.

Table 4.
Young drivers' perceptions of the adequacy of third-party liability insurance premiums relative to accident risk (N = 128)

		Yes	No	it's hard to say
Overall		8%	59%	33%
Sex	Women	5%	62%	34%
	Men	11%	57%	32%
Driving experience	Less than 1 year	13%	69%	19%
	1–2 years	9%	62%	29%
	3–5 years	2%	55%	43%
	More than 5 years	50%	0%	50%
Status regarding the vehicle covered by third-party liability insurance	User without ownership rights	10%	60%	30%
	Co-owner of the vehicle	12%	62%	26%
	I use the car, but I am not its owner or co-owner	5%	58%	38%
Responsibility for payment of the third-party liability insurance premium	Full self-payment	7%	73%	20%
	Partial self-payment	4%	61%	35%
	Paid by another person	9%	53%	37%

Source: Authors' own calculations based on survey data.

Differences between male and female respondents were relatively limited, though women showed slightly stronger scepticism toward insurance pricing practices. Among female respondents, 62% rejected the view that premiums accurately reflect accident risk, compared with 57% among men.

Perceptions of premium adequacy also varied by driving experience. Respondents with less than three years of driving experience most frequently rejected the relationship between premium levels and actual accident risk, with negative responses accounting for 69% and 62%, respectively. Drivers with three to five years of experience demonstrated the highest level of uncertainty, with 43% selecting the response “it is hard to say”. The results for respondents with more than 5 years of driving experience should be interpreted cautiously, given the minimal size of this subgroup.

Differences were also observed regarding vehicle ownership status and responsibility for insurance payments. Respondents fully financing their insurance premiums expressed the strongest disagreement with the statement that premiums accurately reflect accident risk, with 73% selecting the response "no". Similarly, high levels of scepticism were observed among respondents who used vehicles without ownership rights.

Overall, the findings suggest that young drivers frequently perceive insurers' pricing policies as insufficiently linked to individual driving behaviour and actual accident risk. This may indicate a belief that age-based categorisation plays a more significant role in insurance pricing than individual driving characteristics or claim history.

The final question addressed to young drivers was open-ended and aimed to identify potential changes that, in the respondents' opinion, could improve young drivers' position in the motor insurance market. Respondents were invited to freely express their views and propose solutions concerning insurance pricing, policy conditions, and insurer practices. The responses were subsequently grouped into thematic categories to identify the most frequently recurring opinions and expectations among the surveyed individuals (see Figure 6).

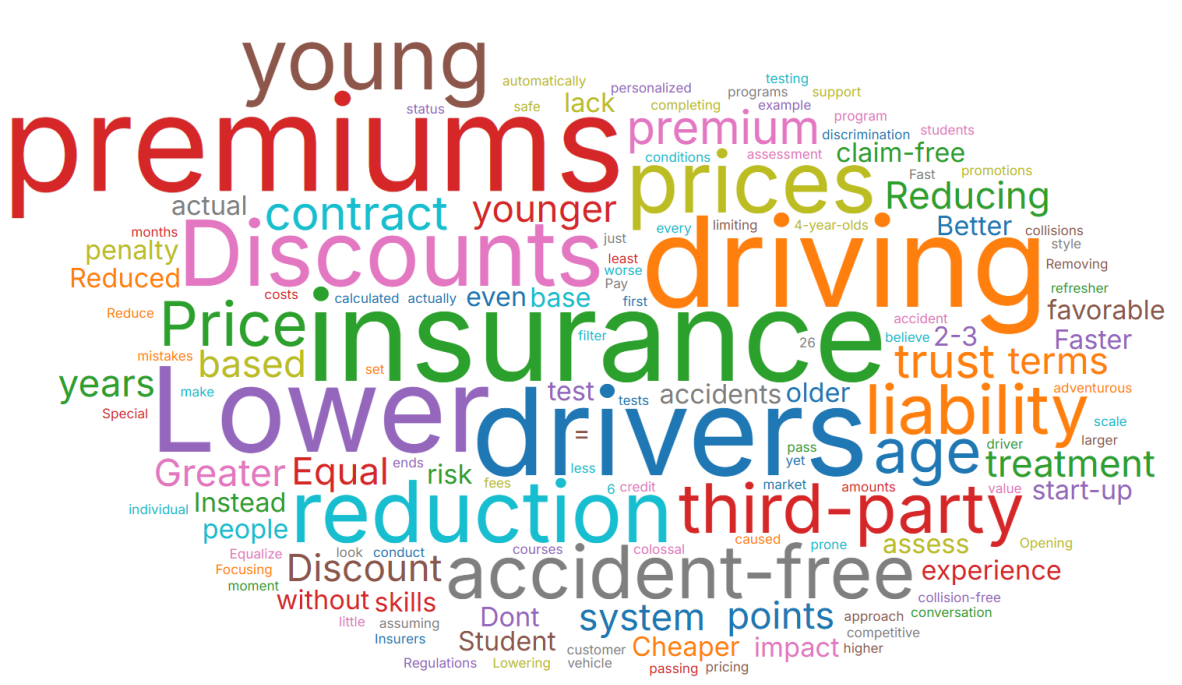


Figure 6. Young drivers' proposals for improving the motor insurance market (word cloud).

Source: Authors' own calculations based on survey data.

The responses to the open-ended question revealed a high degree of dissatisfaction among young drivers with the functioning of the motor insurance market, particularly regarding the pricing policies applied to third-party liability insurance. The dominant theme identified in respondents' statements concerned the need to reduce insurance premiums for young drivers. Numerous respondents directly emphasised that insurance costs were excessively high, using expressions such as "a colossal price reduction", "lower third-party liability insurance premiums", and "pay at least a little less for third-party liability insurance premiums".

Another frequently recurring issue concerned insurers' perceived overreliance on age as a determinant of insurance pricing. Respondents repeatedly argued that premiums should be based primarily on actual driving behaviour, accident history, and penalty points rather than on age or the length of driving licence possession. Several participants explicitly called for "equal treatment of drivers regardless of age or length of driving licence" and argued that insurers should "not look at age, just the lack of accidents". One respondent stated that insurers should "focus on actual accident-free driving instead of driving experience", while another suggested that "premiums should be set based on accident-free driving and penalty points".

The responses also indicate a strong expectation for faster, more accessible discount systems for young drivers. Many respondents expressed frustration that several years of claim-free driving did not result in meaningful premium reductions. One participant noted:

"I've had my licence for three years and still don't get a discount, even though I haven't had a single accident or ticket".

Similarly, respondents proposed mechanisms such as "discounts for claim-free driving every 6 months", "faster discounts", and "discounts calculated from the moment they pass their driving test".

A further recurring theme concerned the perception that insurers demonstrate insufficient trust toward young drivers. Respondents frequently emphasised the need for a more individualised assessment of risk rather than generalised assumptions based on age. Several participants suggested that insurers should assess "actual driving skills to assess risk" or introduce systems based on driving style and safe driving behaviour. One respondent proposed:

"Instead of automatically assuming that younger drivers are worse, conduct tests that actually assess skills and base the premium on them".

In addition to financial issues, some respondents proposed institutional or regulatory changes to limit age-based differentiation in insurance pricing. Suggestions included "regulations limiting age discrimination", "lowering the age at which young driver status ends", and introducing "special programmes for students and people up to 26 years of age".

The collected responses demonstrate that young drivers perceive the current motor insurance system as insufficiently individualised and excessively dependent on age-based risk categorisation. The findings suggest that respondents expect greater recognition of accident-free driving, safer driving behaviour, and personal responsibility within insurance pricing mechanisms.

The final issue addressed in the survey concerned young drivers' opinions regarding the fairness of the system used to determine third-party liability insurance premiums in Poland (see Table 5). The collected responses indicate a predominantly negative assessment of the current pricing system. More than half of respondents (52%) stated that the existing system for determining insurance premiums is unfair, whereas only 7% considered it fair. A substantial proportion of respondents (41%) selected the response "it is hard to say", suggesting uncertainty about the mechanisms insurers use to calculate insurance premiums.

Table 5.
Young drivers' perception of the fairness of the third-party liability insurance premium system in Poland (N = 128)

		Yes	No	it's hard to say
	Overall	7%	52%	41%
Sex	Women	5%	57%	38%
	Men	10%	48%	43%
Driving experience	Less than 1 year	19%	56%	25%
	1-2 years	6%	53%	41%
	3-5 years	5%	48%	48%
	More than 5 years	0%	100%	0%
Status regarding the vehicle covered by third-party liability insurance	User without ownership rights	10%	75%	15%
	Co-owner of the vehicle	5%	40%	55%
	I use the car, but I am not its owner or co-owner	8%	53%	39%
Responsibility for the payment of the third-party liability insurance premium	Full self-payment	3%	60%	37%
	Partial self-payment	13%	61%	26%
	Paid by another person	7%	47%	47%

Source: Authors' own calculations based on survey data.

Differences between male and female respondents were relatively limited, although women more frequently evaluated the system negatively. Among female respondents, 57% considered the premium determination system unfair, compared with 48% of men. Male respondents were more likely to express uncertainty about this issue.

Perceptions of unfairness were also associated with driving experience. Respondents with less than one year of driving experience most frequently assessed the system negatively (56%). Negative evaluations remained dominant among drivers with one to two years (53%) and three to five years of driving experience (48%). Particularly noteworthy is the result among respondents with more than 5 years of driving experience, all of whom rated the system as unfair. However, this finding should be interpreted cautiously due to the limited size of this subgroup.

Substantial differences were also observed regarding vehicle ownership status. Respondents using vehicles without ownership rights expressed the most critical opinions, with 75% considering the premium determination system unfair. Comparatively, lower levels of negative assessment were recorded among co-owners of vehicles (40%), although uncertainty remained particularly high within this group.

The findings further indicate that direct financial responsibility for insurance premiums influences perceptions of fairness. Respondents who fully finance their own insurance premiums showed the greatest dissatisfaction with the current system, with 60% rating it negatively. By contrast, respondents whose premiums were paid by another person more frequently expressed uncertainty regarding the fairness of insurance pricing mechanisms.

The results suggest that young drivers commonly perceive the current system of determining third-party liability insurance premiums as insufficiently transparent and inadequately adjusted to individual driving behaviour and actual accident risk.

5. Discussion and conclusion

The purpose of this study was to examine young drivers' perceptions of the fairness of third-party liability insurance pricing in Poland, with particular emphasis on age-based premium differentiation, perceived unequal treatment by insurers, and attitudes toward the relationship between insurance premiums and actual accident risk. The study also sought to identify the strategies young drivers use to reduce insurance costs and to assess how factors such as driving experience, vehicle ownership status, and financial responsibility for insurance premiums influence these perceptions.

The findings indicate that young drivers constitute a distinct and economically vulnerable group within the Polish motor insurance market. The analysis of statistical data from the National Police Headquarters, combined with the survey conducted among drivers aged 18-24, confirms that this age group continues to be characterised by relatively high accident risk, which is reflected in higher third-party liability insurance premiums. This observation is consistent with previous studies demonstrating that novice drivers are disproportionately represented in road traffic accidents and therefore remain classified by insurers as a high-risk category (European Commission, 2026a, 2026b). However, while the actuarial rationale for age-based premium differentiation is well established in the literature, the present study demonstrates that young drivers frequently perceive the current pricing system as insufficiently reflecting their individual driving behaviour and actual accident risk. This finding highlights the tension between actuarial fairness, based on statistical risk assessment, and perceived fairness, based on individual expectations of equitable treatment, which has been discussed by Landes (2015) and more recently by Xin and Huang (2023).

The statistical analysis confirmed that young drivers remain disproportionately represented in road accident statistics in Poland, particularly in terms of the accident rate per 10,000 population. Although the number of accidents involving young drivers has gradually declined in recent years, this group continues to exhibit one of the highest accident rates among all driver categories. These findings are consistent with reports published by the European Commission (2026a; 2026b), which identify novice drivers as being particularly vulnerable to road accidents due to limited driving experience and a greater propensity for risk-taking behaviours. Similar conclusions have been reported in international studies, which demonstrate that young drivers are overrepresented in speed-related, single-vehicle, and loss-of-control crashes. Consequently, the objective accident statistics support insurers' classification of young drivers as a high-risk category, providing an actuarial justification for higher insurance premiums. However, as demonstrated by the present study, actuarial justification alone does not necessarily translate into acceptance of premium differentiation by those directly affected by it.

The survey findings further indicate that third-party liability insurance premiums constitute a substantial financial burden for young drivers. Most respondents assessed current premium levels as excessively high, while none considered them low. These findings correspond with the results of the Rankomat (2025) survey, in which more than half of Polish respondents also considered premiums for young drivers to be excessive. However, the present study extends these observations by demonstrating that dissatisfaction with insurance pricing is particularly pronounced among respondents who bear the financial responsibility for paying insurance premiums themselves. This suggests that direct exposure to insurance costs significantly shapes perceptions of affordability and fairness, making financial responsibility an important factor influencing attitudes toward insurance pricing. The findings therefore indicate that perceptions of fairness are influenced not only by the objective level of premiums but also by the economic burden experienced by individual policyholders.

The findings further demonstrate that dissatisfaction among young drivers does not stem from opposition to risk differentiation itself, but rather from the perception that current pricing systems insufficiently recognise individual driving behaviour. Respondents frequently indicated that insurers rely excessively on age-based classification while paying limited attention to factors such as accident-free driving history, penalty points, or actual driving skills. These findings suggest that respondents do not reject the principle of risk-based pricing itself; instead, they question the variables currently used to estimate individual risk. Consequently, many respondents perceived existing pricing practices as overly generalised and insufficiently individualised.

The present study extends the existing literature by distinguishing between acceptance of risk-based pricing as a principle and dissatisfaction with the specific variables currently used for risk classification. The findings indicate that young drivers do not reject differentiated insurance premiums per se; rather, they question the predominance of demographic characteristics over behavioural indicators such as accident-free driving, penalty-point records, or actual driving behaviour. While previous studies have largely focused on the efficiency and fairness of actuarial pricing systems, the present study demonstrates that young drivers generally accept differentiated premiums when they are perceived to reflect individual driving behaviour rather than demographic characteristics alone.

This interpretation is reinforced by respondents' perceptions of unequal treatment within the insurance market. Most surveyed drivers believed that insurers treat young drivers less favourably than older policyholders, primarily through higher premiums, limited access to discounts, and less favourable contractual conditions. Particularly significant was the widespread belief that insurance premiums do not accurately correspond to the actual probability of causing accidents. Instead, respondents perceived age itself as the dominant determinant of premium calculation. These findings provide an interesting perspective on the theoretical debate concerning actuarial fairness and risk classification. While previous studies have demonstrated that demographic characteristics, including age, improve insurers' ability to

estimate expected losses (Crocker, Snow, 1986; Dionne, Rothschild, 2014), the present study suggests that young drivers place greater value on behavioural indicators of risk than on demographic proxies. This finding supports the argument advanced by Landes (2015) that perceptions of fairness in insurance extend beyond actuarial accuracy and involve broader social expectations regarding equal and individualised treatment.

The present study extends the existing literature by demonstrating that dissatisfaction among young drivers is directed primarily at the variables currently used for risk classification rather than at the principle of risk-based pricing itself. While previous studies have largely focused on actuarial efficiency, regulatory consequences, or technological developments in insurance pricing, the present findings indicate that young drivers generally accept differentiated premiums when they are perceived to reflect observable driving behaviour rather than demographic characteristics alone.

The open-ended responses provide additional insight into young drivers' expectations of the insurance system. The dominant demand concerned lower premiums for drivers maintaining a claim-free driving history and greater recognition of individual driving behaviour in premium determination. Respondents frequently proposed solutions based on behavioural rather than demographic risk assessment, including premium reductions linked to accident-free driving, penalty-point records, completion of safe-driving courses, and individualised monitoring systems. Faster access to discounts, student-oriented insurance programmes, and more flexible pricing structures were also commonly suggested. These findings indicate that young drivers favour insurance systems that reward demonstrated driving behaviour, rather than relying primarily on demographic characteristics such as age or driving experience.

The respondents' expectations closely correspond with recent developments in motor insurance research. The growing interest in telematics and usage-based insurance reflects a broader shift from demographic toward behavioural risk assessment. Usman et al. (2024) demonstrated that telematics-based pricing can reduce cross-subsidisation by aligning premiums more closely with actual driving behaviour, while Cevolini and Esposito (2022, 2025) argue that although such approaches increase individual responsibility and pricing accuracy, they may simultaneously weaken the solidarity function traditionally associated with insurance. The preferences expressed by respondents therefore mirror broader changes taking place within contemporary insurance markets, where advances in data collection enable increasingly personalised pricing models.

Taken together, these findings reinforce the broader theoretical debate concerning actuarial fairness and redistributive pricing in insurance systems. Although insurers' reliance on age-based risk classification is supported by objective accident statistics and actuarial principles, the surveyed respondents frequently perceived these practices as disproportionate and insufficiently transparent. The present study therefore illustrates a clear distinction between actuarial fairness and perceived fairness. Whereas insurers seek to maximise pricing accuracy through statistically significant risk factors, young drivers evaluate fairness primarily through

the extent to which premiums reflect their own driving behaviour and personal responsibility. Consequently, the findings suggest that dissatisfaction with current pricing mechanisms is driven less by opposition to risk-based pricing itself than by a preference for more individualised and transparent methods of risk assessment.

The results additionally suggest that behavioural pricing mechanisms based on observable driving behaviour may represent a compromise between actuarial efficiency and perceived fairness among young drivers. Many respondents expressed support for pricing mechanisms linked directly to individual driving behaviour and claim history, which closely corresponds with recent developments in telematics-based insurance and usage-based pricing discussed in the literature (Usman et al., 2024). At the same time, these expectations reflect broader concerns identified by Cevolini and Esposito (2022; 2025), who argue that although behavioural pricing may improve actuarial accuracy and individual responsibility, it may also weaken the solidarity function traditionally associated with insurance systems. Consequently, the present findings suggest that young drivers favour insurance systems that combine actuarial precision with greater transparency and recognition of individual driving behaviour, rather than relying predominantly on demographic characteristics.

Taken together, the findings contribute to the growing discussion on the relationship between actuarial fairness and perceived fairness in contemporary motor insurance systems. While previous research has primarily examined the economic efficiency of risk classification and the implications of cross-subsidisation, the present study provides empirical evidence on how these mechanisms are perceived by the group most directly affected by age-based pricing policies. The results demonstrate that young drivers generally accept the principle of differentiated insurance premiums when these are based on observable driving behaviour and individual risk factors. However, dissatisfaction emerges when premium determination is perceived as relying predominantly on demographic characteristics. By combining theoretical considerations regarding actuarial fairness with empirical evidence from the Polish motor insurance market, the study contributes to a better understanding of the social acceptance of risk-based insurance pricing and highlights the importance of transparency and individualisation in future insurance models.

Overall, the findings provide clear answers to the research questions formulated in the literature review. The results indicate that young drivers generally perceive the current premium determination system as unfair (RQ1), question whether age-based differentiation adequately reflects actual accident risk (RQ2), identify high premiums and limited access to discounts as the principal forms of unequal treatment (RQ3), rely primarily on long-term discount mechanisms and insurance packages to reduce costs (RQ4), and demonstrate that financial responsibility for insurance premiums significantly shapes perceptions of fairness (RQ5).

Despite the valuable findings obtained through the study, several limitations should be acknowledged. First, the research was conducted on a relatively small sample of 128 respondents, limiting the generalisability of the results to the broader population of

young drivers in Poland. The study was additionally limited to respondents in the Silesian Voivodeship, primarily in the vicinity of major universities, which may have led to the over-representation of students and individuals pursuing higher education. Second, the research relied on self-reported survey data, which are subject to subjective perceptions, response bias, and individual interpretations of fairness and discrimination. Respondents' evaluations of insurers and premium determination mechanisms, therefore, do not necessarily correspond to the actuarial methodologies actually employed by insurance companies. Another limitation is the study's cross-sectional design. The findings reflect respondents' opinions at a specific point and do not capture potential changes in perceptions resulting from evolving market conditions, regulatory reforms, or fluctuations in insurance premiums. Furthermore, the study focused primarily on perceived fairness and subjective experiences rather than on direct analysis of insurers' pricing algorithms or actuarial data. Finally, certain respondent categories, particularly drivers with longer driving experience, were represented by relatively few participants. Consequently, findings concerning these subgroups should be interpreted cautiously.

The findings demonstrate that although age-based premium differentiation is actuarially justified, young drivers increasingly expect insurance pricing to reflect individual driving behaviour rather than demographic characteristics alone. The study therefore contributes to the ongoing debate concerning the balance between actuarial efficiency and perceived fairness in contemporary motor insurance systems, particularly in markets where compulsory third-party liability insurance plays a central social role.

Future research could therefore benefit from larger, more geographically diverse samples, comparative analyses across additional age groups, and the incorporation of insurer-side actuarial data on premium calculation mechanisms. Further studies examining telematics-based insurance systems and individualised behavioural pricing models may also provide valuable insight into potential alternatives to traditional age-based pricing structures.

References

1. ABI (2026). *Age and motor insurance*. Retrieved from: https://www.abi.org.uk/products-and-issues/choosing-the-right-insurance/motor-insurance/age-and-motor-insurance/, 10.05.2026.
2. Borda, M., Jedrzechowska, A. (2012). *Attitudes and decisions of the motor insurance buyers in Poland. Business and Economic Horizons*, *Vol. 8, Iss. 2,* pp. 2-–32.
3. Cevolini, A., Esposito, E. (2025). *Does proactivity affect insurance solidarity and individual responsibility? British Journal of Sociology, early view*. doi: 10.1111/1468-4446.13176

4. Cimbru, I., Wagner, J., Zeier Roschmann, A. (2025). On IoT-enabled risk prevention and insurance: A systematic literature review. *Risk Management and Insurance Review*, *Vol. 28, Iss. 3, early view*. doi: 10.1111/rmir.12312
5. Crocker, K.J., Snow, A. (1986). The efficiency effects of categorical discrimination in the insurance industry. *Journal of Political Economy*, *Vol. 94, Iss. 2*, pp. 321-344. doi: 10.1086/261382
6. Dionne, G., Rothschild, C. (2014). Economic effects of risk classification bans. *The Geneva Risk and Insurance Review, Vol. 39, Iss. 2,* pp. 184-221. doi: 10.1057/grir.2014.7
7. European Commission (2021). *Facts and figures: Young people aged 15-24. European Road Safety Observatory*. Brussels: European Commission, Directorate-General for Transport.
8. European Commission (2026a). *Novice drivers.* Retrieved from: https://road-safety.transport.ec.europa.eu/european-road-safety-observatory/statistics-and-analysis-archive/young-people/novice-drivers_en, 06.05.2026.
9. European Commission (2026b). *Impairment.* Retrieved from: https://road-safety.transport.ec.europa.eu/european-road-safety-observatory/statistics-and-analysis-archive/young-people/impairment_en, 10.05.2026.
10. Finkelstein, A., Poterba, J., Rothschild, C. (2009). Redistribution by insurance market regulation: Analysing a ban on gender-based retirement annuities. *Journal of Financial Economics*, *Vol. 91, Iss. 1,* pp. 38-58. doi: 10.1016/j.jfineco.2008.03.002
11. Gemmo, I., Browne, M.J., Grundl, H. (2025). Privacy concerns in insurance markets: Implications for market equilibria and customer utility. *Canadian Journal of Economics*, *Vol. 58, Iss. 2,* pp. 509-543. doi: 10.1111/caje.12767
12. GUS (2026). *Transport – activity results in 2024*. Warszawa: Główny Urząd Statystyczny.
13. Handschke, J., Monkiewicz, J. (Eds.) (2010). *Ubezpieczenia: Podręcznik akademicki*. Warszawa: Poltext.
14. Klaro.pl (2026). *Najtańsze OC dla młodego kierowcy – ceny, jak płacić mniej*. Retrieved from: https://klaro.pl, 05.05.2026.
15. Landes, X. (2015). How fair is actuarial fairness? *Journal of Business Ethics*, *Vol. 128, Iss. 3*, pp. 519-533. doi: 10.1007/s10551-014-2100-0
16. Lemaire, J., Zi, H. (1994). A comparative analysis of 30 bonus-malus systems. *ASTIN Bulletin, Vol. 24, Iss. 2,* pp. 287-307. doi: 10.2143/AST.24.2.2005070
17. Polska Izba Ubezpieczeń (2022). *Kierowcy nie widzą nic złego w przekraczaniu prędkości*. Retrieved from: https://piu.org.pl, 10.05.2026.
18. Przewodnik Ubezpieczeniowy (2026). *Rejestracja auta na współwłaściciela – czy to się jeszcze opłaca w 2026 roku*? Retrieved from: https://przewodnikubezpieczeniowy.pl, 12.05.2026.

19. Qi, J., Woolway, M., Kyropoulou, M., Kanellopoulos, P., Steele, D. (2025). Telematics in insurance: Challenges and limitations. *IEEE Access*, *Vol. 13, Article 103245*. doi: 10.1109/ACCESS.2025.3564146
20. Rahou, M. (2026). *How is my car insurance calculated?* Retrieved from: https://www.confused.com/compare-car-insurance/guides/how-car-insurance-is-calculated, 12.06.2026.
21. Rankomat.pl (2025). *Ponad połowa Polaków uważa, że młodzi kierowcy płacą za dużo za OC*. Retrieved from: https://cz.info.pl/cz-temat-dnia/14301-ponad-polowa-polakow-uwaza-ze-mlodzi-kierowcy-placa-za-duzo-za-oc, 10.05.2026.
22. Rogowski, S. (Ed.) (2016). *Ubezpieczenia komunikacyjne*. Warszawa: C.H. Beck.
23. Schmeiser, H., Stormer, T., Wagner, J. (2013). Unisex insurance pricing: Consumers' perception and market implications. *The Geneva Papers on Risk and Insurance – Issues and Practice, Vol. 39, Iss. 2,* pp. 322-350. doi: 10.1057/gpp.2013.37
24. Schwarze, R., Wein, T. (2005). Is the market classification of risk always efficient? Evidence from German third-party motor insurance. *Working Paper No. 59*. Lüneburg: Leuphana University.
25. Sliwinski, A., Kurylowicz, L., Pajewska-Kwasny, R. (2025). Digital transformation and innovation in the insurance sector: Processes, technologies, and challenges. *Wiadomości Ubezpieczeniowe*, *Iss. 2*, pp. 3-22. doi: 10.33995/wu2025.2.1
26. Tennyson, S. (2010). Incentive effects of community rating in insurance markets: Evidence from Massachusetts automobile insurance. *The Geneva Risk and Insurance Review*, *Vol. 35, Iss. 1*, pp. 58-86. doi: 10.1057/grir.2009.6
27. Usman, F., Chan, J.S.K., Makov, U.E., Wang, Y.X.R., Dong, A.X.D. (2024). Claim prediction and premium pricing for telematics auto insurance data using Poisson regression with lasso regularisation. *Risks, Vol. 12, Iss. 9, Article 137*. doi: 10.3390/risks12090137
28. Ustawa z dnia 22 maja 2003 r. o ubezpieczeniach obowiązkowych, Ubezpieczeniowym Funduszu Gwarancyjnym i Polskim Biurze Ubezpieczycieli Komunikacyjnych. *Dz.U. 2003 Nr 124, poz. 1152, as amended*.
29. WHO (2026). *Road traffic injuries*. Retrieved from: https://www.who.int/health-topics/road-safety/children-and-young-people#tab=tab_1, 05.05.2026.
30. Witkowska, J. (2020). *Ubezpieczenia komunikacyjne*. Warszawa: CeDeWu.
31. Xin, X., Huang, F. (2023). Antidiscrimination insurance pricing: Regulations, fairness criteria, and models. *North American Actuarial Journal*, *Vol. 27, Iss. 4*, pp. 625-655. doi: 10.1080/10920277.2022.2132704

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

PREFERENCES OF THE YOUNGER GENERATION IN THE SUSTAINABLE DEVELOPMENT OF LAST-MILE LOGISTICS

Marcin OLKIEWICZ

Koszalin University of Technology; marcin.olkiewicz@tu.koszalin.pl, ORCID: 0000-0001-6181-6829

Purpose: Consumer behavior is one of the most volatile factors influencing the development of services, businesses, and so on. The purpose of article is to examine the extent to which innovation and environmental considerations shape the younger generation's consumer behavior in the context of sustainable last-mile logistics.
Design/methodology/approach: The identified research gap pertains to the limited knowledge and research findings regarding the aspects of innovation and environmentalism that shape the awareness and preferences of the younger generation. A survey conducted using the CAWI method in 2025 among 335 young respondents.
Findings: The survey found that young people have a positive attitude (68%) toward eco-friendly deliveries, but view modern solutions such as drones and robots (79%) and subsidies for eco-friendly solutions negatively.
Research limitations/implications: A limitation of the study is the younger generation's low environmental awareness and lack of knowledge about alternative delivery methods.
Practical implications: The findings of this article can help logistics companies and the e-commerce sector adapt their delivery models to the expectations of young consumers by developing eco-friendly and innovative distribution solutions.
Social implications: The development of sustainable last-mile logistics solutions can help reduce the negative environmental impact of transportation and raise public awareness of responsible consumption and environmental protection.
Originality/value: The value lies in combining the challenges of last-mile logistics with an analysis of the preferences of the younger generation of consumers in the context of innovation and the sustainable development of operational efficiency in deliveries.
Keywords: innovations, young consumer generation, ecology, last-mile logistics, consumer preferences.
Category of the paper: Research paper.

1. Introduction

Logistics is one of the fundamental areas of operation for modern businesses, responsible for organizing and coordinating the flow of goods, services, and information in economic processes from the point of production to the final recipient. Carrying out these tasks requires maintaining high-quality service, the rational use of resources, and cooperation among many market participants, such as raw material suppliers, manufacturers, logistics operators, and distributors. The result is a complex system of organizational and process-related links known as the supply chain, the efficiency of which significantly impacts the competitiveness of enterprises.

Current economic conditions, including advancing globalization, the development of digital technologies, and rising customer expectations, necessitate the continuous improvement of logistics processes. This is particularly evident in the e-commerce services sector, where the rapid growth in online orders is driving an increasing demand for fast and reliable deliveries. In this context, last-mile logistics is becoming increasingly important; it encompasses the final phase of the distribution process, which involves delivering a shipment from a local distribution hub directly to the end recipient. This stage is considered one of the most complex elements of the logistics system, as it is often carried out in densely urbanized areas, involving a large number of individual deliveries and high service quality requirements. At the same time, in response to the growing scale and complexity of distribution processes, logistics companies are implementing a variety of solutions to streamline delivery operations. These include, among other things, the use of modern IT systems supporting the planning and optimization of transport routes, the development of infrastructure enabling the pickup of shipments outside the recipient's place of residence, as well as the implementation of innovative transport technologies. Among the solutions used, parcel lockers and pickup points are playing an increasingly important role, as they help increase the flexibility of the delivery process and reduce the number of failed delivery attempts (Galkin et al., 2018). At the same time, the development of these solutions is increasingly being analyzed in the context of sustainable development, which includes, among other things, reducing the negative impact of transportation on the environment and making more efficient use of urban infrastructure.

The direction of development for modern logistics systems is largely determined by changing consumer behavior. Younger generations of market users play a particularly significant role in this regard, especially members of Generations Y and Z, who operate in an environment marked by rapid advancements in digital technology and widespread internet access. A high level of digital literacy, frequent use of online shopping, and greater awareness of social and environmental issues mean that the preferences of this group of consumers can significantly influence how distribution processes are organized. In particular, there is a growing interest in solutions that enhance the convenience of package delivery while simultaneously reducing the negative environmental impact of transportation.

Given the above circumstances, it is reasonable to gain a deeper understanding of the younger generation's preferences regarding last-mile logistics solutions. The purpose of this article is to examine the extent to which innovation and environmental considerations shape the younger generation's consumer behavior in the context of sustainable last-mile logistics. Despite the rapid growth of research on last-mile logistics and consumer behavior, particularly in e-commerce, a research gap remains, as the impact of environmental factors and innovative logistics solutions on the preferences of the younger generation of consumers has not been sufficiently explored. Previous studies have focused mainly on the operational efficiency of deliveries, cost optimization, or the development of logistics infrastructure, while to a limited extent analyzing the level of awareness among Generations Y and Z regarding the sustainable development of last-mile logistics and their willingness to accept eco-friendly and alternative forms of delivery.

2. Supply chain

Logistics is one of the key areas of modern business operations, responsible for planning, executing, and controlling the flow of goods, services, and information in economic processes (Cooper, Ellram, 1993). Its primary task is to ensure the efficient movement of products from their point of origin to the end recipient, while maintaining high-quality service and optimizing costs (Soler, 2024). Logistics operations encompass several core functions, primarily including transportation, warehousing, inventory management, and customer service (Gołembska, 2009). The execution of these logistics functions requires the coordination of activities among numerous entities involved in the process of delivering products to the market. These include, among others, raw material suppliers, manufacturers, logistics operators, distributors, and trading companies. The cooperation of these entities leads to the creation of a complex system of interconnections known as the supply chain. This concept refers to an integrated system of organizations and processes aimed at the efficient delivery of a product or service to the end customer. In addition to the flow of physical goods, the flow of information also plays a significant role, as it enables the coordination of activities among the various participants in the system

Today, the efficiency of supply chains (Szudrowicz, Ciesielski, 2003) is one of the most important factors influencing a company's competitiveness. In the context of economic globalization, intensifying competition, and rising customer expectations, organizations are compelled to continuously improve their logistics processes. This is because deliveries are expected to be fast, reliable, and flexible, allowing for adaptation to changing market needs. An effective supply chain should ensure a high level of customer service while reducing operating costs and minimizing waste of time and resources (Coyle et al., 2002). The drive to

increase supply chain efficiency is achieved through the implementation of various optimization measures. These include, among other things, shortening order fulfillment times, improving inventory management systems, eliminating unnecessary logistics operations, and reducing delays in the flow of goods. An important element of these efforts is also improving cooperation among business partners participating in the supply chain (Dos Santosa, Alcantary, 2015). Modern companies are also increasingly introducing changes in work organization and modifying their business models so that they better respond to dynamic market conditions. Examples include management concepts based on process integration, outsourcing of logistics services, and the development of partnerships among market participants. Technological innovations play a particularly important role in the process of improving supply chains. The ongoing digitization of the economy enables the use of advanced IT systems that support the planning, monitoring, and analysis of logistics processes. These tools allow for real-time tracking of the flow of goods, the collection and analysis of operational data, as well as the coordination of activities among individual supply chain participants in real time. As a result, companies can respond more quickly to changes in demand, minimize the risk of disruptions, and make more accurate strategic decisions. The implementation of innovations also includes the automation of warehouse processes, the development of intelligent transport systems, and the use of technologies supporting information management.

One area of logistics where the importance of operational efficiency is particularly evident is the CEP (courier, express, parcel) industry. This sector focuses on the fast and reliable delivery of shipments to end recipients and plays an increasingly important role in the functioning of the modern economy (Gulc, 2020; Kawa 2017). The dynamic growth of e-commerce, increasing consumer mobility, and changing purchasing preferences mean (Foltyński, 2016) that the demand for courier services is steadily rising. Customers expect not only short delivery times but also high flexibility in choosing the delivery method and the ability to track the status of their shipment.

The courier sector is growing rapidly, particularly on three continents: North America, Europe, and Asia. The most popular delivery method is parcel lockers (86 percent), the number of which is steadily increasing. Direct delivery to the home or workplace ranks second, followed closely by delivery to a partner location. All of these services are offered by courier companies operating in the Polish market (REE, 2024).

As a result, so-called “last-mile logistics”—the final stage of the delivery process, involving the transport of a shipment from a local distribution center directly to the recipient—takes on particular importance. This stage is considered one of the most demanding elements of the entire supply chain, as it involves the need to complete many individual deliveries in a short time and often under conditions of limited transportation infrastructure. At the same time, it is precisely at this point that direct contact between the company and the customer occurs, which means that the quality of delivery has a significant impact on the perception of the entire service.

3. Last-mile logistics

Last-mile logistics refers to the final stage of the distribution process, in which a product is transported from the last link in the supply chain (most often a distribution center, warehouse, or transshipment point) directly to the end customer. It is one of the most demanding and costly elements of the logistics system, and at the same time a stage of critical importance for assessing the quality of customer service. In practice, it is the moment of order delivery that constitutes the direct point of contact between the company and the consumer; therefore, the manner in which the delivery is carried out influences the level of customer satisfaction (Pluta-Zaręba, Rutkowski, 2005), their brand loyalty, and the overall perception of the quality of logistics services.

The importance of last-mile logistics has grown significantly, particularly with the rapid expansion of e-commerce. The rising number of online orders is placing greater strain on distribution systems and necessitating the adaptation of logistics processes to meet new consumer expectations. Customers increasingly demand short order fulfillment times, the ability to choose a convenient delivery date, and real-time tracking of their shipments. As a result, logistics companies are forced to seek solutions that increase operational efficiency while maintaining a high level of service.

Last-mile deliveries are most often entrusted to CEP (courier, express, parcel) operators, who specialize in handling courier and parcel shipments. However, operating in an urban environment means that this process involves numerous organizational challenges. High levels of urbanization, limited parking spaces, narrow streets, and heavy traffic make deliveries time-consuming and generate significant operational costs. For this reason, last-mile logistics is considered one of the most complex elements of the entire supply chain. Transportation in the final stage of distribution can be carried out using various modes of transport. Delivery vans are the most commonly used, but in urban areas, courier bicycles, scooters, and electric vehicles are also being used more and more frequently. Innovative solutions, such as the use of drones or autonomous delivery robots, are also emerging in the literature and in logistics practice. Depending on the nature of the shipment, specialized services are also utilized, including, for example, white-glove delivery of high-value products, transport of temperature-controlled goods, or the delivery and installation of electronic equipment (PanattoniEurope, 2024). One of the most significant challenges facing logistics companies is reconciling high customer expectations with the need to optimize operating costs (Gupta, Agrawal, 2018, Joshi, Rahman, 2015). In response to these needs, numerous innovative technological solutions are being implemented to support logistics process management. These include, among others, the use of eco-friendly modes of transport, systems for planning and optimizing delivery routes, analytical tools enabling demand forecasting, as well as applications allowing customers to track shipments in real time. The use of modern IT systems enables better coordination of couriers'

work, shorter order fulfillment times, and fewer operational errors (SAP, 2022), as well as improved customer satisfaction and a reduced environmental impact of logistics operations (Olkiewicz, Dyczkowska, 2025a). The use of modern IT systems enables better coordination of couriers' work, shorter order fulfillment times, and fewer operational errors, as well as improved customer satisfaction and a reduced environmental impact of logistics operations. As a result, last-mile logistics is becoming one of the key areas of development in modern logistics systems, integrating organizational, technological, and social elements.

Another significant challenge in last-mile logistics is the issue of failed delivery attempts. During standard courier operating hours, many recipients are at work, in educational institutions, or away from home, which makes direct delivery difficult. Additionally, broad delivery time windows and a lack of precise information about the delivery time can lead to the need for redelivery, increasing costs and extending the time required to complete the service. One solution designed to streamline the distribution process is "out-of-home" (OOH) delivery. This model involves routing packages to PUDO (pick-up/drop-off) locations selected by the customer or to APM (automated parcel machines). This solution allows recipients to pick up their packages at a time convenient for them, often within several days of delivery to the point. Consolidating shipments in a single location simultaneously reduces the number of courier trips, minimizes vehicle stops, and cuts operational costs. Parcel machines play a special role in the development of the OOH delivery model, functioning as local micro-distribution centers. In 2024, the number of APM locations for some operators stood at: 2000 for DHL; 21,969 for InPost; 1000 for Poczta Polska; and 6530 for DPD (Last Mile Experts, 2024). These devices enable 24/7 pickup and drop-off of shipments, which significantly increases the convenience of using logistics services. At the same time, PUDO points are also being developed, located, among other places, in stores, service points, kiosks, and gas stations. For example, in 2024, the number of points included: 10,000 at Żabka; 6000 at Orlen Paczka; 16,000 Poczta Polska, 3714 InPost, 19,723 DPD, and 18,500 DHL (Last Mile Experts, 2024). The popularity of parcel lockers is linked to the growth of online shopping. Some companies in the CEP sector offer their own parcel lockers for package pickup. Referring again to the 2023 Gemius report, the most frequently chosen parcel lockers by consumers making online purchases were identified. The most common and unrivaled choice among recipients is the parcel lockers of the Polish company InPost, accounting for as much as 95 percent. Second and third place go to ORLEN Paczka (23 percent) and Allegro One Box (22 percent), which are similarly preferred by consumers. Their location in places frequently visited by consumers allows for easy integration of package pickup with daily activities.

The growth of parcel pickup points helps improve the efficiency of last-mile logistics, but it also involves a partial shift of logistical responsibility to the recipient. Instead of receiving a package directly in person, the customer picks it up themselves from a selected pickup point or parcel locker. As a result, they become an active participant in the logistics process, which in the traditional model was handled entirely by the operator. The growth of out-of-home

delivery models, parcel lockers, and route optimization systems indicates that the future of last-mile logistics will increasingly rely on integrating technological innovations with the needs of modern consumers (Korneta, Lotko, 2021).

4. Consumer behavior among the younger generation

The contemporary consumer market is a significant area of scientific research, as purchasing decisions made by various social groups reflect their values, attitudes, needs, and expectations regarding goods and services (Borgardt, 2017). Analyzing consumer behavior allows us not only to understand the mechanisms of purchasing decisions but also to identify trends in the economy and society (Garoui, Jarboui, 2012). Of particular importance in this context are younger generations of consumers, who are increasingly shaping the contemporary market through their preferences, lifestyles, and use of new technologies.

Consumer behavior is the result of the interaction of many factors, both internal and external. On the one hand, it is shaped by changes in the socioeconomic, technological, and cultural environment; on the other hand, it is influenced by the individual needs and expectations of consumers seeking to maximize their satisfaction with their purchases. Consumption is understood as the process of acquiring and using goods and services to satisfy specific needs of an individual or household. This phenomenon is analyzed in many academic disciplines, including economics, sociology, and psychology, as it encompasses economic, social, and cultural aspects (McCrindle, Wolfinger, 2014; Rauvola et al., 2019).

Today, consumption also serves a communicative and informational function within the market system. On the one hand, it is an element of consumerism, which supports the development of competition, globalization, and technological innovation; on the other hand, it is associated with consumerism, which emphasizes the importance of an individual's needs, emotions, and aspirations in purchasing processes (Olkiewicz, Dyczkowska, 2025). Information generated by consumer behavior allows companies to better align their marketing strategies and product offerings with market expectations. The purchasing decision-making process is complex and involves several key components. The first is the cognitive aspect, related to existing knowledge, experience, and information obtained from various sources, such as the media, websites, or other users' reviews. The second element is the behavioral aspect, which refers to actual purchasing actions resulting from rational calculations, habits, or impulses. The third factor is the emotional dimension, encompassing feelings and attitudes that influence the evaluation of products, brands, or shopping experiences. The interaction of these elements makes consumer behavior multidimensional and difficult to predict with certainty (Janoś-Kresło, Mróz, 2006; Perchla-Włosik, Wardzała, 2015). The literature on the subject also points to a wide range of determinants influencing buyer behavior. The most

frequently analyzed include demographic factors (e.g., age, gender, education level, or place of residence), economic factors related to income level and purchasing power, social factors resulting from membership in specific groups or value systems, as well as technological, psychological, and legal factors (Błoński et al., 2023; Mazurek-Łopacińska, Sobocińska, 2018; Sobczyk, 2018; Fandrejewska, 2017). Technological determinants have gained particular significance in recent years, linked to the development of the internet, mobile devices, and digital communication channels, which have significantly changed the way people search for product information and complete purchasing transactions (Kucner et al., 2018).

Given the high complexity of consumer processes, researchers have developed various models to explain buyer behavior, such as the Howard-Sheth model and the Nicosia model (Aziewicz, 2023). These models take into account both individual factors and the influence of the market environment, highlighting the dynamic nature of consumer decision-making processes. The diversity of factors influencing purchasing decisions makes the analysis of consumer behavior a broad field of research, enabling the identification of market trends and changes in the structure of demand (Kotler et al., 2024; Kucner et al., 2018). Research on consumption currently focuses particularly on the younger generation of consumers, which primarily includes Generation Y (so-called millennials) and Generation Z. These groups are distinguished by a different approach to technology, communication, and lifestyle, which also influences their market behavior. Members of Generation Y grew up during a period of rapid development in digital technologies and the internet, which is why they are often referred to as "digital natives." Access to a vast amount of information and the rise of social media have significantly influenced how they seek information about products and services. Consumers in this group are typically well-informed, open to innovation, and aware of the importance of social and ethical values in business operations (Plichta, Pyżalski, 2013; Hennelly, Schurman, 2023; Korczyk-Ulman, 2023; Suvalova et al., 2021; Parzonko, 2015; Drzewiecki, Głębicka-Giza, 2018; Rudolph et al., 2018; Czarnecka, 2018; Biesbroek et al., 2010; Hagen et al., 2016; Cecchin et al., 2021; Hariram et al., 2023).

Another group of young consumers is Generation Z, which grew up in a fully digital environment. Unlike previous generations, these individuals have been active on the internet and social media from a very young age, which influences how they communicate, acquire knowledge, and make purchasing decisions. Social media, video platforms, and influencer recommendations play a significant role in shaping opinions about products and brands. At the same time, research indicates that members of Generation Z are paying increasing attention to ethical, social, and environmental issues, which translates into the growing importance of corporate social responsibility initiatives in shaping purchasing decisions (Cochoy et al., 2020; Morris, 2021)

It is also worth noting that young consumers (Generations Y and Z) are highly active in the digital environment and tend to search for product information online. The purchasing process often begins with analyzing other users' reviews, comparing offers, or following

recommendations on social media (Parzonko, 2015). At the same time, younger generations show greater openness to new forms of consumption, such as online shopping, resource sharing, and the use of digital services. Their purchasing decisions are strongly linked to the development of digital technologies, market globalization, and growing social and environmental awareness (Joshi, Rahman, 2015).

5. Methods

The efficient flow of materials within a specified timeframe and at a specific cost is crucial in an era of growing use of modern tools by end-users, particularly the younger generation. Consumer behavior shapes the scale and pace of consumption, which in turn affects the efficiency of logistics systems. The aim of this article is to examine the extent to which aspects of innovation and ecology shape the consumer behavior of the younger generation in the sustainable development of last-mile logistics. The research gap lies in the lack of knowledge and research findings regarding the aspects of innovation and ecology that shape the state of awareness and consumer preferences of the younger generation. The following research hypotheses were formulated for the purposes of this study:

- H1. The younger generation of consumers is aware of the need to implement innovative solutions in logistics.
- H2. The younger generation tends to prefer eco-friendly delivery methods.

The choice of the research method was deliberate because it ensured the respondents' anonymity, the low cost of conducting the research, and in particular easier access to a large number of recipients, in this case the young generation. The research tool was a survey questionnaire, which, in addition to the customer's personal data, included a group of questions related to: identifying preferences for delivery methods and times, perceptions of innovation and environmental friendliness in modern logistics solutions (including those not yet implemented), cost-effectiveness, and quality. Important to the study was the quick and easy distribution method, which allowed for word-of-mouth access to a broader group of participants on platforms, portals, and thematic groups related to the broadly understood world of shopping, e-commerce, environmental protection, and logistics. A limitation is the lack of direct verification of the respondent and the possibility (sometimes necessary) of re-answering in the event of uncertainty or misunderstanding.

The results of a CAWI survey conducted in 2025 among 335 young respondents (including 31% from Generation Y and 69% from Generation Z) revealed variations in the perception of the importance of factors influencing conscious consumption within the context of sustainable last-mile logistics. The survey included 50% women, 47% men, and 2% who did not wish to specify their gender. The largest group of respondents (38%) came from urban areas with

100,000 to 500,000 residents, followed by 27% representing areas with over 500,000 residents. 21% were respondents from towns (21,000-99,000 residents), 4% from towns with up to 20,000 residents, and as many as 10% of respondents represented rural areas. The respondents' educational levels varied, with 58% holding a college degree, 38% a high school diploma, and 4% a vocational diploma.

6. Results and Discussion

In order to better understand the consumer behavior of young people, it is important to determine how often they make online purchases. As many as 61% of respondents indicated that they shop online regularly (several times) a month, 17% indicated sporadically (a few times) a week, and as many as 22% of respondents indicated less than once a month. When analyzing the younger generation of consumers operating in the rapidly evolving e-commerce environment, they are increasingly guided by various conveniences within last-mile logistics, ensuring comfort, speed, and the ability to choose a convenient delivery date and method. The survey revealed an uneven distribution of responses regarding delivery preferences, as 59% chose a parcel locker (APM), 22% opted for home delivery, and 19% selected a local store pickup (PUDO).

The results indicate that the younger generation expects flexibility in line with their lifestyle, as clearly demonstrated by the growing popularity of a solution that offers convenience, eliminates the need to interact with a delivery person, and allows for pickup at a convenient time of day (Fig. 1).

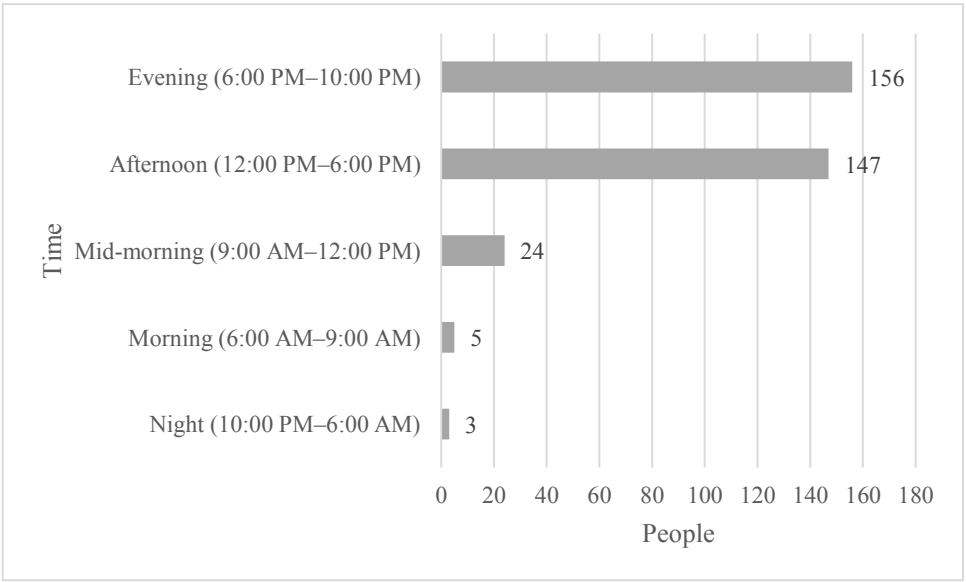


Figure 1. The most convenient time slot for package pickup.

The survey found that as many as 34% of respondents "always" use a parcel locker, 60% "often" while 2% said "rarely" and 4% of respondents said "don't know—can't say", 4% of respondents. This may indicate that the younger Generations Y and Z prioritize values such as sustainability, innovation, convenience, and safety. The ability to pick up a package at a time and place convenient for the customer, in a monitored location secured by an access code, allows customers to shape their requirements and expectations of potential product suppliers. This confirms Hypothesis 1. At the same time, existing conveniences are driving companies to develop innovative technological tools and solutions related to sustainable transport, particularly in the area of last-mile logistics. An analysis of the literature and the results of the study indicate that public awareness and corporate social responsibility in the area of environmental protection are growing through the implementation of innovative eco-friendly solutions in the context of order fulfillment, thereby shaping consumer preferences.

The first step toward environmental sustainability is utilizing the OOH delivery model, which reduces the frequency of courier visits caused by the recipient's absence at the designated delivery location (home), directly leading to lower exhaust emissions and a reduced carbon footprint. Another common practice is the use of an innovative solution such as real-time package tracking, which 38% of respondents always use, 47% sometimes use, 13% rarely use, and 2% never use. The survey showed that young people have a positive attitude (68%) toward deliveries via eco-friendly transport (car, bicycle, scooter); 14% of respondents have a negative attitude, and 17% have not formed an opinion, thereby confirming Hypothesis 2. This attitude among Generations Y and Z, despite their openness to modern solutions, has influenced their willingness to use deliveries via robot or drone. In practice, these solutions provide a sense of security and guarantee it, which is particularly important because "security of supply" is a key factor in the younger generation's online shopping preferences. (Fig. 2).

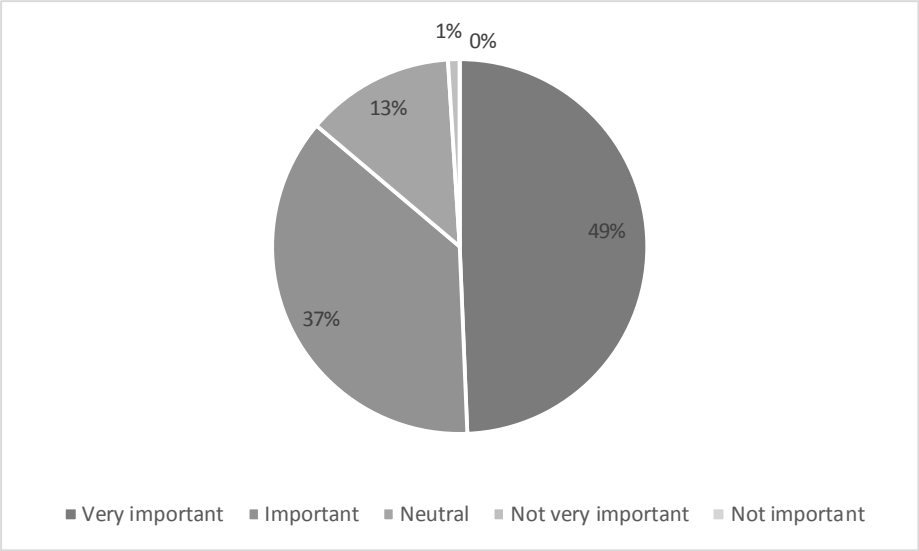


Figure 2. Security of supply as a preference for sustainable supply.

The survey revealed that only 12% of respondents have a positive attitude toward modern logistics solutions (with only 5% answering a decisive "yes"), 9% were undecided, and as many as 79% expressed a negative view. This distribution of responses indicates that although autonomous delivery technologies are perceived as innovative, their acceptance among the younger generation is still in its infancy and may stem from a lack of knowledge, trust, or experience with such delivery methods. Customers likely need more information, demonstrations of effectiveness, and assurances of safety before they accept such solutions as a viable alternative to traditional delivery methods. There was also a negative attitude among respondents (as high as 75%, including 56% who strongly said "no") toward the option of paying extra for delivery via eco-friendly transportation. Thirteen percent of respondents answered positively, and 12% were undecided.

Thanks to the ever-expanding opportunities for online shopping and the growing popularity of mobile devices with Internet access, mobile commerce, known as m-commerce, has emerged (Sarkar et al., 2020, p. 286). This form of commerce is treated as a new channel, though in practical terms it still pertains to online distribution (Skorupska, 2017, p. 26). It is generally described as one of the components of online commerce, though in exceptional cases it is treated separately, depending on the context. Modern e-commerce solutions utilize advanced technologies that streamline online shopping and enhance the customer experience.

Nevertheless, the survey results indicate that the younger generation, when considering various delivery options, including eco-friendly ones, in the context of sustainable delivery practices, tends to be rather skeptical despite the significant climate changes felt in recent years (Fig. 3).

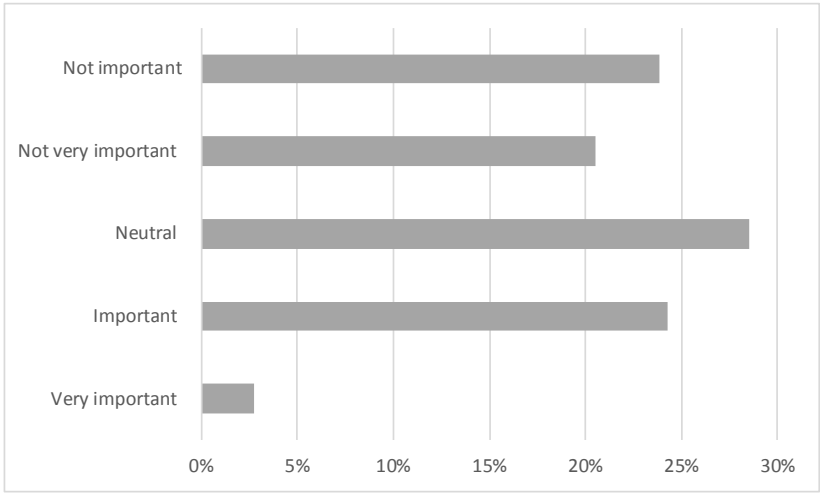


Figure 3. Preference for an eco-friendly solution as part of a sustainable supply chain.

Therefore product offerings are personalized and tailored to customers' needs. Data analysis facilitates this process by, among other things, tracking user behavior online. Social media commerce enables interaction and the exchange of opinions. An important element in this process is the security of both the buyer and the seller. Modern tools make online commerce more tailored to users and ensure adequate data protection.

An analysis of the results indicates that the younger generation is aware of the importance of environmental protection, but the idea of paying additional fees for this type of service is viewed negatively. This may mean that, given the high frequency of online shopping, the environmental aspect will not be as significant. Furthermore, a low level of skepticism or a lack of confidence in innovative transportation solutions may limit their development, while improving operations within the PUDO and APM frameworks.

7. Summary

Recent years have seen dynamic development in the e-commerce industry. Despite the growing demand for effective and flexible logistics solutions, particularly in last-mile delivery, analytical research in Poland and abroad is limited. Limited access to analytical data prevents in-depth comparative studies that would identify best practices or effective solutions. A few studies indicate that the expectations of young generations Z and Y, heightened by the era of digitalization, globalization, and consumerism, shape purchasing behaviors, including delivery methods and environmental awareness, which directly impacts the development directions of companies in the CEP sector. The aim of this article was to examine the extent to which aspects of innovation and ecology shape the consumer behavior of the young generation in the sustainable development of last-mile logistics. The results of this study, which fall within the research area of "Management and Quality Sciences" and other disciplines, indicate that the preferences of the young generation in delivery, particularly the last mile, are shaped by delivery methods such as parcel lockers (APM) and pickup points (PUDO). The data obtained confirms this trend presented in the "E-commerce in Poland 2022" report (Gemius, 2022). A key aspect of the study was the environmental aspect, which is becoming increasingly important in sustainable delivery solutions. This is particularly evident in the context of delivery methods, as they are most often perceived (defined) through the prism of cost. This finding was confirmed when respondents did not have to incur additional costs and chose (or were willing to choose) an eco-friendly mode of transport; otherwise, environmental considerations were irrelevant. The study also found that modern delivery methods have not yet gained widespread acceptance among young consumers. Nevertheless, last-mile logistics is an area that will evolve in close connection with consumer preferences, technological developments, and economic conditions. Therefore, a multi-faceted comparative analysis across EU countries should be conducted in the future.

References

1. Aziewicz, A. (2023). Modele postępowania konsumentów na rynku a wybrane czynniki wpływające na zachowania konsumentów na rynku energii elektrycznej w Polsce. *Ekonomia Międzynarodowa*, *44*, 5-26. https://doi.org/10.18778/2082-4440.44.01
2. Biesbroek, G.R., Swart, R.J., Carter, T.R., Cowan, C., Henrichs, T., Mela, H., Morecroft, M.D., Rey, D. (2010). Europe adapts to climate change: comparing national adaptation strategies. *Global Environmental Change*, *20*(3), 440-450. https://doi.org/10.1016/j.gloenvcha.2010.03.005
3. Błoński, K., Dąbrowska, A., Shulhina, L. (2023). Similarities and differences in the green attitudes of consumers from different age generations – international comparisons. *Acta Sci. Pol. Oeconomia*, *22*(4), 15-30, DOI:10.22630/ ASPE.2023.22.4.22
4. Borgardt, E. (2017). Motivation and Consumer Behaviour. *Konsumpcja i Rozwój*, *4*(21), 5-22.
5. Cecchin, A., Salomone, R., Deutz, P., Raggi, A., Cutaia, L. (2021). What is in a name? The rising star of the circular economy as a resource-related concept for sustainable development. *Circular Economy and Sustainability*, *1*(1), 83-97. https://doi.org/10.1007/s43615-021-00021-4
6. Cochoy, F., Licoppe, Ch., Petersson McIntyre, M., Sörum, N. (2020). Digitalizing consumer society: equipment and devices of digital consumption. *Journal of Cultural Economy, 13(1)*, 1-11. doi:10.1080/17530350.2019.1702576.
7. Cooper, M.C., Ellram, L.M. (1993). Characteristics of Chain Managment and the Implications for Purchasing and Logistics Strategy. *The International Journal of Logistics Management*, *4(2)*, 13-24, https://doi.org/10.1108/09574099310804957
8. Coyle, J., Bardi, E.J., Langley, C.J. (2002). *Zarządzanie logistyczne.* Warszawa: PWE.
9. Czarnecka, M. (2018). Information sources affecting consumer behaviour in the electricity market. *Management Sciences, 23*(2), 4-11. DOI: 10.15611/ms.2018.2.01
10. Dos Santos, M.G., Alcantara, R.L.C. (2015). *Management capabilities in supply chain resilience*. Proceedings of the POMS 26th Annual Conference. Waszyngton, USA.
11. Drzewiecki, P., Głębicka-Giza, B. (2018). *Mały Leksykon Postprawdy. Fake news*. Narodowy Instytut Wolności – Centrum Rozwoju Społeczeństwa Obywatelskiego. https://wid.org.pl/wp-content/uploads/E_wydanie-Ma%C5%82y-Leksykon-Postprawdy.pdf, 18.02.2026.
12. Fandrejewska, A. (2017). The Cultural and Social Context in an Analysis of Contemporary Consumer Behaviour. *Konsumpcja i Rozwój, 2*(*19*), 88-103.
13. Foltyński, M. (2016). Management tool for streamlining city logistics. *Transportation Research Procedia*, *16*, 89-103.

14. Galkin, A., Obolentseva, L., Balandina, I., Kush, E., Karpenko, V., Bajor, P. (2019). Last-Mile Delivery for Consumer Driven Logistics. *Transportation Research Procedia, 39,* 7483.
15. Garoui, N., Jarboui, A. (2012). Stakeholder theory, corporate governance, and cognitive mapping techniques. *International Refereed Research Journal*, *2*(2), 50-61.
16. Gemius (2022). *E-commerce w Polsce 2022*. https://gemius.com/pl/news/raport-e-commerce-2022-juz-dostepny/
17. Gemius (2024). *Raport e-commerce w Polsce w roku 2023*. Retrieved from: https://gemius.com/documents/54/RAPORT_e-commerce_2023.pdf , 20.04.2026.
18. Gołembska, E. (2009). *Logistyka w gospodarce światowej*. Warszawa: C.H. Beck.
19. Gulc, A.M. (2020). *Relacyjny model systemu kształtowania jakości usług kurierskich w branży e-commerce*. Białystok: Oficyna Wydawnicza Politechniki Białostockiej.
20. Gupta, S., Agrawal, R. (2018). Environmentally responsible consumption: Construct definitio, scale development, and validation. *Corporate Social Responsibility and Environmental Management*, *25*(4), 17-24.
21. Hagen, B., Middel, A., Pijawka, D. (2016). European climate change perceptions: Public support for mitigation and adaptation policies. *Environmental Policy and Governance*, *26*(3), 170-183. https://doi.org/10.1002/eet.1701
22. Hariram, N.P., Mekha, K.B., Suganthan, V., Sudhakar, K. (2023). Sustainalism: An integrated socio-economic-environmental model to address sustainable development and sustainability. *Sustainability*, *15*(13), 10682. https://doi.org/10.3390/su151310682
23. Hennelly, D.S., Schurman, B. (2023). *Bridging Generational Divides in Your Workplace*. London, UK: Harvard Business Review. https://hbr.org/2023/01/bridging-generational-divides-in-your-workplace
24. Janoś-Kresło, M., Mróz, B. (2006). *Konsument i konsumpcja we współczesnej gospodarce*. Warszawa: Szkoła Główna Handlowa w Warszawie.
25. Joshi, Y., Rahman, Z. (2015). Factors affecting green purchase behaviour and future research directions. *International Strategic Management Review*, *3*(1-2), 128-143
26. Kawa, A. (2017). *Analiza rynku KEP w Polsce*. Poznań: GS1 Polska.
27. Korczyk-Ulman, J. (2023). *Pokolenia konsumentów. Jak do nich mówić, żeby nas słuchali i kupowali?* Poland Kraków: Veneo, 34-43.
28. Korneta, P.A., Lotko, A. (2021). Determinanty i modele zachowań konsumenta. Wnioski z przeglądu literatury. *Marketing i Rynek*, *9*, 3-13.
29. Kotler, P., Hermawan, K., Iwan, S. (2024). *Marketing 6.0 Przyszłość jest immersyjna*. Warszawa: MT Biznes.
30. Kucner, A., Sierocki, R., Wasiluk, P. (Ed.) (2018). *Trendy. Interpretacje i konfrontacje*. Olsztyn: Instytut Filozofii UWM.
31. Last Mile Experts (2024). *Out of home delivery in Europe, PUDOs and automated parcel machines report*. https://lastmileexperts.com/index.php/reports-subscriptions/, 25.02.2026.

32. Mazurek-Łopacińska, K., Sobocińska, M. (2018). Ecologisation of consumption as a trend in consumer behaviour– implications for future research. *International Business and Global Economy*, *37*, 409-420.
33. McCrindle, M., Wolfinger, E. (2014). *The ABC of XYZ: Understanding the Global generations.* Bella Vista NSW: McCrindle Research.
34. Morris, A. (2021). Generations in the workplace training: How to train employees in a multi-generation workplace. *Employee Experience Magazine*. https://www.emexmag.com/generations-in-the-workplace-training/, 17.02.2026.
35. Olkiewicz, M., Dyczkowska, J.A. (2025). The Importance of Environmental Protection in Identifying Consumer Behavior Among the Young Population in the Area of Sustainable Energy Development. *Rocznik Ochrona Środowiska*, *27*, 799-815. https://doi.org/10.54740/ros.2025.064
36. Olkiewicz, M., Dyczkowska, J.A. (2025a). Green Logistics at Selected Logistics Operators in Poland. *Sustainability, 17(10)*, 4587. https://doi.org/10.3390/su17104587
37. PanattoniEurope (2024). *Efektywna logistyka ostatniej mili.* https://panattonieurope.com/pl-pl/aktualnosci/efektywna-logistyka-ostatniej-mili, 17.02.2026.
38. Parzonko, A.J. (2015). Wpływ mediów społecznościowych na zachowania konsumentów. *Handel Wewnętrzny,6(359),* 122-131.
39. Perchla-Włosik, A., Wardzała, J. (2015). Młodzi członkowie gospodarstw domowych jako konsumen ci mediów masowych w świetle badań jakościowych. *The Wroclaw School of Banking Research Journal, 15,* 397-405.
40. Plichta, P., Pyżalski, J. (Ed.) (2013). *Wychowanie i kształcenie w erze cyfrowej*. Łódź: Regionalne Centrum Polityki Społecznej w Łodzi.
41. Pluta-Zaręba, A., Rutkowski, K. (ed.) (2005). *Logistyka dystrybucji*. Warszawa: Szkoła Główna Handlowa.
42. Rauvola, R.S. Rudolph, C.W., Zacher, H. (2019). Generationalism: Problems and implications. *Organizational Dynamics, 48(4)*, 160-166.
43. REE 2024. *Raport Ecommerce Europe - European e-commerce report 2024*. Retrieved from: http://www.eurocommerce.eu/app/uploads/2024/10/european-e-commerce-report-2024-light-version.pdf , 24.04.2026.
44. Rudolph, C.W., Rauvola, R.S., Zacher, H. (2018). Leadership and generations at work: A critical review. *The Leadership Quarterly, 29* (1), 44-49.
45. SAP (2022). *Logistyka ostatniej mili: Rozwiązania dla zmieniającego się świata*. https://www.sap.com/poland/insights/last-mile-logistics.html, 17.02.2026.
46. Sarkar, S., Chauhan, S., Khare, A. (2020). A meta-analysis of antecedents and consequences of trust in mobile commerce. *International Journal of Information Management, 50*, 286-301.
47. Skorupska, J. (2017). *E-Commerce. Strategia. Zarządzanie. Finanse.* Warszawa: PWN.

48. Sobczyk, G. (2018). Współczesne uwarunkowania konsumpcji w Polsce i ich implikacje na rynku. *Handel Wewnętrzny, 3*(374), 347-357
49. Soler, D. (2024). *Digitalizing Transport Management.* Barcelona: Marge Books.
50. Suvalova T.V., Troitskiy, A.V., Zhaxybayeva, G.Sh. (Ed.). (2021). *Digital Economy and the New Labor Market: Jobs, Competences and Innovative HR Technologies*. Springer. DOI:10.1007/978-3-030-60926-9_11
51. Szudrowicz, A., Ciesielski, M. (2003). *Logistyka we współczesnym zarządzaniu*. Poznań: Wydawnictwo Akademii Ekonomicznej.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

SERIOUS GAMES FOR SUSTAINABLE BUSINESS TRANSFORMATION: EVIDENCE AND PRACTICE GAPS

Marcin OPAS[1*], Marcin WARDASZKO[2], Yulduz ALIMOVA[3]

[1] Department of Quantitative Methods & Information Technology, Kozminski University, Warsaw; mopas@kozminski.edu.pl, ORCID: 0000-0003-3941-1846
[2] Department of Quantitative Methods & Information Technology, Kozminski University, Warsaw; wardaszko@kozminski.edu.pl, ORCID: 0000-0001-5411-7894
[3] Doctoral School Kozminski University, Warsaw; yalimova@kozminski.edu.pl, ORCID: 0000-0002-4558-6581
* Correspondence author

Purpose: This paper aims to examine how serious games are used to support sustainable business transformation and to identify gaps between academic evidence and practice-oriented simulation tools.
Design/methodology/approach: The study adopts a two-stage review design. First, a structured literature review of English-language journal articles indexed in Scopus and Web of Science and published between 2015 and 2024 was conducted at the intersection of sustainability, serious games, and business transformation. Second, the academic review was complemented by an exploratory scan of publicly documented practitioner-oriented SDG-related business games and simulations. The analysis focused on game purpose, structure, target audience, facilitation context, evaluation evidence, and transfer to practice.
Findings: The structured review identified four peer-reviewed studies describing serious games relevant to sustainable business or organizational transformation. The available evidence was concentrated on cognitive and relational outcomes, including awareness-building, systems thinking, collaborative problem framing, stakeholder dialogue, and reflective learning, although the strength and design of the evaluations varied substantially.
Research limitations/implications: The academic review was limited to English-language journal articles indexed in Scopus and Web of Science. The exploratory scan depended on the availability and quality of publicly available documentation. Future research should use broader search strategies, include grey literature, and develop longitudinal evaluation designs capable of assessing cognitive, relational, normative, behavioral, and organizational outcomes.
Practical implications: Serious games can serve as useful entry points for corporate sustainability training, SDG awareness, strategic conversation, and experimentation with sustainability trade-offs. They should be embedded in broader change programs, including preparation, facilitated gameplay, structured debriefing, action planning, managerial sponsorship, and follow-up measurement.
Social implications: By supporting dialogue on sustainability trade-offs and stakeholder responsibilities, serious games may foster more reflective and participatory approaches to corporate sustainability and SDG implementation.

Originality/value: The paper integrates academic evidence with an exploratory assessment of practitioner tools, clarifying an emerging field and identifying priorities for serious game design, evaluation and application in sustainable business transformation.
Keywords: serious games; sustainable business transformation; SDGs; business simulations; organizational change.
Category of the paper: Literature review.

1. Introduction

Sustainable development has become a central strategic concern for contemporary organizations. Since the adoption of the Sustainable Development Goals (SDGs) in 2015, companies have been increasingly expected to contribute to economic, social, and environmental objectives through their strategies, operations, partnerships, and reporting practices (Jiménez et al., 2021; de Almeida et al., 2023). This expectation reflects the growing recognition that businesses are not only affected by sustainability challenges but also play an important role in addressing them. At the same time, translating broad global goals into concrete organizational priorities, investment decisions, operational practices, and performance measures remains difficult.

The complexity of the SDGs creates several challenges for organizations. The goals are interconnected, long-term, and often require decisions that involve trade-offs among financial, environmental, and social outcomes. Companies may therefore struggle to identify which goals are most relevant to their activities, how to incorporate them into business models and strategies, and how to balance competing stakeholder expectations (Sullivan et al., 2018; Montiel et al., 2021). Sustainable business transformation also requires more than formal commitments or reporting. It may involve changes in organizational culture, managerial routines, employee behavior, stakeholder relationships, and resource allocation. Such changes frequently generate uncertainty and resistance, particularly when sustainability objectives appear to conflict with short-term commercial priorities (De Matos, Clegg, 2013; van der Waal, Thijssens, 2020).

These conditions create a need for approaches that enable managers and other organizational stakeholders to explore sustainability challenges, discuss alternative courses of action, and examine the potential consequences of their decisions. Conventional training methods may be useful for communicating concepts and frameworks, but they are often less suited to representing the interdependencies, uncertainties, and competing interests that characterize sustainable business transformation. Serious games and gaming simulations offer a potentially valuable response to this problem because they allow participants to engage with simplified representations of complex systems, assume organizational roles, negotiate trade-offs, receive feedback, and reflect on the consequences of their choices in a controlled environment (Rumeser, 2018; Kikkawa et al., 2022).

In this paper, serious games are understood as structured game-based artifacts designed for purposes beyond entertainment. They combine rules, roles, resources, decisions, feedback, facilitation, and reflection to support learning, inquiry, dialogue, and decision-making (Meijer et al., 2025). They are distinct from gamification, which refers to the use of selected game elements in non-game contexts. This distinction is important because sustainable business transformation typically requires participants to engage with open-ended situations rather than solve problems with a single correct answer. Serious games may therefore provide a space in which participants can test assumptions, explore stakeholder perspectives, and examine the interaction between economic, social, and environmental consequences without exposing real organizations to direct operational risk.

Previous research has shown that game-based interventions can support knowledge acquisition, engagement, systems thinking, collaborative problem-solving, and attitude change in sustainability-related contexts (Janakiraman et al., 2018; Jääskä et al., 2021; Boncu et al., 2022). However, the evidence base remains fragmented. Much of the literature focuses on education, environmental awareness, or short-term learning outcomes, while relatively few studies examine whether serious games contribute to sustained behavioral, strategic, or organizational change in business settings. Meanwhile, practitioner-oriented sustainability simulations are increasingly used by consultancies, universities, foundations, and training providers, although their claimed effects are not always independently evaluated or reported in peer-reviewed publications.

This creates a gap between the apparent availability of practice-oriented tools and the strength of the evidence concerning their contribution to sustainable business transformation. The problem is not only whether such games exist, but also what purposes they serve, how they are designed and facilitated, what kinds of outcomes have been documented, and whether the effects extend beyond awareness and learning to changes in organizational practice. A clearer synthesis is therefore needed to distinguish established evidence from plausible but insufficiently validated claims.

The purpose of this paper is to examine how serious games are used to support sustainable business transformation and to identify the principal gaps between academic evidence and practice-oriented simulation tools. The study addresses the following research question:

What types of serious games currently exist that aim to support sustainable business transformation, and what gaps remain for future development?

The study adopts an exploratory, two-stage review design. It does not test a formal hypothesis. First, a structured review of peer-reviewed studies indexed in Scopus and Web of Science is conducted. Second, the academic evidence is complemented by an exploratory scan of publicly documented practitioner-oriented games and simulations. The two strands are analyzed separately to avoid treating developer descriptions as equivalent to independently evaluated research evidence.

The paper makes three contributions. First, it synthesizes the limited academic evidence on serious games explicitly connected with sustainable business transformation. Second, it compares this evidence with the broader landscape of practitioner-oriented tools. Third, it identifies an evidence–practice gap by showing that serious games appear to be better established as instruments for sustainability learning, dialogue, and reflection than as independently validated mechanisms for sustained organizational transformation.

The remainder of the paper is structured as follows. Section 2 reviews the literature on sustainable business transformation and the use of serious games in sustainability-related learning and change processes, concluding with the research gap and analytical perspective. Section 3 explains the review design, database selection, search strategy, eligibility criteria, exploratory practice scan, and synthesis procedure. Section 4 presents the results of the academic review and the practice-oriented scan, including a comparative analysis of the identified games. Section 5 discusses the findings in relation to previous research and develops their theoretical and practical implications. Section 6 summarizes the main conclusions, limitations, and directions for future research.

2. Literature review

2.1. SDGS and sustainable business transformation

The Sustainable Development Goals provide organizations with a common framework for addressing interconnected economic, social, and environmental challenges. Although the SDGs were originally formulated as global policy objectives, they have increasingly become reference points for corporate strategy, reporting, innovation, stakeholder engagement, and partnership development (Jiménez et al., 2021; Ordonez-Ponce et al., 2021). Companies may contribute to sustainable development by reducing negative impacts, creating positive social and environmental value, and aligning their core activities with selected goals and targets. The SDGs can therefore support strategic positioning, risk identification, opportunity recognition, and communication with stakeholders (WBCSD, 2015; Jones et al., 2016; Ordonez-Ponce, Khare, 2020).

However, integrating the SDGs into business practice is not a straightforward process. The framework includes 17 goals, 169 targets, and numerous indicators, creating a level of complexity that may be difficult to translate into organizational priorities and operational decisions. The goals are also interdependent, meaning that progress in one area may support, constrain, or conflict with progress in another (Nilsson et al., 2018). Organizations must therefore decide which goals are materially relevant, how they relate to the company's value chain and stakeholders, and how to allocate limited resources among competing sustainability priorities (Sullivan et al., 2018; Montiel et al., 2021).

A further challenge arises from the gap between the macro-level formulation of the SDGs and the micro-level realities of individual organizations. The SDGs were designed primarily as global and national development objectives, whereas companies operate within specific industries, markets, regulatory environments, and organizational cultures. Translating broad goals into measurable corporate objectives requires interpretation, prioritization, and adaptation (van Zanten, van Tulder, 2018). This translation process may introduce ambiguity because organizations often lack a shared understanding of what constitutes meaningful SDG implementation and how progress should be assessed.

Corporate engagement with the SDGs may also vary considerably in depth. Some organizations integrate sustainability into their business models, strategic decision-making, investment criteria, and performance systems. Others adopt the language of the SDGs mainly in response to external pressures or reputational expectations, without substantially changing established practices. This creates the risk of symbolic engagement or "SDG-washing", in which organizations communicate alignment with sustainable development while avoiding more demanding operational or strategic changes (Saizarbitoria et al., 2021). Genuine integration, therefore, requires more than mapping existing activities against selected goals. It involves reconsidering how value is created, how impacts are assessed, and how organizational priorities are negotiated.

Sustainable business transformation may include changes to business models, products, technologies, supply chains, procurement practices, managerial routines, and stakeholder relationships. It can also require redefining performance beyond short-term financial results. Companies often face tensions between immediate profitability and longer-term environmental and social objectives, particularly when sustainability investments generate uncertain returns or require changes in established operating models (van der Waal, Thijssens, 2020). These tensions make sustainability transformation a strategic and organizational challenge rather than merely a technical or reporting exercise.

Organizational culture is a critical condition for the successful integration of sustainability goals. Sustainability initiatives are less likely to become embedded when they remain peripheral to managerial decision-making or are assigned to a single department. A supportive culture requires shared understanding, consistent leadership, cross-functional cooperation, and the inclusion of sustainability considerations in everyday routines and decisions (Camelo, Nogueira, 2024). Organizational learning and knowledge management are also important because employees and managers must be able to interpret sustainability challenges, exchange knowledge across functional boundaries, and adapt existing practices (Iqbal, Ahmad, 2020).

Resource allocation constitutes another important barrier. Sustainability initiatives compete with other organizational priorities for financial, human, and managerial resources. Smaller organizations may experience particular difficulties because they often lack specialized sustainability functions, formal measurement systems, and extensive implementation capacity. The integration of sustainability into procurement and supply chain management, for example,

requires coordination across organizational boundaries and cooperation with suppliers whose objectives and capabilities may differ (Cooper, 2024). Effective implementation therefore depends not only on internal commitment but also on the ability to influence and collaborate with external partners.

Stakeholder engagement further increases the complexity of transformation. Organizations must consider the expectations of employees, customers, investors, suppliers, regulators, communities, and other stakeholders. These groups may differ in their understanding of sustainability, their priorities, and their willingness to accept short-term costs in exchange for long-term benefits. As a result, sustainable transformation frequently involves negotiation, conflict resolution, and the reconciliation of competing interests. It also requires transparent communication and credible evidence that organizational commitments are being translated into action.

These challenges suggest that sustainable business transformation should be understood as a process of organizational change rather than as the simple adoption of a set of external goals. Organizational change may generate uncertainty, resistance, and conflicts over resources, responsibilities, and strategic direction (De Matos, Clegg, 2013). Employees may question the necessity of proposed changes, perceive sustainability initiatives as additional workload, or doubt whether senior management is genuinely committed. Sustainable transformation therefore depends on the organization's capacity to build shared meaning, support participation, and connect global sustainability objectives with the practical concerns of organizational members.

Training and learning interventions can contribute to this process by helping managers and employees understand the relevance of the SDGs, recognize interdependencies, and explore the consequences of alternative decisions. Sustainability-related learning may strengthen awareness, engagement, collaboration, and the ability to incorporate environmental and social considerations into business practice (Bilderback, 2023; Teixeira et al., 2022). Nevertheless, the complexity of sustainability transformation limits the effectiveness of approaches based primarily on information transfer. Organizations need learning formats that allow participants to examine trade-offs, confront different stakeholder perspectives, and experiment with possible courses of action.

This creates a potential role for experiential and participatory interventions. Unlike conventional instructional approaches, such interventions can represent sustainability as a dynamic system of interacting decisions, consequences, and stakeholder interests. Serious games and simulation-based methods are particularly relevant in this context because they can provide a structured environment for exploring complexity, testing assumptions, and reflecting on organizational choices. The next section, therefore, examines serious games as learning and change interventions and considers the mechanisms through which they may support sustainability-related transformation.

2.2. Serious games as learning and change interventions

Serious games are designed for purposes that extend beyond entertainment. They use rules, roles, goals, resources, feedback, and decision structures to create environments in which participants can explore problems, test assumptions, and experience the consequences of their actions (Zyda, 2005; Djaouti, 2011). In management and organizational contexts, serious games are often used to support learning, decision-making, collaboration, and reflection. Business simulations represent a related category in which participants manage simplified representations of organizations, markets, projects, or value chains and make decisions under conditions of uncertainty (Feinberg, Johnson, 1988; Klabi, Klabi, 2012).

The terminology used in this field is not always consistent. Serious games, simulation games, business simulations, game-based learning, and gamification are sometimes treated as interchangeable, although they refer to different forms of intervention. Serious games and simulation games are complete systems with defined rules, participant roles, decision spaces, and consequences. Gamification, by contrast, involves adding selected game elements, such as points, badges, rankings, or challenges, to activities that are not games in themselves. This distinction is important because the present study focuses on complete game or simulation artifacts that allow participants to engage with a problem environment rather than on isolated motivational mechanisms.

From a game science perspective, a serious game should not be understood solely as a teaching tool or a digital product. It is better viewed as a structured social and cognitive system in which meaning emerges from the interaction between rules, roles, resources, participants, facilitation, and reflection (Meijer et al., 2025). The educational or organizational value of a game, therefore, does not reside only in its content. It also depends on how participants interpret the situation, how they interact with one another, what feedback they receive, and how the experience is connected to real-world practice.

Serious games are closely associated with experiential learning. Participants learn by acting within a simulated environment, observing the consequences of their decisions, and reflecting on the results. This sequence is consistent with experiential learning approaches in which concrete experience is followed by reflection, conceptualization, and further experimentation (Kolb, 1984). Games can therefore provide opportunities to move beyond passive knowledge acquisition and engage learners in repeated cycles of action and feedback.

The capacity to experiment is one of the principal advantages of serious games. In organizational settings, many strategic and managerial decisions involve uncertainty, interdependence, and potentially significant consequences. Testing alternative approaches in real organizations may be costly, risky, or impractical. A simulation allows participants to examine possible courses of action in a controlled environment, where failure becomes a source of learning rather than an operational threat (Kikkawa et al., 2022). Participants can compare strategies, observe delayed effects, and reconsider assumptions without exposing an actual organization to direct harm.

Serious games can also support systems thinking. A single factor rarely causes organizational problems, and decisions taken in one functional area may produce consequences elsewhere. By representing relationships between variables, actors, and outcomes, games can help participants recognize feedback loops, unintended consequences, and competing objectives. Even relatively simple simulations can make causal relationships more visible by reducing the complexity of reality to a manageable set of decisions and indicators (Endress et al., 2023).

Another important mechanism is role-based learning. Participants may be asked to represent managers, employees, customers, suppliers, regulators, or other stakeholders. Assuming a role can expose them to perspectives different from their own and help them understand why actors interpret the same problem differently. In business simulations, participants often make decisions from the perspective of specific organizational functions, such as operations, finance, marketing, or procurement. This structure can reveal conflicts between local objectives and overall organizational performance.

The social dimension of gameplay is equally important. Many serious games require participants to cooperate, negotiate, exchange information, and coordinate decisions. These activities can develop communication skills, shared understanding, and collective problem-solving capacity. Business simulations may also expose differences in assumptions and priorities that remain hidden in conventional discussions. In this sense, games can act as boundary objects that provide participants from different functions or professional backgrounds with a common situation and language for examining complex problems.

However, interaction alone does not guarantee learning. The outcomes of serious games depend substantially on facilitation and debriefing. Facilitation helps participants understand the rules, remain engaged, and connect the simulated situation with the purpose of the intervention. Debriefing enables them to reconstruct what occurred, explain their decisions, examine unexpected results, and relate the experience to broader concepts or organizational challenges (Kriz, 2010). Without structured reflection, participants may focus on winning, operational details, or entertaining aspects of the game while overlooking the intended learning outcomes.

Debriefing is particularly important when games address open-ended problems. In such settings, there may be no single optimal strategy or correct answer. The value of the intervention lies instead in comparing interpretations, examining trade-offs, and understanding the assumptions behind different decisions. A skilled facilitator can help participants move from observations about the game to conclusions about real organizational systems. This transfer from simulated experience to practice is essential if the intervention is intended to influence managerial behavior or organizational change.

Research has generally shown that serious games can improve engagement, motivation, knowledge acquisition, and selected cognitive outcomes (Wouters, 2013). Business simulations have also been associated with the development of decision-making skills, entrepreneurial

attitudes, and understanding of cross-functional relationships (Blakely et al., 2018; Nkhoma et al., 2014). Nevertheless, the evidence is not uniform. Outcomes differ depending on game design, participant characteristics, duration, facilitation quality, assessment methods, and the organizational or educational context in which the game is used.

A further limitation concerns the transfer and persistence of effects. Immediate reactions, satisfaction, or knowledge gains are easier to measure than changes in behavior or organizational practice. Participants may perform well in a simulation without applying the same reasoning in their workplace. Organizational routines, incentive systems, managerial support, resource constraints, and cultural norms can prevent the application of insights generated during gameplay. Consequently, serious games should not automatically be treated as stand-alone change mechanisms.

Their contribution is more likely to be significant when they are embedded in broader learning or organizational development processes. Such processes may include preparation before the game, facilitated reflection, action planning, managerial sponsorship, opportunities to test new practices, and follow-up evaluation. The game can create a shared experience and stimulate reflection, but sustained change usually requires additional organizational conditions and reinforcement.

These characteristics make serious games potentially relevant to sustainable business transformation. Sustainability problems involve interdependent systems, long-term consequences, conflicting stakeholder interests, and uncertainty regarding the effects of managerial decisions. Games can represent these conditions in an accessible form and allow participants to explore them through action and dialogue. The following section examines how serious games have been applied in sustainability education and sustainable development contexts, and what outcomes have been reported.

2.3. Serious games for sustainability

Serious games have increasingly been used to support sustainability-related learning, awareness, and decision-making. Sustainability challenges are particularly well-suited to game-based interventions because they involve complex systems, long-term consequences, competing stakeholder interests, and uncertainty about the effects of individual and collective actions. Games can make these relationships more visible by transforming abstract sustainability concepts into concrete decisions, roles, and consequences.

In educational settings, game-based learning has been associated with higher engagement and a deeper understanding of sustainability issues. Interactive scenarios allow participants to explore how environmental, social, and economic factors interact and to observe how decisions made in one area may generate consequences elsewhere (Jääskä et al., 2021). Learner-centered game design can also support knowledge transfer by encouraging participants to apply sustainability concepts rather than merely reproduce them (Oliveira et al., 2021).

Role-playing and simulation formats are particularly relevant because they expose participants to multiple perspectives. Sustainability problems rarely involve only one decision-maker or one objective. Participants may need to represent businesses, public authorities, consumers, communities, or other stakeholders with differing priorities. By negotiating these perspectives, players can better understand the conflicts and interdependencies that shape sustainability decisions. Blanchard and Buchs (2015), for example, showed that role-play can clarify sustainable development concepts while also supporting interpersonal and collaborative skills.

Games can also foster a sense of agency. Sustainability issues are often perceived as distant, highly technical, or beyond the influence of individuals and organizations. Simulation-based activities can reduce this distance by allowing participants to experience how specific choices affect environmental and social outcomes. Studies in sustainability education indicate that hands-on and participatory approaches can strengthen responsibility, engagement, and willingness to address sustainability challenges (Nascimento et al., 2023).

A further advantage of serious games is their potential to support systems thinking. Feedback loops, delays, trade-offs, and unintended consequences characterize sustainability problems. Conventional teaching methods may describe these relationships, but games enable participants to experience them in a dynamic way. By observing how decisions accumulate over time, players can develop a better understanding of the systemic nature of sustainability challenges and the limitations of isolated interventions.

Existing research also suggests that serious games can contribute to environmental knowledge and awareness. Boncu et al. (2022), in a systematic review of serious games and gamified applications, found generally positive effects on pro-environmental knowledge, attitudes, and selected behaviors. Similarly, Ivens et al. (2020) reported that a digital simulation game addressing sustainable agriculture supported participants' knowledge and self-efficacy. These findings indicate that games can make sustainability concepts more accessible and provide learners with opportunities to practice decision-making in a low-risk environment.

Attitudinal change is another frequently reported outcome. Janakiraman et al. (2018) found that game-based learning can influence attitudes towards environmental sustainability by enabling participants to experiment with alternative behaviors without fear of real-world failure. This safe environment may reduce resistance to unfamiliar ideas and encourage reflection on the consequences of established practices. However, changes in attitudes do not necessarily translate into sustained behavioral change, particularly when participants return to organizational or social contexts that do not support new practices.

The use of competitive and cooperative mechanics can further influence engagement. Competition may increase attention and motivation, while cooperation can encourage information sharing and collective problem-solving. In sustainability contexts, cooperative structures are often especially valuable because many problems require coordinated action across organizational and institutional boundaries. Games that combine competition and

collaboration can help participants experience the tension between individual or organizational interests and collective sustainability outcomes.

Technology has expanded the range of sustainability games and how they can be delivered. Digital simulations, online platforms, and augmented reality applications can increase accessibility, provide immediate feedback, and enable visualization of complex environmental processes. Wang et al. (2021), for example, showed that augmented reality games can increase environmental awareness and support pro-environmental learning through interactive experiences. Nevertheless, technological sophistication alone does not guarantee educational or organizational effectiveness. The quality of the scenario, decision structure, feedback, facilitation, and debriefing remains critical.

Several studies have examined serious games in environmental and climate-related contexts. Douglas and Bräuer (2021) identified gamification and game-based applications as potentially useful tools for raising climate awareness and encouraging sustainable action. Madani et al. (2017) similarly argued that serious games can support environmental management by enabling participants to explore complex resource-allocation and policy problems. The Climate Adaptation Game, discussed by Neset et al. (2020), illustrates how game-based formats can integrate systems thinking, stakeholder dialogue, and action-oriented learning to address climate risks.

Board games and facilitated workshop formats have also been used to explore the Sustainable Development Goals. Chen and Ho (2022) demonstrated that a board game can support discussion and understanding of the SDGs by making the relationships among goals more tangible. Such formats can be particularly effective in group settings because they create a common reference point for discussion and allow participants to compare interpretations and priorities.

Despite these promising findings, the existing literature is dominated by educational and short-term outcomes. Most studies focus on knowledge acquisition, engagement, awareness, self-efficacy, or attitudes. These outcomes are important, but they provide limited evidence of sustained behavioral change, strategic reorientation, or organizational transformation. Even when participants report positive learning experiences, it is often unclear whether these effects persist or influence subsequent decisions in real organizational settings.

The sustainability games literature also covers a wide range of contexts, including schools, universities, environmental education, agriculture, urban planning, and climate adaptation. Although this diversity demonstrates the flexibility of game-based approaches, it makes it difficult to draw specific conclusions about business transformation. Findings from educational settings cannot be automatically transferred to corporate environments, where organizational structures, incentives, leadership, resource constraints, and commercial priorities shape implementation.

Another limitation concerns evaluation. Many studies rely on self-reported reactions, post-game surveys, or short-term measures collected immediately after gameplay. Fewer studies use comparison groups, repeated measures, behavioral indicators, or longitudinal follow-up. Consequently, the available evidence is stronger for immediate learning and engagement than for long-term behavioral or organizational outcomes.

Overall, serious games appear to offer considerable potential for supporting sustainability-related learning, systems thinking, stakeholder dialogue, and reflective decision-making. However, the extent to which they contribute to sustainable business transformation remains uncertain. The next section therefore identifies the specific research gap this study addresses and explains the analytical perspective used to compare academic evidence with practice-oriented sustainability simulations.

2.4. Research gap and analytical perspective

The literature reviewed above indicates that serious games can support sustainability-related knowledge, engagement, systems thinking, stakeholder dialogue, and selected attitudinal outcomes. Existing studies also show that games can create safe environments in which participants explore complex problems, test alternative decisions, and reflect on their consequences (Janakiraman et al., 2018; Jääskä et al., 2021; Boncu et al., 2022). However, the available evidence does not yet provide a sufficiently clear account of how serious games contribute specifically to sustainable business transformation.

The first gap concerns the dominant context of previous research. Much of the literature addresses sustainability education, environmental awareness, climate communication, or learning in schools and universities. These studies provide useful evidence on engagement and knowledge acquisition, but their findings cannot be directly applied to organizational transformation. Corporate settings introduce additional conditions, including formal authority structures, functional specialization, strategic priorities, incentive systems, resource constraints, and accountability for commercial performance. A game that improves understanding in an educational setting may not necessarily influence managerial decisions, organizational routines, or investment priorities.

The second gap concerns the types of outcomes that are evaluated. Existing studies predominantly measure immediate or short-term effects, such as participant satisfaction, perceived engagement, knowledge, awareness, self-efficacy, or attitudes. These outcomes are relevant because they may constitute early stages of a broader change process. Nevertheless, they do not demonstrate that participants subsequently alter their behavior or that organizations change their strategies and practices. Evidence becomes substantially more limited when the expected outcome shifts from cognitive and relational learning towards behavioral, strategic, or organizational transformation.

This distinction is particularly important because sustainable business transformation requires more than awareness of sustainability problems. It may involve changes to business models, procurement criteria, resource allocation, cross-functional cooperation, performance measures, and stakeholder relationships. Such changes occur over longer periods and depend on organizational conditions that extend beyond the game session. Consequently, positive post-game reactions should not be interpreted automatically as evidence of sustained transformation.

The third gap relates to the reporting and evaluation of game interventions. Studies differ considerably in the extent to which they describe game rules, participant roles, decision structures, feedback mechanisms, facilitation, debriefing, and implementation context. They also use heterogeneous evaluation methods and outcome measures. This variation makes it difficult to compare interventions and identify which design characteristics are associated with particular outcomes. In some cases, the game itself is described in detail while the evaluation is limited. In others, outcome measures are reported without sufficient information about the intervention that produced them.

The fourth gap concerns the relationship between academic research and professional practice. Consultancies, universities, foundations, and specialist training providers offer a growing number of sustainability-oriented games and business simulations. These tools suggest that game-based approaches are already being applied in corporate sustainability training and strategic workshops. However, publicly available descriptions are often promotional and provide limited information about evaluation procedures, participant samples, or sustained outcomes. Developer materials and user testimonials may indicate perceived usefulness, but they cannot be treated as equivalent to independently reviewed empirical evidence.

The emerging field therefore displays an evidence–practice gap. Practice-oriented tools appear to be more numerous than the peer-reviewed literature suggests, yet their contribution to behavioral and organizational change is rarely assessed independently. At the same time, academically documented games are relatively few and are often evaluated primarily in terms of learning-related outcomes. A review restricted to peer-reviewed studies would therefore provide an incomplete picture of the available tools, whereas an assessment based only on practitioner documentation would risk overstating their effectiveness.

This study addresses that problem through a two-stage design. The first stage examines peer-reviewed academic studies that explicitly connect serious games to sustainability and to business, management, organizational, or strategic transformation. The second stage maps publicly documented practitioner-oriented tools separately. This distinction is maintained throughout the analysis to prevent conflation of evidence from academic studies with claims in developer documentation. The exploratory scan is used to identify practice trends, design patterns, and research opportunities rather than to establish effectiveness.

To structure the comparison, the study applies four analytical dimensions. The first is purpose and transformation logic, which concerns the problem the game addresses, the type of change it is intended to support, and the relationship between gameplay and the expected transformation outcome. This dimension distinguishes, for example, between games designed mainly to raise awareness and those intended to support strategy development, business model innovation, or organizational adaptation.

The second dimension is game structure and action space. It includes participant roles, decision variables, interaction patterns, feedback, competition or cooperation, scenario development, and the extent to which players can influence the simulated system. his dimension is relevant because games may present sustainability either as a set of predefined choices or as an open-ended problem requiring negotiation and collective interpretation.

The third dimension is the target audience and facilitation context. It considers who participates, whether the game is designed for students, managers, professionals, mixed stakeholder groups, or organizational teams, and how facilitation and debriefing support the intervention. This dimension also captures the duration, delivery format, and degree of adaptation to a specific organizational or sectoral context.

The fourth dimension is evidence of outcomes and transfer to practice. It distinguishes among cognitive, relational, normative, behavioral, and organizational outcomes. It also considers the evaluation design, the timing of measurement, the use of comparison groups, and whether the reported effects extend beyond the game session. This distinction enables the separation of documented learning outcomes from claims of sustained business transformation.

On this basis, the study addresses the following research question:

What types of serious games currently exist that aim to support sustainable business transformation, and what gaps remain for future development?

The study is exploratory and does not test a formal hypothesis. Its objective is to clarify the current state of evidence, compare the main characteristics of identified games, and determine where claims of transformational potential exceed the available empirical support. By combining a structured academic review with a separate exploratory scan of practitioner tools, the paper seeks to provide a more balanced account of both the field's development and its principal methodological and practical limitations.

3. Methodology

3.1. Review design

This study adopted a two-stage review design combining a structured review of peer-reviewed academic literature with a separate exploratory scan of practitioner-oriented serious games and business simulations. The design was selected to capture both the state of research evidence and the broader landscape of tools used in professional practice.

The first stage consisted of a structured literature review. Its purpose was to identify peer-reviewed studies examining serious games or simulation-based interventions at the intersection of sustainability and business, management, organizational change, or strategic transformation. The review followed a transparent sequence of database selection, search, screening, eligibility assessment, data extraction, and comparative synthesis. This approach was intended to improve the study's reproducibility and reduce the risk of selecting cases solely based on their visibility or perceived relevance.

The academic review focused on studies published between 2015 and 2024. The beginning of this period coincides with the adoption of the United Nations Sustainable Development Goals. It reflects the emergence of the SDGs as an important framework for business strategy, management education, and organizational sustainability. The review was limited to English-language peer-reviewed journal articles to maintain a consistent minimum standard of scholarly reporting and enable comparison across studies.

The second stage consisted of an exploratory scan of publicly documented practitioner-oriented games and simulations. This stage was added because sustainability-related tools used in corporate training, strategic workshops, and organizational development are frequently developed by consultancies, universities, foundations, or specialist training providers and may not be described in peer-reviewed publications. Restricting the study to academic databases would therefore have provided only a partial view of the field.

The exploratory scan was designed as a mapping exercise rather than as a systematic review of effectiveness. Its purpose was to identify publicly available tools, describe their intended users and design characteristics, and examine the extent to which their claimed outcomes were supported by accessible evidence. Developer websites, training descriptions, game repositories, professional portals, award databases, and expert contacts were used to identify candidate tools.

The two stages were analyzed separately. Peer-reviewed studies were treated as sources of academic evidence, whereas practitioner documentation was treated as descriptive material concerning the availability, positioning, and design of practice-oriented tools. Claims reported by developers, training providers, or users were not interpreted as equivalent to independently evaluated outcomes.

The two-stage design therefore served two complementary purposes. The academic review established what has been examined and documented in scholarly research. The exploratory scan showed what appears to be available and used in practice. Comparing the two strands made it possible to identify differences in the development of the market for sustainability-oriented serious games and in the strength of the empirical evidence regarding their outcomes. Because the study was exploratory, no formal hypothesis was tested. The analysis was intended to identify recurring patterns, differences, and evidence gaps across the games and simulations identified. Both stages were examined using the analytical dimensions introduced in Section 2.4: purpose and transformation logic; game structure and action space; target audience and facilitation context; and evidence of outcomes and transfer to practice.

3.2. Database selection and search strategy

The academic search was conducted in Scopus and Web of Science. These databases were selected because they provide broad and partly complementary coverage of peer-reviewed research in business and management, environmental science, education, engineering, computer science, economics, and the social sciences. This multidisciplinary coverage was necessary because research on serious games for sustainable business transformation is dispersed across several disciplinary fields rather than concentrated in a single publication stream.

Scopus and Web of Science also support transparent and reproducible search procedures. Both databases allow structured Boolean queries and the application of filters for publication period, language, document type, and subject area. Searching both databases reduced the risk of omitting relevant studies because their journal coverage overlaps but is not identical.

The search was conducted from November 2023 to March 2025 and was limited to English-language, peer-reviewed journal articles published between 2015 and 2024. The year 2015 was selected as the starting point because it marks the adoption of the United Nations Sustainable Development Goals and the subsequent growth of interest in their application to corporate strategy, management education, and organizational transformation.

The search strategy combined three conceptual blocks derived from the research question:

1. sustainability and the Sustainable Development Goals,
2. serious games and related game-based interventions, and
3. business transformation, organizational change, and strategic management.

The first block included terms referring to the SDGs, corporate sustainability, corporate social responsibility, and sustainable business practices. The second covered serious games, simulation games, game-based learning, training games, and related interventions. The third included business transformation, organizational change, business strategy, and strategic planning.

The term gamification was included in the search stage to improve sensitivity, as the terminology used in the literature is not always consistent. However, publications that addressed only isolated game elements, such as points, badges, rankings, or rewards, were excluded during screening unless they described a complete game or simulation artifact. This procedure maintained consistency with the conceptual distinction introduced in Section 2.2.

Subject-area filters were applied to improve the search's relevance while retaining its interdisciplinary scope. The filters extended beyond business and management, as sustainability-oriented games may be reported in environmental science, education, engineering, computer science, or social science journals, even when their application concerns organizational decision-making or business transformation. The complete search formula and database-specific filters are provided in Appendix A.

The search generated 102 records in Web of Science and 97 in Scopus, for a total of 199 records before duplicate removal. The subsequent duplicate removal, title and abstract screening, and full-text eligibility assessment are described in Section 3.3.

The strategy prioritized precision by requiring publications to address all three conceptual domains. This reduced the number of records concerning general environmental education or game-based learning that lacked a recognizable business or organizational context. At the same time, the strategy may have omitted relevant studies that use adjacent terminology, including sustainability transitions, circular economy, climate resilience, responsible innovation, transition management, regenerative business, or organizational learning. This limitation is addressed in Section 5.5 and informs the future research agenda presented in Section 5.6.

3.3. Eligibility and screening

The database searches produced 199 records: 102 from Web of Science and 97 from Scopus. The records were combined into a single dataset, after which duplicates and multiple records referring to the same study were removed. The remaining records were assessed through two consecutive stages: title and abstract screening, followed by full-text eligibility assessment.

Studies were eligible for inclusion when they met all of the following criteria:

- they were peer-reviewed journal articles published in English between 2015 and 2024,
- they described or evaluated a complete serious game, simulation game, business simulation, or closely related game-based intervention,
- the intervention addressed sustainability, sustainable development, or the Sustainable Development Goals,
- the study was situated in a business, management, organizational, strategic, or professional context relevant to sustainable business transformation, and
- the publication provided sufficient information to assess the purpose of the intervention, its target group, its principal design characteristics, and the evidence concerning its outcomes.

Eligibility required explicit relevance to all three substantive domains of the review: a game or simulation intervention, a sustainability-related purpose, and a business or organizational transformation context. This intersection was deliberately applied to distinguish the review from broader bodies of research on environmental education, general sustainability awareness, or game-based learning that lack managerial or organizational application.

Studies were excluded when they:

- focused solely on children's or school-level education,
- addressed general environmental awareness without a clear business, management, organizational, or strategic context,
- examined gamification through isolated elements such as points, badges, rankings, or rewards without describing a complete game or simulation artifact,
- concerned games designed primarily for entertainment without a documented serious purpose,
- discussed sustainability or serious games only conceptually without presenting an identifiable intervention,
- did not provide sufficient information to determine whether the intervention met the inclusion criteria, or
- fell outside the defined publication period, language, document type, or peer-review requirements.

During the first screening stage, titles and abstracts were examined to determine whether the publication appeared to address all three domains. Records clearly unrelated to the research question were excluded at this stage. When relevance could not be determined from the title and abstract alone, the publication was retained for full-text assessment.

During the second stage, the full texts of potentially relevant publications were assessed against the complete eligibility criteria. Particular attention was given to whether the publication described a complete game or simulation, whether sustainability was an explicit purpose rather than a peripheral theme, and whether the intervention was connected with business, management, organizational change, strategic planning, or professional practice.

Where several publications or database records referred to the same study or game intervention, they were treated as a single case for the synthesis. Publications were retained only when they provided sufficiently direct evidence concerning the intervention and its application. Studies dealing exclusively with gamification or general sustainability education were not included in the academic synthesis, even when they were used elsewhere in the paper to contextualize the broader literature.

Following duplicate removal, title and abstract screening, and full-text eligibility assessment, four academic studies met all inclusion criteria and were retained for analysis. These studies concerned MainKassandra (Fischer et al., 2024), the Theory of Change Game (Tribaldos, Schneider, 2021), the Sustainability Futures Game (Ampatzidou et al., 2022), and The Road to Flourishing (Niessen et al., 2024).

The limited final number of studies reflects the deliberately narrow intersection defined by the research question. A publication had to address not only sustainability and a game-based intervention but also a recognizable business, management, organizational, or strategic transformation context. The implications of this narrow yield for the review's interpretation and completeness are considered in the Discussion.

3.4. Exploratory practice scan

The exploratory practice scan was conducted to complement the academic review by providing information on sustainability-oriented games and simulations available in professional practice. This additional stage was necessary because tools used in corporate training, strategic workshops, management education, and organizational development are not always described in peer-reviewed publications. Many are developed and distributed by consultancies, universities, foundations, specialist training providers, or serious-game designers and are documented primarily through websites, brochures, demonstration materials, or facilitator descriptions.

The scan was conducted between November 2023 and March 2025. Candidate tools were identified through Google searches, serious-gaming portals, game repositories, international gaming award databases, developer and provider websites, and expert contacts. Searches combined terms related to serious games, business simulations, sustainability, the Sustainable Development Goals, corporate responsibility, management training, and organizational transformation.

The practice scan was exploratory rather than systematic. Its purpose was to identify visible examples of tools used or promoted in professional contexts, describe their main characteristics, and examine the extent to which publicly available documentation supported claims about their outcomes. It was not designed to provide a comprehensive inventory of all existing sustainability games or to establish their effectiveness.

A tool was eligible for inclusion when it met the following criteria:

- it was publicly identifiable as a complete game, simulation, or facilitated game-based intervention,
- it addressed sustainability, sustainable development, the SDGs, or related environmental and social business challenges,
- it was intended for business, management, professional, organizational, or higher-education audiences,
- it involved decision-making, strategy development, stakeholder interaction, or the exploration of organizational sustainability trade-offs, and
- sufficient public documentation was available to assess its purpose, target group, delivery format, principal gameplay characteristics, and sustainability scope.

Tools were excluded when they were designed primarily for entertainment, focused exclusively on children or the general public for awareness without a clear business or management context, consisted solely of isolated gamification elements, or lacked sufficient documentation for meaningful assessment. Tools whose websites or promotional materials provided only a name or a general sustainability claim, without information about gameplay or intended application, were also excluded.

For each eligible tool, publicly available information was collected on its developer or provider, target audience, intended purpose, physical or digital format, participant roles, decision structure, sustainability themes, SDG coverage, delivery mode, facilitation requirements, and reported outcomes. Information about evaluation was recorded separately, with particular attention to whether independent studies, internal assessments, participant testimonials, or developer descriptions supported claims.

The scan identified fourteen publicly documented SDG-related business games and simulations. These tools are listed in Appendix B. They varied in their thematic focus, complexity, delivery format, and level of available documentation. Some addressed broad corporate sustainability and the triple bottom line, while others focused on climate change, supply chains, circular economy, stakeholder management, or the integration of the SDGs into strategic decision-making.

Two tools—Green Business Lab and Triple Connection—were selected for closer discussion in the main text. They were chosen because they were explicitly positioned for business training or strategic management, provided sufficient public information to assess their design and intended application, and addressed a broad range of sustainability or SDG-related issues. Their inclusion was intended to illustrate recurring features of practitioner-oriented simulations rather than to identify the most effective tools.

The documentation available for the identified games varied considerably. In many cases, information was limited to provider websites, marketing materials, workshop descriptions, demonstrations, or user testimonials. Such materials were considered useful for describing the availability, positioning, and design of the tools, but they were not treated as independent evidence of behavioural or organisational effectiveness. Statements about learning or transformation outcomes were therefore reported as developer or provider claims unless supported by peer-reviewed or independently conducted evaluation.

The results of the practice scan were analyzed separately from those of the academic review. This separation was maintained to avoid equating commercial or promotional descriptions with empirical research evidence. The scan was used to identify design trends, professional applications, and areas where widely available tools have not yet undergone transparent evaluation.

The exploratory nature of the scan creates several limitations. Search results depended on online visibility, search-engine indexing, language, access to documentation, and the continued availability of websites. Commercial tools with restricted documentation may have been

overlooked, while highly visible tools may be overrepresented. Consequently, the fourteen identified games should be interpreted as an indicative sample of publicly documented practice rather than as a complete representation of the market.

3.5. Data extraction and synthesis

Data from the included academic studies were extracted using a standardized coding template. The purpose of the template was to ensure that each serious game was analyzed according to the same criteria and to reduce the risk of presenting the identified interventions as unrelated descriptive cases. The extraction process focused on both the characteristics of the games and the strength of the evidence concerning their outcomes.

For each academic study, the following information was recorded:

- bibliographic information and country or context of origin,
- name and purpose of the game,
- sustainability problem or transformation challenge addressed,
- target audience and participant characteristics,
- physical, digital, or hybrid delivery format,
- duration and facilitation context,
- participant roles and gameplay structure,
- decision variables, interaction patterns, and feedback mechanisms,
- sustainability concepts, SDGs, or theoretical frameworks incorporated into the intervention,
- intended learning or transformation outcomes,
- evaluation design and data-collection methods,
- observed outcomes,
- reported limitations, and
- implications for future development, evaluation, and transfer to practice.

The extraction distinguished between intended and documented outcomes. Intended outcomes referred to the objectives stated by game designers or study authors, whereas documented outcomes referred to effects supported by data reported in the publication. This distinction was necessary because a game's transformational ambitions may be broader than the outcomes that can be assessed empirically.

Evaluation evidence was coded descriptively according to the research design used in each study. The analysis considered whether the evidence was based on participant reactions, qualitative observations, self-reported learning, pre- and post-intervention measurements, comparison groups, behavioral indicators, or longer-term follow-up. No formal risk-of-bias score was assigned because the small number of included studies and the heterogeneity of their designs would have made a standardized quantitative appraisal of limited interpretive value. Instead, the strengths and limitations of the evidence were examined by evaluating the evaluation design, outcome measures, sample characteristics, and measurement timing.

Reported outcomes were organized into five categories:

1. cognitive outcomes, including knowledge, conceptual understanding, awareness, and systems thinking,
2. relational outcomes, including communication, collaboration, stakeholder dialogue, shared understanding, and trust,
3. normative outcomes, including changes in values, attitudes, perceived responsibilities, and social norms,
4. behavioral outcomes, including intentions, individual decisions, and reported changes in practice, and
5. organizational outcomes, including changes in strategies, routines, policies, investments, business models, or implemented sustainability initiatives.

This outcome structure made it possible to distinguish immediate learning effects from evidence of sustained transformation. Cognitive and relational outcomes may constitute important early stages of change, but they do not by themselves demonstrate that a game has influenced subsequent behavior or organizational practice.

Data from the exploratory practice scan were extracted using a related but more limited template adapted to the quality of publicly available documentation. For each practitioner-oriented tool, the analysis recorded the provider, target audience, stated purpose, delivery format, participant roles, decision structure, sustainability themes, reported SDG coverage, facilitation requirements, and claimed outcomes. The source and status of the evidence were also recorded, distinguishing between peer-reviewed evaluation, independent assessment, internal provider evidence, user testimonials, and general promotional claims.

The academic studies and practitioner tools were not combined into a single evidence set. The academic review was used to assess documented research evidence, while the exploratory practice scan was used to map tool availability, design trends, and professional applications. Maintaining this separation reduced the risk of interpreting developer claims as equivalent to independently evaluated outcomes. The synthesis was structured around the four analytical dimensions introduced in Section 2.4:

1. purpose and transformation logic,
2. game structure and action space,
3. target audience and facilitation context, and
4. evidence of outcomes and transfer to practice.

The first dimension examined what type of sustainability problem the game addressed and how gameplay was expected to contribute to change. The second compared roles, decisions, feedback, interaction patterns, and the degree of freedom available to participants. The third considered participant groups, delivery conditions, facilitation, debriefing, and adaptation to organizational contexts. The fourth assessed what outcomes were measured, how they were evaluated, and whether the reported effects extended beyond the game session.

The findings were synthesized through structured comparison rather than statistical aggregation. A meta-analysis was not appropriate because the identified studies differed substantially in intervention design, participant groups, outcome measures, evaluation methods, and reporting practices. The synthesis therefore focused on recurring mechanisms, similarities, differences, and evidence gaps across the cases.

The comparative analysis was used to identify three types of patterns. First, it examined characteristics shared across the identified games, such as the use of stakeholder roles, collaborative decision-making, systems thinking, facilitation, and debriefing. Second, it identified differences in transformation focus, target audience, theoretical foundation, game structure, and evaluation design. Third, it assessed where claims concerning sustainable business transformation were supported by empirical evidence and where they remained primarily conceptual, aspirational, or based on short-term learning outcomes.

The results of this process are presented in Section 4. The academic games are first described using a consistent structure and then compared across the analytical dimensions. The practice-oriented tools are reported separately, followed by a synthesis of the evidence–practice gap between the availability of sustainability simulations and the strength of independent evidence regarding their behavioral and organizational effects.

4. Results

4.1. Review and scan outcomes

The database searches generated 199 records in total: 102 from Web of Science and 97 from Scopus. After combining records from both databases, duplicates and multiple records for the same study were removed. The remaining publications were screened by title and abstract, and potentially relevant articles were assessed in full text against the eligibility criteria described in Section 3.3.

Four peer-reviewed studies met all inclusion criteria. Each study described a distinct serious game addressing sustainability in a business, management, organizational, strategic, or professional context. The included games were:

1. MainKassandra, a simulation addressing corporate climate adaptation (Fischer et al., 2024).
2. The Theory of Change Game, a facilitated intervention supporting collaborative planning for sustainability-related change (Tribaldos, Schneider, 2021).
3. The Sustainability Futures Game, a participatory futures-oriented game involving urban and cross-sector stakeholders (Ampatzidou et al., 2022); and
4. The Road to Flourishing, a game addressing strongly sustainable business models and related behavioral constructs (Niessen et al., 2024).

The four studies differed in their target audiences, delivery formats, theoretical foundations, gameplay structures, and evaluation methods. They also addressed different levels of sustainability-related activity, ranging from individual learning and stakeholder dialogue to business model development and organizational adaptation. Their detailed characteristics are presented in Section 4.2 and Appendix B.

The exploratory practice scan identified fourteen publicly documented sustainability- or SDG-related games and simulations with a business, management, professional, or higher-education application. The identified tools addressed a range of topics, including corporate sustainability, climate change, supply chain management, stakeholder engagement, the triple bottom line, the circular economy, and SDG integration.

The level of publicly available documentation varied across the fourteen tools. For some games, the available materials included descriptions of participant roles, decision structures, sustainability indicators, and workshop formats. For others, the information was limited to general descriptions, promotional materials, demonstrations, or user testimonials. The complete set of identified tools and their principal characteristics is reported in Appendix B.

Two practitioner-oriented simulations were selected for closer presentation in the main text:

- **Green Business Lab**, a configurable business simulation in which management teams make cross-functional decisions and monitor financial, environmental, and social performance; and
- **Triple Connection**, a web-based supply-chain simulation in which participants assume functional management roles and make coordinated decisions across the People–Planet–Prosperity dimensions.

These tools were selected because they were explicitly designed for business or management audiences, addressed multiple sustainability dimensions, and provided sufficient documentation to describe their structure and intended application. Their inclusion did not indicate that they were more effective than the other tools identified in the scan.

Table 1 summarizes the outcomes of the two review stages.

Table 1.
Overview of the academic review and exploratory practice scan

Review component	Sources searched	Initial records or tools identified	Final material included	Role in the study
Structured academic review	Scopus and Web of Science	199 records	4 peer-reviewed studies	Assessment of documented academic evidence
Exploratory practice scan	Search engines, game repositories, professional portals, award databases, provider websites, and expert contacts	14 eligible tools	14 tools mapped; 2 discussed in detail	Mapping of publicly documented professional practice

Source: own elaboration.

The academic review and exploratory practice scan therefore produced two separate datasets. The first comprised four peer-reviewed studies subjected to detailed comparative analysis. The second comprised fourteen publicly documented practitioner tools, two of which were selected as illustrative cases for closer description.

4.2. Academic serious games

The structured review identified four serious games that met all eligibility criteria: MainKassandra, the Theory of Change Game, the Sustainability Futures Game, and The Road to Flourishing. The games address different sustainability challenges and use different formats, target groups, and evaluation approaches. The principal characteristics of each intervention are presented below. A detailed comparison is provided in Appendix B.

4.2.1. Main Kassandra

MainKassandra is a facilitated business simulation designed to support learning about corporate climate adaptation and mitigation (Fischer et al., 2024). Its target audience consists primarily of company employees and managers. The game was developed in Germany through an iterative process involving researchers, climate specialists, and representatives of business practice.

During a workshop lasting approximately four to eight hours, participants work in teams of three or four and manage fictitious companies operating in the MainKassandra region. The scenario exposes the companies to climate-related risks and extreme weather events. In successive rounds, teams select adaptation and mitigation measures from a catalog of approximately 80 options, discuss their managerial implications, and present interim decisions. Their performance is represented by a maturity score indicating the degree to which the company is prepared for climate impacts. The session concludes with a facilitated debriefing linking the simulated decisions to participants' professional contexts.

Fischer et al. (2024) evaluated the didactic and contextual requirements for the development of MainKassandra through expert interviews and focus groups rather than testing its learning effectiveness in completed gameplay. The findings, therefore, concern perceived design requirements, pragmatism, transferability, and implementation conditions rather than demonstrated participant outcomes. The study did not assess whether participation increased climate-risk awareness, changed managerial behavior, or resulted in the implementation of organizational adaptation measures.

4.2.2. Theory of Change Game

The Theory of Change Game is an analog board-and-card game designed to help participants develop a shared theory of change for sustainability-related projects and initiatives (Tribaldos, Schneider, 2021). It is intended for researchers, students, practitioners, and stakeholder groups involved in sustainable development or transdisciplinary projects.

The game is typically played by groups of approximately five or six participants. The board provides a visual template on which players map actors, actions, intermediate outcomes, and intended impacts. Gameplay consists of two principal stages. A preliminary brainstorming round is used to generate relevant ideas, after which color-coded prompt cards guide a more detailed discussion of strategies, contextual conditions, causal assumptions, and stakeholder roles. The process is collaborative rather than competitive and depends on facilitated dialogue.

The game was developed through repeated cycles of conceptualization, prototyping, testing, and refinement. Different versions were tested internally, at academic conferences, and during a stakeholder workshop, involving approximately 90 participants in total. The reported evidence concerned mainly cognitive and relational outcomes, including clearer articulation of assumptions, shared understanding of project pathways, and improved stakeholder dialogue. The study did not evaluate whether the jointly developed theories of change subsequently improved project implementation or produced sustained collaboration among participants.

4.2.3. Sustainability Futures Game

The Sustainability Futures Game is a facilitated participatory intervention designed to help stakeholders imagine desirable sustainable urban futures and identify pathways towards them (Ampatzidou et al., 2022). Its participants include city officials, urban planners, sustainability specialists, business representatives, and students in sustainability- and design-related programs. The game has been delivered in both physical and digital formats.

A typical session lasts approximately three hours. Participants select an actual city and collaboratively construct a vision of its desirable sustainable future, usually using 2030 as the reference horizon. They then work backward to identify the decisions, actions, barriers, and intermediate steps required to achieve the proposed future. The game combines storytelling, futures thinking, the SDGs, and structured group discussion. Facilitation supports the development of a shared narrative and the translation of broad sustainability objectives into proposed pathways.

The game was developed through a participatory and iterative process within the CreaTures research project, in cooperation with the design consultancy Hellon. The development process involved at least five design iterations and seven test sessions with professionals and students. Evaluation evidence was mainly qualitative and design-oriented, drawing on user feedback, facilitator observations, and analysis of the iterative development process. Reported outcomes included generating alternative future visions, reflecting on existing assumptions, identifying possible pathways, and recognizing opportunities for stakeholder collaboration. Direct measures of subsequent behavioral, policy, or organizational effects were not reported.

4.2.4. The Road to Flourishing

The Road to Flourishing is a board game designed to increase knowledge of highly sustainable business models and to examine changes in attitudes, perceived social norms, and behavioral intentions (Niessen et al., 2024). Its target audience includes corporate

professionals, sustainability consultants, entrepreneurs, and business students. The game can be delivered in person or online using a virtual board.

Participants progress through five levels of sustainable business strategy: Efficiency, Net Zero, Circularity, Sufficiency, and Regeneration, before reaching the final stage of Flourishing. Gameplay combines quiz questions, business examples, scenario events, and reflective prompts. Participants may play individually or in teams and are asked to distinguish between incremental sustainability practices and more transformative approaches to value creation.

The game was developed using a Design Science Research approach that combined theory-informed design with iterative testing. Its evaluation involved a pre- and post-game survey completed by 220 participants from academic, business, and consultancy contexts. The results showed significant improvements in participants' understanding of concepts including flourishing, regeneration, and sufficiency. Positive changes were also reported in selected attitudes and perceived social norms concerning sustainable business practices. However, the study did not identify a significant short-term change in participants' stated behavioral intentions.

Among the four included studies, The Road to Flourishing provided the most extensive quantitative evaluation. Nevertheless, its outcome measurement was conducted directly around the intervention, and the study did not assess whether the observed knowledge and attitudinal changes were sustained or translated into subsequent business decisions or organizational practices.

4.3. Comparative synthesis

The four serious academic games differed in their sustainability focus, target audiences, game structures, and evaluation approaches. However, they also shared several recurring characteristics. Across the studies that evaluated gameplay, the strongest documented outcomes were cognitive or relational. Main Kassandra contributed design-oriented evidence rather than participant outcome evidence.

Table 2.
Comparative characteristics of the academic serious games

Game	Sustain-ability and transfor-mation focus	Target audience	Format and duration	Main gameplay mechanism	Facilitation and debriefing	Evaluation design	Main documented outcomes	Behavioral or organizational evidence
Main Kassandra	Corporate climate adaptation and mitigation	Company employees and managers	Facilitated business simulation; approximately 4–8 hours	Team management of fictitious companies, selection of adaptation measures, and response to climate events	Central to the workshop, connects decisions with participants' organizational contexts	Expert interviews and focus groups informed the development of the simulation; no evaluation of completed gameplay outcomes	Design requirements concerning relevance, pragmatism, transferability, and implementation conditions	Participant learning, behavioral change, and organizational outcomes were not assessed

Cont. table 2.

Theory of Change Game	Planning and coordination of sustainability -related projects and initiatives	Researchers, students, practitioners, and stakeholder groups	Analogue board-and-card game; group-based workshop	Collaborative mapping of actors, actions, assumptions, outcomes, and impacts	Required to structure dialogue and develop a shared theory of change	Iterative testing in academic and stakeholder settings; mainly qualitative feedback	Shared under-standing, clarification of assumptions, stakeholder dialogue, and collaborative planning	No evidence of subsequent project performance or sustained collaboration
Sustainability Futures Game	Visioning and pathway development for sustainable urban futures	City officials, planners, sustainability professionals, business representatives, students	Physical or digital facilitated session; approxima-tely 3 hours	Storytelling, future visioning, backcasting, and collaborative pathway development	Central to the creation of shared narratives and action pathways	Iterative design process, facilitator observations, and qualitative participant feedback	Systems thinking, alternative future visions, identification of pathways, and stakeholder interaction	No direct evidence of later policy implementation or organizational change
The Road to Flourishing	Strongly sustainable business models and progression from incremental to regenerative strategies	Corporate professionals, consultants, entrepreneurs, and business students	Physical or virtual board game	Progression through sustainability levels, quizzes, examples, scenarios, and reflective prompts	Supports interpretation of sustainability concepts and comparison of business strategies	Pre- and post-intervention survey; 220 participants	Increased knowledge, improved understanding of flourishing, regeneration, and sufficiency; selected attitudinal and normative changes	No significant short-term change in behavioral intention; no organizational follow-up

Source: own elaboration.

The games addressed sustainability transformation at different levels. Main Kassandra focused most directly on organizational adaptation by placing participants in the role of company decision-makers responding to climate-related risks. The Road to Flourishing addressed business-model transformation by contrasting incremental sustainability practices with sufficiency, regeneration, and flourishing. The Theory of Change Game focused primarily on project planning and stakeholder alignment. At the same time, the Sustainability Futures Game focused on collective visioning and pathway development in an urban, cross-sector context.

The target audiences also varied. Main Kassandra was designed mainly for organizational employees and managers. The Road to Flourishing included corporate professionals but was also tested with students, entrepreneurs, and consultants. The Theory of Change Game and the Sustainability Futures Game involved more heterogeneous groups, including researchers, practitioners, public-sector representatives, students, and other stakeholders; consequently, the four games covered both internal organizational learning and broader multi-stakeholder processes.

All four games required participants to work with simplified representations of sustainability problems. Main Kassandra used fictitious companies, climate events, and predefined adaptation options. The Theory of Change Game used a visual causal structure to connect actors, activities, assumptions, and expected impacts. The Sustainability Futures Game used future narratives and backcasting to construct pathways from a desirable future to present decisions. The Road to Flourishing organized sustainable business strategies into successive levels and asked participants to distinguish between incremental and transformative approaches.

The degree of structure differed across the interventions. MainKassandra and The Road to Flourishing provided relatively explicit decision environments, predefined options, and visible progress indicators. The Theory of Change Game and the Sustainability Futures Game offered more open action spaces in which participants generated content, negotiated meanings, and constructed shared outcomes. The latter two games depended more strongly on discussion and collective interpretation, whereas the former two placed greater emphasis on making choices within a prepared simulation framework.

None of the games was designed as an individual, self-directed intervention. Interaction among participants was a central feature in all cases. MainKassandra required teams to formulate company responses to climate risks. The Theory of Change Game relied on collaborative planning and the exchange of assumptions. The Sustainability Futures Game used storytelling and group visioning, while The Road to Flourishing combined quiz, scenario, and reflection activities that could be completed in teams. Cooperation was more prominent than competition across the four games.

Facilitation and debriefing were reported as important components of the interventions. In MainKassandra, facilitation supported the interpretation of climate impacts and the connection between game decisions and company practice. In the Theory of Change Game, facilitators guided participants through causal reasoning and stakeholder discussion. In the Sustainability Futures Game, facilitation supported inclusive participation, future visioning, and backcasting. In The Road to Flourishing, reflective prompts and discussion supported the interpretation of sustainability concepts and business strategies.

The studies differed substantially in their evaluation designs. MainKassandra, the Theory of Change Game, and the Sustainability Futures Game were evaluated mainly through qualitative or design-oriented procedures, including iterative testing, focus groups, observations, expert feedback, and participant reflections. The Road to Flourishing used a pre- and post-intervention survey with 220 participants, thereby providing the most extensive quantitative evidence among the four studies.

Among the studies that evaluated participant outcomes, the strongest documented effects were cognitive, including increased sustainability knowledge, improved understanding of sustainable business concepts, greater awareness of interdependencies, and enhanced systems thinking. Relational outcomes were also frequently reported, particularly improved stakeholder dialogue, shared understanding, collaboration, and joint problem framing.

Normative outcomes were assessed less frequently. The Road to Flourishing reported changes in selected attitudes and perceived social norms, whereas the other studies primarily described reflections on values, assumptions, or responsibilities using qualitative evidence. Behavioral outcomes were limited. The Road to Flourishing did not identify a significant short-term change in behavioral intentions, and the other studies did not systematically measure post-game behavior.

None of the four studies provided direct longitudinal evidence of organizational transformation. The evaluations did not establish whether participation led to the implementation of sustainability initiatives, changes in organizational routines, revisions to strategies, new investment decisions, or sustained cross-functional cooperation. Where organizational or policy effects were discussed, they were presented primarily as intended applications or potential consequences rather than empirically documented outcomes.

Overall, the comparison showed a consistent progression in the strength of available evidence. Evidence was strongest for immediate cognitive and relational outcomes, less developed for normative and behavioral outcomes, and absent or highly limited for sustained organizational effects. The evaluated games provided documented support primarily for sustainability learning, dialogue, and collaborative exploration, while MainKassandra contributed evidence concerning design and implementation requirements.

4.4. Practice-oriented simulations

The exploratory practice scan identified fourteen publicly documented sustainability- or SDG-related games and simulations intended for business, management, professional, or higher-education audiences. The identified tools addressed corporate sustainability, climate change, supply chain management, stakeholder engagement, the circular economy, social responsibility, the triple bottom line, and the integration of the SDGs into managerial decision-making. Their detailed characteristics are presented in Appendix B.

The tools differed in their delivery formats and level of complexity. The scan included physical board games, facilitated workshop formats, digital simulations, and web-based business games. Some interventions focused on a single sustainability issue, whereas others represented interactions among financial, environmental, and social performance. The duration of the identified tools ranged from short workshop activities to multi-round simulations delivered over several sessions.

Participant roles were used frequently. Players were commonly assigned managerial, functional, stakeholder, or institutional responsibilities and were required to make decisions from these perspectives. Several games included roles related to operations, procurement, marketing, finance, sustainability, public administration, or community interests. Team-based decision-making and negotiation were more common than individual gameplay.

Cross-functional trade-offs were another recurring feature. The tools typically required participants to balance financial performance with environmental and social considerations. Some simulations used indicators, dashboards, scores, or scenario events to show the consequences of participant decisions. Facilitated discussion and debriefing were also frequently mentioned in provider documentation, although the scope and structure of these activities were not always described in detail.

Public documentation differed substantially in quality. For some tools, the available materials provided information on gameplay, participant roles, decision variables, workshop structure, sustainability indicators, and target audiences. For others, the available evidence consisted mainly of general descriptions, marketing statements, demonstrations, or participant testimonials. Independent evaluation studies were identified for only a limited proportion of the tools.

Two simulations, Green Business Lab and Triple Connection, were selected for closer presentation because they were explicitly intended for business and management audiences, addressed several dimensions of sustainability, and were sufficiently documented to permit an assessment of their principal design features.

4.4.1. Green Business Lab

Green Business Lab is a configurable business simulation designed to help management teams examine the economic, environmental, and social consequences of corporate decisions (The Green Business Lab, 2025). The simulation is based on the triple-bottom-line perspective and is intended for executives, managers, employees, business students, and other participants involved in organizational decision-making.

Participants manage a simulated company and make decisions across strategy, innovation, operations, resources, and stakeholder relations. Decisions are made across a sequence of simulation cycles. Their consequences are presented through financial, environmental, and social performance indicators, which allow teams to compare results and reconsider their strategies.

The simulation can be delivered in different formats, ranging from a single-cycle workshop to a multi-cycle development program. Provider documentation indicates that the tool can be adapted to different learning objectives and organizational contexts. Sessions include facilitated reflection in which participants review their results and discuss the relationships between business performance and sustainability.

Publicly available materials describe Green Business Lab as supporting awareness, strategic thinking, cooperation, and understanding of sustainability trade-offs. The available documentation includes provider descriptions and participant or client statements. No peer-reviewed independent study was identified that examined sustained behavioral, strategic, or organizational outcomes following participation in the simulation.

4.4.2. Triple Connection

Triple Connection is a web-based business simulation focused on a consumer goods supply chain (Inchainge, 2025). It is intended for corporate training, management education, and professional development. The simulation addresses the integration of financial, environmental, and social performance through the People–Planet–Prosperity framework.

Participants work in teams and assume functional executive roles, including Sustainability, Operations, Purchasing, and Marketing. Each role controls a different set of decisions, requiring participants to exchange information and coordinate their actions. Teams make decisions

concerning the supply chain, product strategy, sourcing, operations, and sustainability performance over several simulation rounds.

The simulation uses a "true return on investment" concept to combine conventional financial results with environmental and social outcomes. Performance information is provided between rounds, enabling teams to observe the consequences of their decisions and revise their approach. Structured debriefing is used to review coordination problems, trade-offs, and the alignment of functional decisions.

Provider materials indicate that Triple Connection is used in corporate and higher-education settings and can support cross-functional collaboration, systems thinking, and sustainability-related decision-making. Publicly available documentation describes its gameplay structure, functional roles, and performance framework. However, no independent peer-reviewed evaluation was identified that measured whether participation resulted in sustained changes in managerial behavior, organizational routines, or supply-chain practices.

Table 3 summarizes the principal characteristics of the two simulations.

Table 3.
Comparative characteristics of selected practice-oriented simulations

Simulation	Main focus	Target audience	Format	Participant roles and decisions	Performance feedback	Publicly documented outcomes	Independent evidence
Green Business Lab	Corporate sustainability and triple-bottom-line performance	Executives, managers, employees, and business students	Configurable team-based simulation; single or multiple cycles	Cross-functional decisions concerning strategy, innovation, operations, resources, and stakeholders	Financial, environmental, and social indicators	Awareness, strategic reflection, cooperation, and understanding of sustainability trade-offs	No independent peer-reviewed evaluation of sustained behavioral or organizational outcomes has been identified.
Triple Connection	Sustainable consumer-goods supply chains and People–Planet–Prosperity performance.	Corporate participants, managers, and business students	Web-based, multi-round team simulation	Functional executive roles in Sustainability, Operations, Purchasing, and Marketing	Integrated performance results and "true return on investment"	Cross-functional collaboration, systems thinking, and sustainability decision-making	No independent peer-reviewed evaluation of downstream organizational change has been identified

Source: own elaboration.

The two simulations shared several design features observed across the broader set of practice-oriented tools. Both allocated managerial responsibilities to participants, required coordination across functional areas, represented trade-offs among financial, environmental, and social outcomes, and used performance feedback to inform facilitated debriefing.

The practice scan also showed that the existence of a publicly available tool did not necessarily correspond with the availability of evaluation evidence. The identified materials generally provided more information about intended purposes, delivery formats, and claimed benefits than about research design, participant samples, outcome measurement, or follow-up. Consequently, the scan produced a detailed map of practice-oriented applications but a more limited body of independently documented outcomes.

The comparison of the structured academic review and the exploratory practice scan revealed a clear difference between the availability of sustainability-oriented serious games and the strength of evidence concerning their outcomes.

The academic review identified four peer-reviewed studies that met the full eligibility criteria. These studies provided relatively detailed information on the game's purpose, participant groups, gameplay structure, facilitation, and evaluation. However, the number of qualifying interventions was small, and the reported evidence concerned mainly immediate cognitive and relational outcomes.

The exploratory practice scan identified fourteen publicly documented games and simulations intended for business, management, professional, or higher-education audiences. This broader set of tools demonstrated that sustainability-oriented simulations are more widely available in practice than the peer-reviewed literature alone would suggest. The tools addressed a range of applications, including corporate sustainability, climate adaptation, sustainable supply chains, stakeholder engagement, circular economy, and SDG integration.

The two strands differed substantially in the type and quality of available documentation. Academic publications generally describe the research context, participants, intervention design, data-collection procedures, and observed outcomes. Practitioner documentation was more likely to describe a tool's intended purpose, format, target audience, and claimed benefits. Information concerning sample characteristics, measurement instruments, comparison conditions, and follow-up periods was often unavailable.

Table 4 compares the principal characteristics of the evidence identified in the two strands.

Table 4.
Comparison of academic evidence and practitioner documentation

Dimension	Academic serious games	Practice-oriented simulations
Number identified	4 peer-reviewed studies	14 publicly documented tools
Main source of information	Journal articles	Provider websites, brochures, demonstrations, repositories, testimonials, and training descriptions
Typical level of intervention detail	Purpose, participants, gameplay, facilitation, evaluation procedure, and outcomes	Purpose, target audience, delivery format, roles, indicators, and claimed benefits
Most frequently reported outcomes	Knowledge, awareness, systems thinking, shared understanding, stakeholder dialogue, and selected attitudes.	Awareness, engagement, strategic reflection, collaboration, systems thinking, and decision-making
Evaluation methods	Qualitative observations, focus groups, iterative testing, participant feedback, and one pre–post survey study	Mainly provider descriptions, internal materials, client statements, and testimonials
Behavioral evidence	Limited; one study assessed behavioral intentions without significant short-term change.	Generally not independently assessed
Organizational evidence	No direct longitudinal evidence of changed strategies, routines, investments, or implemented initiatives	No independent peer-reviewed evidence was identified for most tools.
Follow-up beyond the intervention	Rare or absent	Rarely reported
Status of claims	Partly supported by research evidence, mainly for immediate outcomes	Predominantly descriptive or provider-reported

Source: own elaboration.

Across the academic studies, evidence was strongest for outcomes measured during or immediately after gameplay. Knowledge acquisition, conceptual understanding, systems thinking, dialogue, and collaborative problem framing were documented more frequently than behavioral or organizational effects. Only The Road to Flourishing used a quantitative pre- and post-intervention design with a relatively large sample of participants. Even in that study, changes in knowledge and selected attitudes were not accompanied by a significant short-term change in behavioral intentions.

The Theory of Change Game and the Sustainability Futures Game were evaluated primarily through qualitative feedback, observations, participant outputs, and iterative development. MainKassandra contributed design-oriented evidence based on expert interviews and focus groups rather than participant outcome evidence. None of these studies established whether the interventions led to subsequent changes in organizational practice.

The practitioner tools displayed several design characteristics similar to those found in the academic games. These included role allocation, team-based decision-making, sustainability indicators, cross-functional trade-offs, scenario events, performance feedback, and facilitated debriefing. However, the presence of similar game mechanisms was not accompanied by comparable evidence concerning outcomes.

For most practitioner-oriented tools, publicly available materials reported intended benefits rather than independently measured effects. Statements concerning improved awareness, collaboration, strategic thinking, or decision-making were typically based on provider descriptions, workshop summaries, or participant testimonials. Information on research design, baseline measurements, participant selection, or long-term follow-up was generally unavailable.

The identified evidence–practice gap therefore had two components. First, practice-oriented tools were more numerous than the academic literature indicated. Second, the level of empirical validation was substantially lower than the level of market availability and professional application. This pattern is illustrated in Figure 1.

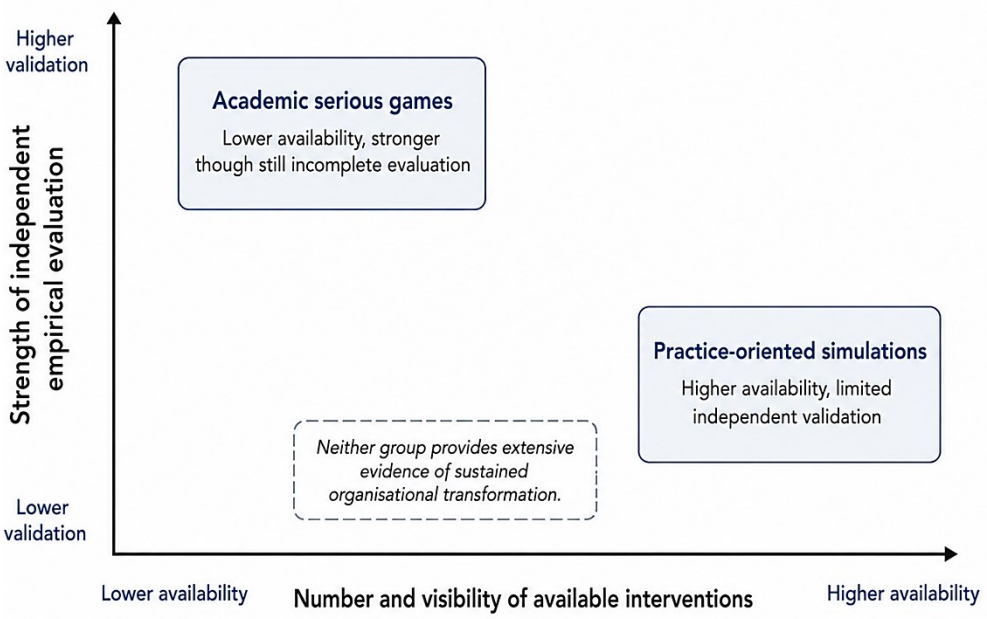


Figure 1. Availability and independent validation of serious games for sustainable business transformation.

Source: own elaboration.

The comparison therefore identified a progressive reduction in the strength of evidence across outcome levels. Evidence was most frequently available for cognitive and relational outcomes, less frequently for normative and behavioral outcomes, and rarely, if at all, for organizational outcomes. Figure 2 presents this distribution.

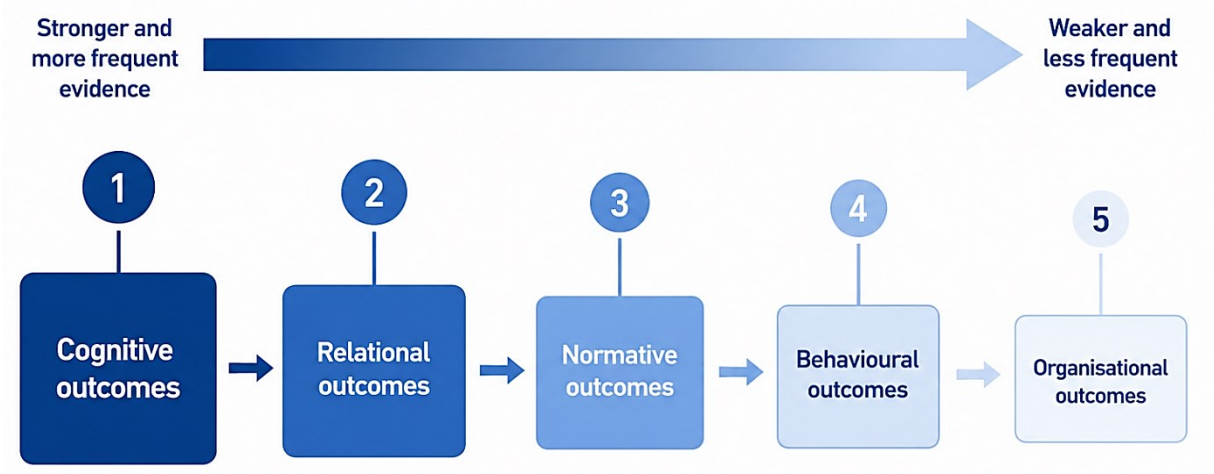


Figure 2. Strength of evidence across outcome levels.

Source: own elaboration.

The available material thus documented a substantial number of sustainability-oriented game applications but a much smaller body of independently evaluated interventions. It also showed that the reported evidence was concentrated at the level of learning, awareness, and interaction rather than sustained changes in managerial behavior, business strategy, or organizational practice.

5. Discussion

5.1. What was known and what this review adds

Previous research has established that serious games can support learning, engagement, and reflection in sustainability-related contexts. Studies conducted in education, environmental management, climate communication, and sustainable development have reported improvements in knowledge, awareness, systems thinking, self-efficacy, stakeholder dialogue, and selected attitudes (Janakiraman et al., 2018; Jääskä et al., 2021; Boncu et al., 2022). These findings are consistent with the broader serious-games literature, which associates game-based interventions with experiential learning, feedback, active participation, and structured reflection (Wouters, 2013; Kikkawa et al., 2022).

The present review confirms this general conclusion but narrows its relevance to sustainable business transformation. This distinction is important because an intervention can be successful as a learning activity without producing organizational change. Participants may understand sustainability trade-offs more clearly after gameplay, but applying these insights in practice depends on decision-making authority, organizational culture, incentives, resources, managerial support, and opportunities for implementation.

The structured review identified only four peer-reviewed studies that met the full intersection of three criteria: a complete game or simulation intervention, an explicit sustainability-related purpose, and a business, management, organizational, strategic, or professional context. This limited number contrasts with the broader literature on sustainability education and environmental awareness. It shows that the evidence base becomes much smaller when the expected application is defined as sustainable business transformation rather than sustainability learning more generally.

The main new finding is the identification of a hierarchy of documented outcomes. Across the reviewed academic games, evidence was strongest for cognitive outcomes, including knowledge, awareness, conceptual understanding, and systems thinking. Relational outcomes, such as dialogue, collaboration, shared framing, and stakeholder understanding, were also frequently reported or qualitatively indicated. Evidence concerning normative change was more limited, while behavioral and organizational outcomes were rarely assessed.

This pattern extends previous research by showing that the strength of evidence decreases as the expected outcome moves further away from the game session. Immediate learning and interaction are relatively visible and measurable. Changes in values, intentions, behavior, organizational routines, strategic decisions, or business models are more difficult to demonstrate and require longer observation periods, different indicators, and access to organizational data. The reviewed studies, therefore, provide stronger support for serious games as instruments of learning and dialogue than as independently validated mechanisms of sustained business transformation.

A second contribution lies in comparing academic evidence with practitioner-oriented tools. The exploratory scan identified fourteen publicly documented sustainability or SDG-related business games and simulations, indicating that practice-oriented tools are more widely available than the peer-reviewed literature alone suggests. These tools frequently use managerial roles, cross-functional decision-making, sustainability indicators, performance dashboards, and facilitated debriefing. At the same time, their public documentation generally provides more information about intended benefits than about independently measured effects.

The review therefore identifies an evidence–practice gap. Practice-oriented tools are relatively visible and numerous, but their behavioral and organizational effects are rarely assessed independently. Academic studies provide more transparent evidence, but they remain few in number and are concentrated mainly on immediate learning-related outcomes. The central conclusion is not that serious games are ineffective. Rather, their current contribution concerns learning, dialogue, and reflection, while their contribution to sustained organizational transformation remains plausible but insufficiently validated.

5.2. Common mechanisms and differences

The comparison indicates that the four academic cases shared a general intervention logic: each translated a complex sustainability problem into a structured setting for exploration, interaction, and reflection. However, the games differed substantially in how this logic was operationalized. The most important differences concerned the openness of the action space, the type of participant contribution, the role of facilitation, the level of transformation addressed, and the design of the evaluation.

The Theory of Change Game and the Sustainability Futures Game created relatively open-ended action spaces. Participants generated causal pathways, future visions, assumptions, stakeholder relationships, and possible actions through facilitated group work. Their central outputs were, therefore, collectively constructed representations of a sustainability problem rather than performance against a predefined solution. These formats were particularly oriented towards collaborative problem framing, clarification of assumptions, and the development of shared interpretations.

The Road to Flourishing used a more structured conceptual progression. Participants moved through predefined levels of sustainable business practice, from efficiency-oriented approaches to regeneration and flourishing. Quizzes, examples, scenarios, and reflective prompts directed attention towards distinctions among different levels of sustainability ambition. The intervention was therefore more strongly oriented towards conceptual learning and the assessment of short-term changes in knowledge, attitudes, perceived social norms, and behavioral intentions.

MainKassandra also represented a comparatively structured design, based on fictitious companies, climate-related events, predefined adaptation options, and a maturity score. However, its position in the comparison requires particular caution. Fischer et al. (2024)

examined the didactic and contextual requirements for developing the simulation through expert interviews and focus groups. The study therefore provides evidence on design requirements, relevance, and conditions for transfer, rather than demonstrating outcomes of completed gameplay.

The cases also differed in the function assigned to participant perspectives. In the Theory of Change Game and the Sustainability Futures Game, heterogeneous stakeholder knowledge formed part of the content generated during the session. Participants contributed different interpretations and jointly constructed pathways or narratives. In The Road to Flourishing, participant engagement was organized more strongly around the interpretation of an existing conceptual framework. MainKassandra was designed to position participants as organizational decision-makers who respond to climate-related risks and consider alternative adaptation measures.

These differences reveal two broad design orientations. The first uses a game to structure collective construction, allowing participants to formulate the problem, identify relationships, and negotiate possible futures. The second uses a game to structure guided exploration, directing participants through predefined concepts, decisions, or sustainability levels. Neither orientation is inherently superior. Their suitability depends on whether the intervention is intended primarily to support shared problem framing or to communicate and apply a particular conceptual model.

Facilitation was relevant across all four cases, but its function varied. In the more open-ended games, facilitators supported dialogue, causal reasoning, inclusion of different perspectives, and the integration of participant-generated contributions. In the more structured games, facilitation helped participants interpret predefined choices and relate them to professional or organizational contexts. This variation indicates that facilitation should be considered part of the intervention design rather than a uniform delivery condition.

The games also addressed different levels of transformation. Main Kassandra is concerned with organizational adaptation to climate risk. The Theory of Change Game supported the planning and coordination of sustainability-related projects. The Sustainability Futures Game focused on collective visioning and the development of urban transition pathways. The Road to Flourishing addressed the understanding of strongly sustainable business models and progression beyond incremental sustainability practices. Consequently, the identified games should not be treated as interchangeable examples of a single intervention category.

Evaluation design created an additional source of difference. The Road to Flourishing provided the clearest quantitative pre- and post-intervention evidence. The Theory of Change Game and the Sustainability Futures Game relied mainly on qualitative feedback, participant outputs, observation, and iterative development. MainKassandra examined expert-informed design requirements rather than gameplay effects. Apparent differences in effectiveness may therefore reflect differences in what was evaluated and how, rather than differences in the inherent quality of the interventions.

Overall, the comparison suggests that the shared value of the games lies in their capacity to structure complex sustainability problems and create conditions for participation and reflection. Their specific contribution, however, depends on the configuration of the action space, participant roles, facilitation, the purpose of transformation, and the evaluation design. More structured formats appear particularly well-suited to guided conceptual exploration, whereas open-ended formats appear better suited to collaborative framing and stakeholder dialogue. Across both orientations, the available evidence remains concentrated on proximal cognitive and relational outcomes rather than sustained behavioral or organizational change.

5.3. Theoretical implications

The findings suggest that serious games should not be conceptualized as self-contained mechanisms of sustainable business transformation. The reviewed studies provide evidence that games can generate cognitive and relational outcomes, including knowledge development, systems thinking, stakeholder dialogue, and shared understanding. However, they do not demonstrate that gameplay alone produces sustained behavioral or organizational change. A more appropriate theoretical interpretation is that serious games create enabling conditions within a broader process of organizational learning and transformation.

This distinction extends experiential learning perspectives. Experiential learning theory explains how participants may develop understanding through action, feedback, reflection, and experimentation (Kolb, 1984). The serious-games literature similarly emphasizes active participation, role-taking, decision-making, and debriefing as mechanisms through which learning occurs (Kriz, 2010; Kikkawa et al., 2022). These mechanisms explain immediate cognitive and relational effects, but they are insufficient to explain whether insights generated during gameplay become embedded in organizational routines, strategies, or decision systems.

Based on the comparative findings, the contribution of a game to sustainable business transformation can be illustrated by the provisional process logic in Figure 3.

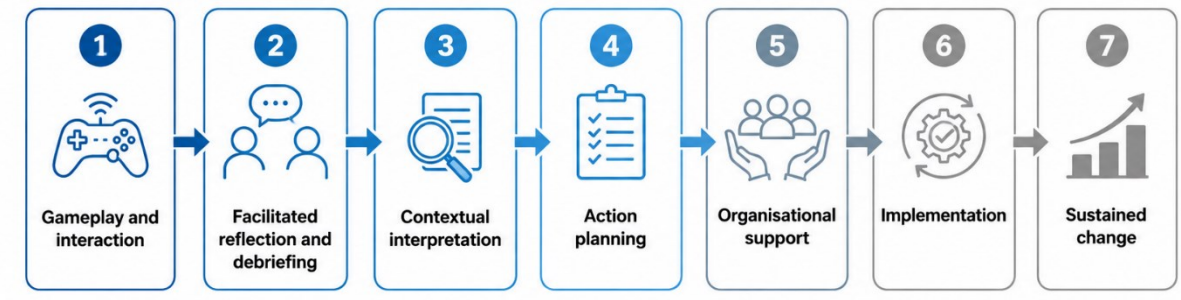


Figure 3. Proposed process linking serious game participation to sustained organizational change.
Source: own elaboration.

This sequence should be understood as an analytical model rather than as a validated causal framework. It identifies the stages through which game-based learning may be transferred into organizational practice and clarifies where this transfer may be interrupted. Gameplay creates

a shared experiential setting; reflection and debriefing transform experience into articulated learning; contextual interpretation relates game-based insights to organizational realities; action planning converts general insights into proposed decisions or initiatives; organizational support determines whether these proposals can be implemented; and implementation and sustained change refer to the adoption and continuation of new practices over time.

The process logic implies that serious-game outcomes should be analyzed at multiple levels. Immediate learning outcomes, behavioral intentions, implemented actions, and organizational transformation are not equivalent indicators of effectiveness. They represent different stages in a possible transformation process and require different methods of assessment. Knowledge acquisition does not demonstrate behavioral change, and behavioral intention does not demonstrate organizational implementation.

The review therefore supports a distinction between proximal and distal outcomes. Proximal outcomes occur during or shortly after the intervention and include knowledge, awareness, dialogue, and shared understanding. Distal outcomes occur later and include behavior change, implementation, strategic reorientation, and organizational transformation. Claims about effectiveness should correspond to the level of outcome actually measured.

The findings also suggest that serious games can be understood both as learning artifacts and as components of organizational change processes. As learning artifacts, games create structured environments for experimentation, feedback, and reflection. As components of change processes, they may help initiate dialogue, align stakeholders, and generate action proposals. Their transformational potential depends on whether these outputs are connected to subsequent organizational processes.

Another theoretical implication concerns the relational character of sustainable business transformation—the reviewed games produced outcomes not only through individual cognition but also through interaction among participants. Shared understanding, stakeholder dialogue, and collective problem framing were among the most consistently reported effects. This suggests that serious games may serve as boundary objects that connect actors across different organizational functions, professional backgrounds, or stakeholder groups.

Finally, the evidence–practice gap has theoretical significance. Practice-oriented simulations are more numerous than the academic evidence base suggests, but their transformational claims are often not independently assessed. This means that game-based practice has advanced faster than theory and evaluation. Future theory development should therefore examine not only whether games work, but through which mechanisms, under what conditions, for which participants, and at which level of outcome.

Overall, the review supports a conditional and process-oriented conceptualization of serious games. Their theoretically plausible contribution lies in generating proximal cognitive and relational conditions that may support subsequent organizational change. The transition from these proximal outcomes to sustained transformation is not inherent in the game itself but depends on transfer mechanisms and organizational conditions operating after gameplay.

5.4. Practical implications

The process model presented in Figure 3 has direct implications for the design and implementation of serious-game interventions. Organizations should treat gameplay as one component of a broader sustainability or change program and ensure that the intervention is connected with contextual interpretation, action planning, implementation support, and follow-up. In practice, this requires alignment among the intended outcome, game design, participant group, facilitation approach, organizational context, and evaluation method.

The first practical requirement is to define the intended outcome before selecting a game. Organizations should distinguish among awareness building, knowledge development, stakeholder alignment, strategy formulation, behavioral experimentation, and organizational implementation. A game designed primarily to introduce sustainability concepts may be appropriate for awareness raising but insufficient for business-model redesign or cross-functional decision-making. The objective of the intervention should therefore be matched with the game's structure, target audience, decision space, and evaluation approach.

Participant selection is equally important. When the objective is general sustainability education, the game may be used with broad groups of employees or students. When the objective is organizational change, participants should include individuals with relevant knowledge, decision-making authority, and responsibility for implementation. Cross-functional sustainability challenges may require participation from managers across strategy, operations, procurement, finance, marketing, human resources, and sustainability.

Contextual adaptation should also form part of the intervention design. Generic games can support conceptual learning, but their relevance to organizational practice may be limited when participants cannot relate simulated conditions to their own decisions and responsibilities. Adaptation may involve industry-specific scenarios, organizational terminology, realistic stakeholder roles, company data, relevant sustainability indicators, or current strategic challenges. The aim is not to reproduce reality in full, but to create a credible connection between the game and the organization's actual sustainability challenges.

Facilitation and debriefing should be treated as central elements of the intervention. Effective facilitation involves more than explaining the rules. It includes encouraging balanced participation, questioning assumptions, identifying conflicts, and helping participants connect game experience with organizational practice. Debriefing should address what occurred, why particular decisions were made, which assumptions influenced them, which trade-offs became apparent, and how the simulated experience differs from organizational reality.

Reflection should be followed by action planning. Participants should identify a limited number of concrete actions, responsibilities, resources, and decision points arising from the session. These may include testing a new sustainability criterion, revising a procedure, initiating a cross-functional working group, assessing climate-related risks, or developing a pilot

initiative. Without this transition, positive engagement may remain limited to the workshop experience.

Managerial sponsorship and follow-up are particularly important when proposed actions require resources, authority, or cross-departmental coordination. Senior managers should clarify how game outputs will be reviewed and which recommendations may be developed further. Follow-up mechanisms may include review meetings, progress reports, coaching sessions, repeated gameplay, or the integration of actions into existing project and performance management systems.

Evaluation should correspond to the intended level of change. Satisfaction surveys can indicate whether participants found the game engaging, but they do not demonstrate learning or transformation. Knowledge tests, reflection reports, and pre- and post-session measures can assess cognitive or attitudinal outcomes. Behavioral and organizational claims require additional indicators, such as implemented action plans, revised procedures, new sustainability initiatives, changed investment criteria, or evidence of cross-functional cooperation.

For organizations purchasing or commissioning serious games, the findings provide criteria for selecting providers. Potential users should request information about the target audience, learning objectives, participant roles, decision mechanisms, facilitation requirements, debriefing process, evaluation evidence, and possibilities for adaptation. Claims of behavioral or organizational impact should be examined carefully when they are supported only by testimonials or promotional descriptions.

Overall, serious games are most useful as structured components of broader sustainability and change programs. Their contribution is strongest when organizations define clear objectives, involve relevant decision-makers, adapt the intervention to context, provide skilled facilitation, connect debriefing with action planning, ensure managerial sponsorship, and measure outcomes beyond the game session.

5.5. Alternative interpretations and limitations

The limited evidence of behavioral and organizational outcomes should not be interpreted as proof that serious games are ineffective in supporting sustainable business transformation. The reviewed studies show that games can produce immediate cognitive and relational outcomes. However, they provide insufficient evidence to determine whether these outcomes persist or lead to changes in organizational practice. The distinction between absence of evidence and evidence of absence is therefore essential.

One possible interpretation is that serious games generate useful effects that were not captured by the evaluation designs used in the reviewed studies. Most assessments were conducted during or shortly after the intervention and focused on outcomes that could be measured within a short time frame, such as knowledge, awareness, participant reactions, shared understanding, or attitudes. Organizational transformation, by contrast, may develop over several months or years and may therefore remain invisible in short-term evaluation.

The choice of outcome measures may also have influenced the observed pattern. Cognitive and attitudinal variables can be assessed relatively easily through questionnaires, interviews, or participant feedback. Behavioral and organizational outcomes require access to subsequent decisions, implementation processes, performance data, and organizational records. Researchers may therefore select proximal outcomes not because they are the only relevant effects, but because they are more feasible to observe.

A related interpretation concerns the indirect nature of game-based influence. A serious game may contribute to a later decision or initiative without being identified as its primary cause. Participants may draw on concepts, relationships, or insights developed during gameplay when contributing to sustainability projects, but the intervention's influence may be difficult to isolate from other factors. Multiple interacting influences, including regulation, leadership priorities, market conditions, stakeholder pressure, available technologies, and existing sustainability programs, usually shape organizational change.

The lack of observed behavioral change may also reflect barriers occurring after the game rather than weaknesses in the intervention itself. Participants may develop new knowledge or intentions but lack authority, resources, time, or managerial support to act on them. Established routines, incentive systems, departmental boundaries, and short-term performance pressures may prevent the application of game-based insights. In such cases, the intervention may succeed at the learning level while transfer fails at the organizational level.

Participant characteristics and self-selection create further interpretive uncertainty. Individuals who voluntarily participate in sustainability-related games, research projects, workshops, or training programs may be more motivated and receptive than the wider organizational population. In some cases, prior interest in sustainability may also reduce the potential for measurable attitudinal change. Positive reactions may therefore partly reflect participant predispositions, while the challenge of engaging skeptical or less motivated groups remains underexamined.

The role of facilitation also complicates attribution. The reviewed games depended substantially on discussion, reflection, and debriefing. Consequently, observed outcomes cannot be attributed solely to the game artifact. They may result from the combined influence of game design, facilitator competence, participant composition, group dynamics, and organizational context. The same game may therefore produce different outcomes in different settings.

Several limitations of the present study should also be acknowledged. First, the structured academic review was limited to Scopus and Web of Science. These databases provide broad multidisciplinary coverage, but they do not include all relevant publications. Second, the review included only English-language, peer-reviewed journal articles published between 2015 and 2024. This restriction improved consistency but excluded books, conference proceedings, reports, dissertations, non-English publications, and other forms of grey literature.

Third, the search strategy deliberately required an explicit intersection between sustainability, game-based intervention, and business or organizational transformation. This improved precision but may have reduced recall. Relevant studies using adjacent terminology, such as transition management, circular economy, responsible innovation, organizational learning, climate resilience, or business-model experimentation, may not have been retrieved. The inconsistent use of terms such as “serious games”, “simulation games”, “game-based learning”, and “gamification” may also have affected the search results.

Fourth, the final academic sample consisted of only four studies. This small number limits the generalizability of the conclusions and prevents statistical aggregation. The included studies were also heterogeneous in purpose, participants, duration, game structure, theoretical foundations, and evaluation design. The synthesis was therefore interpretive rather than meta-analytic.

Fifth, no formal risk-of-bias assessment was conducted. Evidence was evaluated descriptively based on study design, outcome measures, sample characteristics, and assessment timing. This approach was appropriate for a small and methodologically diverse sample, but it does not provide a standardized quality score for the included studies.

Sixth, the exploratory practice scan was not designed as a comprehensive market review. The identification of tools depended on online visibility, search-engine indexing, available documentation, expert contacts, and the continued accessibility of provider websites. Commercial tools with limited public information may have been overlooked, while highly visible tools may have been overrepresented. The selection of Green Business Lab and Triple Connection for closer discussion was purposive and should not be interpreted as evidence that they are representative of all practice-oriented simulations.

Finally, the analytical hierarchy of cognitive, relational, normative, behavioral, and organizational outcomes is a useful organizing framework, but the categories are not entirely independent. Improved knowledge may support dialogue, dialogue may influence norms, and normative change may affect behavior. The relationships among these outcomes are likely to be recursive rather than strictly linear. The process model presented in Figure 3 should therefore be treated as a heuristic framework for future research rather than as a confirmed sequence.

Despite these limitations, the study provides a transparent comparison of academic evidence and publicly documented practice. Its conclusions are deliberately cautious: serious games have demonstrated value for sustainability learning and stakeholder interaction, while their contribution to sustained business transformation remains plausible but insufficiently documented.

5.6. Future research agenda

Future research should move beyond documenting participant reactions and short-term learning outcomes towards examining whether, how, and under what conditions serious games contribute to sustained changes in managerial behavior and organizational practice. This requires broader search strategies, more transparent reporting, longitudinal evaluation, stronger attention to transfer mechanisms, and independent assessment of practitioner-oriented tools.

A priority is to broaden the evidence base. Future reviews should include additional databases, specialist repositories, conference proceedings, dissertations, reports, and grey literature. Search terms should also be expanded to include related concepts such as sustainability transitions, climate resilience, circular economy, responsible innovation, organizational learning, business model experimentation, transition management, and regenerative business. This would help determine whether the limited number of included studies reflects a genuinely narrow evidence base or is partly due to disciplinary fragmentation and inconsistent terminology.

A second priority is developing a common reporting framework for serious games in sustainable business transformation. Future studies should describe the purpose and transformation logic of the game, target group, format, duration, delivery conditions, participant roles, rules, resources, interaction patterns, feedback mechanisms, facilitation, debriefing, theoretical basis, organizational context, intended outcomes, measured outcomes, timing of evaluation, and conditions affecting transfer to practice. A standardized reporting framework would make it easier to compare interventions, replicate studies, and identify which design features are associated with particular outcomes.

A third priority is longitudinal and multi-level evaluation. Future studies should distinguish clearly among cognitive, relational, normative, behavioral, and organizational outcomes. These categories represent different levels of change and should not be treated as interchangeable indicators of effectiveness. Immediate post-game evaluation can capture engagement and learning. However, follow-up after several weeks or months is needed to assess whether participants applied the insights, changed decision-making practices, initiated sustainability-related actions, implemented action plans, maintained cross-functional cooperation, or influenced strategies, investments, policies, and routines.

A fourth priority is the analysis of transfer mechanisms. The process model proposed in Figure 3 suggests that gameplay may contribute to transformation through facilitated reflection, contextual interpretation, action planning, organizational support, implementation, and sustained change. Future studies should examine where transfer succeeds or fails. Research should investigate whether debriefing quality, contextual relevance, action planning, managerial sponsorship, decision authority, resource availability, organizational culture, and follow-up support mediate or moderate the relationship between gameplay and later outcomes.

A fifth priority is the independent evaluation of practitioner-oriented simulations. The exploratory scan showed that many tools are already used in professional practice, yet their effects are rarely documented through peer-reviewed research. Collaboration among providers, client organizations, and independent researchers could strengthen the evidence base while preserving practical relevance. Evaluations should document participant characteristics, delivery conditions, game mechanisms, outcome measures, and follow-up procedures. Independent assessment would also reduce the risk of selective reporting and enable more credible comparison between commercial tools and academically developed interventions.

Future studies should also consider stronger comparative and mixed-method designs. Comparative research could examine serious games versus conventional training, one-off gameplay versus gameplay combined with follow-up support, generic versus organization-specific scenarios, facilitated versus minimally facilitated delivery, competitive versus collaborative structures, and individual participants versus intact organizational teams. Mixed methods would be particularly useful because quantitative designs can measure changes in knowledge, attitudes, intentions, behavior, or organizational indicators. In contrast, qualitative methods can explain how participants interpret the game, how group dynamics shape outcomes, and why transfers succeed or fail.

Finally, future research should examine not only intended benefits but also possible limitations and unintended effects. Serious games may oversimplify complex sustainability problems, privilege particular assumptions, create false confidence, reinforce dominant perspectives, or encourage participants to focus on winning rather than reflection. These risks are especially important when simulations are used to support strategic or policy decisions.

Overall, the future research agenda should move the field from descriptive accounts and immediate post-game evaluation towards cumulative, theory-informed, longitudinal, and context-sensitive evidence. The central challenge is no longer only to demonstrate that serious games can engage participants or improve knowledge, but also to establish how game-based learning translates into action and whether it contributes to sustained, sustainable business transformation.

6. Summary

This study addressed the following research question: *What types of serious games currently exist that aim to support sustainable business transformation, and what gaps remain for future development?* The review identified a small group of academically evaluated games and a broader set of practice-oriented simulations designed to support sustainability learning, strategic reflection, stakeholder dialogue, scenario exploration, and business decision-making.

The main finding is that serious games are supported most consistently as instruments for generating cognitive and relational outcomes. They can improve participants' sustainability knowledge, systems thinking, shared understanding, and dialogue. Evidence becomes progressively weaker for normative, behavioral, and organizational outcomes. In particular, the available studies do not provide sufficient longitudinal evidence that game-based interventions produce sustained changes in managerial behavior, organizational routines, strategies, or business models.

The scientific contribution of the study lies in combining a structured review of peer-reviewed research with an exploratory scan of practitioner-oriented tools. This comparison revealed an evidence–practice gap: sustainability-related business games are more widely available in professional practice than the academic literature suggests, but their organizational effects are rarely evaluated independently. The study also distinguishes between proximal learning outcomes and distal transformation outcomes. It proposes a process model that links gameplay to reflection, contextual interpretation, action planning, organizational support, implementation, and sustained change.

From a practical perspective, serious games should be treated as components of broader sustainability and organizational change processes rather than as stand-alone training events. Their potential value increases when the intervention has clearly defined objectives, involves participants with relevant knowledge and decision authority, is adapted to the organizational context, includes skilled facilitation and structured debriefing, and leads to specific action plans supported by management and follow-up mechanisms.

The conclusions should be interpreted in light of several limitations. The academic review covered two databases of English-language peer-reviewed journal articles published between 2015 and 2024, yielding a small, methodologically heterogeneous final sample. The exploratory practice scan was dependent on publicly available online documentation and was not a comprehensive market analysis. Moreover, the practitioner tools differed considerably in the transparency and quality of the evidence provided.

Future research should therefore focus primarily on longitudinal, multilevel evaluation of the transfer of gameplay to organizational practice. Studies should examine not only whether participants learn or engage, but also whether game-generated insights influence later decisions, behaviors, implemented initiatives, organizational routines, and sustainability performance. Particular attention should be given to the mechanisms and contextual conditions that enable or prevent this transfer.

References

1. Ampatzidou, C. et al. (2022). New insights, new rules: What Shapes the Iterative Design of an Urban Planning Game? *Urban Planning*, *Vol. 7, No. 2,* pp. 295-305.
2. Bilderback, S. (2023). Integrating training for organizational sustainability: The application of Sustainable Development Goals globally. *European Journal of Training and Development*, *Vol. 48, No. 7-8*, pp. 730-748.
3. Blakely, G., Skirton, H., Cooper, S., Allum, P., Nelmes, P., Brimicombe, J. (2018). An analysis of the influence of business simulation games on business school students' attitude and intention toward entrepreneurial activities. *Journal of Education for Business*, *Vol. 93, No. 2,* pp. 53-61.
4. Blanchard, O., Buchs, A. (2015). Clarifying sustainable development concepts through role-play. *Simulation & Gaming*, *Vol. 46, No. 6*, pp. 697-712.
5. Boncu, Ș., Candel, O., Popa, N. (2022) Gameful green: a systematic review on the use of serious computer games and gamified mobile apps to foster pro-environmental information, attitudes, and behaviors. *Sustainability*, *Vol. 14, No. 16,* p. 10400. doi: 10.3390/ su141610400
6. Camelo, G., Nogueira, M. (2024). The ESG menu. *Sustainability*, *Vol. 16, No. 11*, p. 4377.
7. Chen, F., Ho, S. (2022). Designing a board game about the SDGs. *Sustainability*, *Vol. 14, No. 18,* p. 11197
8. Cooper, M. (2024). *Integrating sustainability into procurement*. doi: 10.20944/preprints202407.0614.v1.
9. de Almeida, F.P., van Tulder, R., Rodrigues, S.B. (2023). Walking the talk: Making the SDGs core business - An integrated framework. *International Business and Sustainable Development Goals, Vol. 17*. Bingley: Emerald Publishing, pp. 49-82
10. De Matos, J.A., Clegg, S.R. (2013). Sustainability and organizational change. *Journal of Change Management*, *Vol. 13, No. 4*, pp. 382-386.
11. Djaouti, D.A. (2011). Classifying serious games: The G/P/S model. *Handbook of Research on Improving Learning and Motivation Through Educational Games*. Hershey, PA: IGI Global, pp. 118-136.
12. Douglas, B., Bräuer, M. (2021). Gamification to prevent climate change. *Current Opinion in Psychology*, *Vol. 42*, pp. 89-94.
13. Endress, T., Pussep, A., Schief, M. (2023). Digital serious game to engage business students in active lectures: A pilot study. *Journal of International Education in Business*, *Vol. 16, No. 1*, pp. 115-128.
14. Feinberg, W.E., Johnson, N.R. (1988). A survey of the use of business games in academia and business. *Simulation & Games*, *Vol. 18*, pp. 207-224.

15. Fischer, S., Göhlich, M., Schmitt, J. (2024). Adapting to climate change through play? Didactically effective elements of business simulation game. *Frontiers in Education*, *vol. 9,* p. 1303107
16. *Inchainge "Triple Connection"*. Retrieved from: https://inchainge.com/business-games/ttc/, 15/11/2025.
17. Iqbal, Q., Ahmad, N. (2020). Sustainable development: The colors of sustainable leadership. *Sustainable Development*, *Vol. 29, No. 1*, pp. 108-119.
18. Ivens, S. et al. (2020). Education for sustainable development through a digital simulation game. *Sustainability*, *Vol. 12, No. 20*, p. 8743
19. Jääskä, E., Aaltonen, K., Kujala, J. (2021). Game-based learning in project sustainability management education. *Sustainability*, *Vol. 13, No. 15*, p. 8204.
20. Janakiraman, S., Watson, S., Watson, W. (2018). Using game-based learning to facilitate attitude change. *Journal of Education for Sustainable Development*, *Vol. 12, No. 2*, pp. 176-185.
21. Jiménez, D., Franco, I.B., Smith, T. (2021). A review of corporate purpose: An approach to actioning the Sustainable Development Goals (SDGs). *Sustainability*, *Vol. 13, No. 7*, p. 3899.
22. Jones, P., Hillier, D., Comfort, D. (2016). The sustainable development goals and business. *International Journal of Sales, Retailing and Marketing*, *Vol. 5, No. 2*, pp. 38-48.
23. Kikkawa, T., Kriz, W., Sugiura, J. (Eds.) (2022). *Gaming as a Cultural Commons: Risks, Challenges, and Opportunities*. Singapore: Springer.
24. Klabi, S., Klabi, N. (2012). Analysing the required properties of business simulation games to be used in e-learning and education. *International Journal of e-Education, e-Business, e-Management and e-Learning*, *Vol. 2, No. 3*, pp. 204-208.
25. Kolb, D.A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice Hall.
26. Kriz, W. (2010). A systems-oriented constructivism approach to the facilitation and debriefing of simulation and games. *Simulation & Gaming*, *Vol. 41, No. 5*, pp. 663-680.
27. Madani, K., Pierce, T., Mirchi, A. (2017). Serious games on environmental management. *Sustainable Cities and Society*, *vol. 29*, pp. 1-11.
28. Meijer, S.A., Lukosch, H., de Wijse-van Heeswijk, M., Klabbers, J.H.C. (2025). Positioning game science for gaming and simulation: A reflection on the research philosophical underpinnings. *Proceedings of the 2025 Winter Simulation Conference (WSC)*. Seattle, WA, USA, pp. 2204-22, doi: 10.1109/WSC68292.2025.11339030
29. Montiel, I. et al. (2021). Implementing the United Nations' sustainable development goals in international business. *Journal of International Business Studies*, *Vol. 52, No. 5*, pp. 999-1030.

30. Nascimento, M. et al. (2023). ESG+ P Evolution: A Videogame Proposal for Teaching the New ESG Concept. *Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames)*. Porto Alegre: SBC.
31. Neset, T. et al. (2020). Serious gaming for climate adaptation. *Sustainability*, *Vol. 12, No. 5*, p. 1789.
32. Niessen, L., Bocken, N.M.P., Dijk, M. (2024). The road to flourishing – Can we drive strongly sustainable business intention through a game-based tool? *Journal of Cleaner Production*, *vol. 474*, p. 143567
33. Nilsson, M. et al. (2018). Mapping interactions between the sustainable development goals: Lessons learned and ways forward. *Sustainability Science*, *Vol. 13*, pp. 1489-1503.
34. Nkhoma, M. et al. (2014). Towards an understanding of real-time continuous feedback from simulation games. *Interactive Technology and Smart Education*, *Vol. 11, No. 1*, pp. 45-62.
35. Oliveira, R. et al. (2021). Gamification in e-learning and sustainability. *Sustainability*, *Vol. 13, No. 21*, p. 11945.
36. Ordonez-Ponce, E., Khare, A. (2020). GRI 300 as a measurement tool for the United Nations sustainable development goals. *Journal of Environmental Planning and Management*, *Vol. 64, No. 1*, pp. 47-75.
37. Ordonez-Ponce, E., Clarke, A., MacDonald, A. (2021). Business contributions to the sustainable development goals through community sustainability partnerships. *Sustainability Accounting, Management and Policy Journal*, *Vol. 12, No. 6*, pp. 1239-1267.
38. Rumeser, D. (2018). Project management serious games: Identifying gaps, trends, and directions for future research. *Journal of Modern Project Management*, *Vol. 6, No. 1*, pp. 48-59.
39. Saizarbitoria, I., Urbieta, L., Boiral, O. (2021). Organizations' engagement with SDGs. *Corporate Social Responsibility and Environmental Management*, *Vol. 29, No. 2*, pp. 316-328.
40. Sullivan, K., Thomas, S., Rosano, M. (2018). Using industrial ecology and strategic management concepts to pursue the Sustainable Development Goals. *Journal of Cleaner Production*, *Vol. 174*, pp. 237-246.
41. Teixeira, T.B., Battistelle, R.A., Teixeira, A.A., Bonacina, C.Z., Vitoreli, M.C. (2022). Sustainability in the supply chain: Analysing the role of the focal company and training in the implementation of SDGs. *Sustainability*, *Vol. 14, No. 19,* p. 12882.
42. *The Green Business Lab.* Retrieved from: https://www.gblsim.com/, 15/11/2025.
43. Tribaldos, T., Schneider, F. (2021). Enabling players to develop theories of change for sustainable development: A serious game. *Simulation & Gaming*, *vol. 52, no. 5*, pp. 664-678.
44. van der Waal, J.W.H., Thijssens, T. (2020). Corporate involvement in Sustainable Development Goals: Exploring the territory. *Journal of Cleaner Production*, *Vol. 252*, p. 119625.

45. van Zanten, J.A., van Tulder, R. (2018). Multinational enterprises and the Sustainable Development Goals: An institutional approach to corporate engagement. *Journal of International Business Policy*, *Vol. 1*, pp. 208-233.
46. Wang, K. et al. (2021). Evaluating the effectiveness of an augmented reality game. *Sustainability*, *vol. 13, no. 24*, p. 13912.
47. World Business Council for Sustainable Development (WBCSD) (2015). *The Guide for Business Action on the SDGs.* Geneva: World Business Council for Sustainable Development, p. 4.
48. Wouters, P. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, *Vol. 105, No. 2*, pp. 249-265.
49. Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer*, *Vol. 38, No. 9*, pp. 25-32.

Appendix A – Review protocol and exploratory scan procedure

This appendix documents the protocol used in the structured literature review and the exploratory scan of practice-oriented serious games. The study does not claim to be an exhaustive systematic review of all sustainability-related games. Instead, it combines a transparent academic review with an exploratory mapping of publicly documented practitioner tools, because many serious games used in corporate sustainability training are developed and disseminated outside peer-reviewed publication channels.

1. Academic database search

Scopus and Web of Science were searched for English-language peer-reviewed journal articles published between 2015 and 2024. The year 2015 was selected because it marks the adoption of the SDGs. The search string combined three conceptual blocks: (a) sustainability and SDGs; (b) serious games, simulation games, game-based learning, gamification, training games, and learning and development; and (c) business transformation, organizational change, business strategy, and strategic planning.

The search formula was: ("Sustainable Development Goal*" OR "SDG*" OR "SDG Integration" OR "Sustainability Initiative*" OR "Corporate Social Responsibility" OR "CSR Initiative*" OR "Sustainable Business Practice*" OR "Corporate Sustainability") AND ("Serious Game*" OR "Gamification" OR "Game-Based Learning" OR "Training Game*" OR "Sustainability Training" OR "Simulation Game*" OR "Impactful Game*" OR "Learning and Development") AND ("Business Transformation" OR "Organizational Change*" OR "Business Strategy*" OR "Strategic Planning").

In Scopus, the search was limited to the following subject areas: Social Sciences; Computer Science; Environmental Science; Business, Management and Accounting; Energy; Engineering; Economics, Econometrics and Finance. In Web of Science, the search was limited to Environmental Sciences and Ecology; Business and Economics; Computer Science; Engineering; Social Sciences - Other Topics; Education and Educational Research; and Science and Technology - Other Topics.

2. Screening procedure

The Web of Science search generated 102 records, and the Scopus search generated 97 records. Duplicates and multiple records referring to the same study were removed. Titles and abstracts were screened for explicit relevance to all three domains: a game or simulation intervention; a sustainability- or SDG-related purpose; and a business, management, organizational, or strategic transformation context. Full texts were then assessed when the title and abstract indicated potential relevance. Four academic studies met the inclusion criteria and were retained for synthesis.

3. Data extraction and coding

A common extraction template was used for all academic games. The following fields were coded: country of origin; game purpose; target audience; physical or digital format; gameplay structure; sustainability concepts addressed; intended and observed learning outcomes; underlying theory or framework; design process, including co-design and iteration; evidence of evaluation; reported limitations; and future development implications. These fields were

selected to support a comparable synthesis across games and to avoid describing each case according to a different set of criteria.

4. Exploratory scan of practice-oriented games

Because the academic search yielded few directly relevant studies, an exploratory scan was conducted to identify publicly documented practice-oriented serious games and simulations. From November 2023 to March 2025, searches were conducted through Google, serious gaming portals, game repositories, international gaming awards, developer websites, and expert contacts. Candidate tools were included in the mapping table when they were publicly identifiable, related to sustainability or the SDGs, relevant to business or management audiences, and sufficiently documented to assess their purpose, target group, format, and SDG coverage. Entertainment-only titles and tools without adequate documentation were excluded.

Fourteen candidate SDG-related business games were identified in the exploratory scan. Two games, Green Business Lab and Triple Connection, were selected for closer discussion in the manuscript because they were explicitly positioned for business training or strategy work, offered public documentation sufficient for assessment, and reported broad SDG coverage. The exploratory scan was treated as a mapping exercise rather than as evidence of effectiveness. Developer claims, testimonials, and website descriptions were therefore interpreted with caution and not treated as equivalent to independent empirical evaluation.

5. Synthesis logic and limitations

The synthesis was organized around four analytical dimensions: purpose and transformation logic; game structure and action space; target audience and facilitation context; and evidence of outcomes. This framework enabled comparison of game purpose, game elements, validation, and transfer to practice. The review is limited by database coverage, language, keyword selection, and public availability of practitioner documentation. The narrow yield indicates that future reviews should test broader keyword strategies, including terms such as transition management, circular economy, climate adaptation, responsible innovation, organizational learning, and sustainability transitions.

Appendix B – Supplementary comparison tables

Table B1.
Comparison of serious games based on the structured literature review.

Category	MainKassandra	Theory of Change Game	Sustainability Futures Game	The Road to Flourishing
Country of origin	Germany	Switzerland and Germany	Finland	Netherlands
Game purpose	Engage corporate teams in learning about climate change adaptation and mitigation by role-playing a fictitious company.	Apply "Theory of Change" (ToC) thinking to sustainable development projects. Help players collaboratively articulate how a project or initiative can achieve its desired impact by mapping out actors, actions, and outcomes.	Enable stakeholders to imagine desirable sustainable futures for an urban context and explore pathways to achieve them.	Raise players' knowledge of sustainable business models and influence their attitudes and intentions to implement more transformative sustainability practices.
Target audience	Employees and managers in companies.	Researchers, students, and practitioners involved in sustainability projects or transdisciplinary initiatives.	Primarily aimed at professionals in urban planning and sustainability, such as city officials, urban planners, business leaders, and sustainability specialists. The game has also been played with master's students in sustainability/design programs.	People working in or with business, including corporate professionals, sustainability consultants, and business students.
Format (physical/digital)	Physical simulation board game with printed materials and some digital supplements.	Purely analog board and card game.	Both physical and digital.	Both physical and digital.
Gameplay structure	A facilitated simulation workshop (~4–8 hours). Players form teams of 3–4, each team managing a fictitious company in the "MainKassandra" region, which faces the impacts of climate change. The game is scenario-based and unfolds in rounds. In	A board-and-card game for ~5–6 players. The board displays a Theory of Change (ToC) template, and players collaboratively fill it in through guided discussion. The game involves two phases: a quick brainstorming round to identify key ideas, followed by a deeper	A facilitated narrative workshop (~3 hours), focused on imagining and planning sustainable urban futures. Participants choose a real city and first co-create a vision of what a desirable, sustainable version of that city might look like in 2030. Then they work backward	A board game (playable in person or online via a virtual board on Miro) that uses quiz questions and scenario "events" to simulate a company's journey toward sustainability. Players (individuals or teams) start at the beginning of a game board and progress through

	each round, teams discuss and select climate adaptation or mitigation measures (from a provided catalog of ~80 options) to protect their companies from extreme weather and climate risks. They must make managerial decisions, role-play discussions, and present interim results after each round, thereby helping to share knowledge. Success is measured by a "maturity" score indicating how well the company is prepared for climate impacts. The final debriefing closes the session, during which all players reflect on what they learned and how it applies to their real work environment.	discussion using color-coded prompt cards. These cards help players reflect on strategies, context, and assumptions, while encouraging participation and structured dialogue. A facilitator typically concludes the session with a debrief to consolidate learning and insights.	to identify the key steps, challenges, and actions needed to reach that future. The game blends storytelling, collaboration, and strategic thinking, often using the UN SDGs as a guide. Sessions end with presentations and reflections. The game can be played as a physical board game or as an online workshop using a digital collaboration platform (e.g., Miro), with facilitators guiding the exercises in either format.	five levels of sustainable business strategy: Efficiency → Net Zero → Circularity → Sufficiency → Regeneration, ultimately reaching "Flourishing" at the end. The board is essentially a path with these stages. On each turn, a player must answer a multiple-choice question about a sustainability concept or a real-world case. A correct answer allows the player/team to move forward to the next step. Along the way, they encounter event and explanation cards that deepen their understanding of each sustainability concept. In the latest version, players also reflect on how each strategy could apply to their own context. A facilitator may guide discussion and debrief at the end to reinforce learning and support real-world application.
Sustainability concepts covered	Climate change adaptation and mitigation in a business context.	Theory of Change and project planning for sustainable development.	Urban sustainability and futures thinking.	Sustainable business models and "strong sustainability."
Learning outcomes (intended and observed)	Intended outcomes include improved understanding of corporate climate adaptation; participant learning outcomes were not empirically evaluated in the reported study.	Qualitative feedback from iterative testing indicated clearer articulation of assumptions, shared understanding of project pathways, and appreciation of diverse perspectives. No long-term behavioral or organizational outcomes were assessed.	Qualitative observations and participant-generated outputs indicated reflection on assumptions, development of alternative visions, identification of possible pathways, and opportunities for stakeholder collaboration. No direct behavioral, policy, or organizational outcomes were measured.	The game was shown to significantly increase players' knowledge of sustainable business concepts, helping them better understand strategies like circularity and sufficiency. Some positive shifts were also observed in attitudes and social norms around sustainability. However, a single session did not lead to significant changes in players' stated intention to act more sustainably in their work. Still, participants found the real-world

				examples engaging and appreciated the quiz-based format, which likely supported retention. The game's updated version includes reflective prompts to help players connect the content to their own context, aiming to strengthen future behavioral impact.
Evidence of evaluation	Expert interviews and focus groups were used to identify didactic, contextual, and implementation requirements. No formal evaluation of completed gameplay outcomes was reported.	Evidence from iterative playtesting and stakeholder workshops. Reported outcomes primarily focus on cognitive and relational learning; long-term behavioral evidence remains limited.	Mainly qualitative, design-oriented evidence from iterative testing, user feedback, and facilitator observations. Limited direct measurement of learning outcomes or behavioral effects.	Strongest evidence among the four cases: pre- and post-game survey with 220 participants, showing significant knowledge gains and some attitudinal/social-norm effects, but no significant short-term change in behavioral intention.
Transfer/validation gap	Unclear whether workshop learning leads to implemented climate adaptation measures, changes in investment decisions, or changes in organizational routines.	Unclear whether shared theories of change improve later project implementation or sustained stakeholder collaboration.	Unclear whether visions and pathways generated in the game are integrated into real planning, policy, or organizational decision-making.	Unclear whether improved knowledge and attitudes translate into actual strategic or behavioral change without repeated use, action planning, and organizational support.
Underlying theory or framework	Climate adaptation theory and serious gaming pedagogy.	Theory of Change (ToC) methodology and social learning concepts.	Transformative design frameworks.	Sustainable business model theory and behavioral theory.
Design process (co-design & iteration)	The game was developed as part of a climate adaptation training project using an iterative, user-informed process. The team reviewed literature and interviewed HR and sustainability experts to identify practical elements for managers, then created a prototype. Feedback from manager focus groups led to key refinements, such as simplifying the structure and adding realistic scenarios. While not fully co-designed, the game was significantly shaped by	The creators followed a systematic process of conceptualization → prototyping → testing → refinement, repeating this over several rounds. Drawing on the Theory of Change literature and earlier serious games, the team built an initial prototype that was tested internally and led to significant changes. Subsequent iterations were tested at academic conferences and a stakeholder workshop, which together involved around 90 participants. Feedback-	The game was developed through a participatory, multi-iteration design process as part of the CreaTures research project. Co-developed with the design consultancy Hellon, the game evolved over at least five design iterations and seven test sessions. Early prototypes focused on refining core mechanics and storytelling prompts to support futures thinking. Later sessions involved target users—including professionals and students—which helped adapt the	The Road to Flourishing was developed using a Design Science Research (DSR) approach, combining theory-driven design with iterative testing. The team identified a gap in sustainability education tools—particularly the dominance of weak sustainability—and proposed a game to foster stronger paradigms. After reviewing existing tools, they created a prototype and tested it in five rounds with sustainability academics, refining the game based

	stakeholder input. Formative evaluations during testing guided further improvements. The current version reflects at least two design cycles, with additional updates planned based on future workshop use.	informed continuous improvements—such as more precise wording, better pacing, and smoother discussion flow. This iterative, feedback-driven approach allowed players to act as co-developers. By the final version, only minor adjustments were needed, and the game effectively supported its intended learning outcomes.	game to different contexts. Feedback from each round informed changes in structure, content, and facilitation. This collaborative, iterative approach ensured the game was both practical and adaptable across settings.	on feedback. Once early feedback stabilized, they launched a larger evaluation phase and introduced Version 2.0, tailored to business audiences. These updates—such as adding reflective steps and adjusting the pacing—were based on user input. The process reflects a structured, evidence-based cycle blending academic design with real-world relevance.

Source: own elaboration.

Table B2.

Practice-oriented sustainability games identified in the exploratory scan

No.	Game	Type		Created by	Target group				Purpose		No. of SDGs	Country	Source of information
		Board game	Web based		Business	Education	Public administration	NGOs	Strategy	Awareness			
1	BUSINESS SIMULATION		X	Edumundo		X			X		3-4 out of 17	Netherlands	https://www.edumundo.com/gamification/business-games/sustainable-business-simulatie
2	Corporate Sustainability Dilemma Game		X	EU-funded "Gamify Project"	X					X	13	European Union	https://www.gamify.site/corporate-sustainability
3	Ecologic	X		Sabirov & Kormakov	X	X	X	X		X	Not publicly reported	Russia	https://www.ecologic4people.ru/en
4	Green Business Lab		X	Realia Group LLC	X				X		10 out of 17	USA	Sustainability Simulation Game Home - The Green Business Lab (gblsim.com)
5	Green&Great		X	Center for Systems Solutions		X				X	Not publicly reported	Poland/ Germany	https://greenandgreat.socialsimulations.org/#main
6	In the Loop ® Game: Board Game	X		In the Loop Games	X	X				X	Not publicly reported	Netherlands	In the Loop Games – Making circular economy fun and understandable
7	MIT CleanStart		X	MIT Management Sloan	X	X	X			X	9	USA	https://mitsloan.mit.edu/teaching-resources-library/cleanstart-simulating-a-clean-energy-startup
8	Save the Future		X	Centre for Systems Solutions	X	X	X	X	X		Not publicly reported	European Union.	https://games4sustainability.org/gamepedia/save-the-future/
9	Sustainability Game Experience		X	Contur	X					X	16	Germany	https://www.contur-online.de/en/sustainability-game-experience/
10	Sustainable Business Model Innovation Game	X		threebility		X			X		Not publicly reported	Germany	https://www.threebility.com/post/playing-games-to-facilitate-sustainable-product-and-business-innovation
11	Teamplay		X	The Sustainability Games		X				X	17	Netherlands	The Sustainability Games - Online employee engagement, learning, and development accelerator to enable a circular economy and achieve the SDGs
12	Sustainable Business		X	Hubro Education		X			X		Not publicly reported	Norway	https://hubro.education/en/hubro-sustainable-business-simulation

13	The Net Zero Game 2050	X		Net Zero Game ApS	X	X	X	X		X	4	Denmark	https://netzerogame.com/
14	Triple Connection		X	Inchainge	X				X		13 out of 17	Netherlands	The Triple Connection: Sustainability Business Game Simulation (inchainge.com)

Source: own elaboration.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

DYSFUNCTIONS IN ORGANIZATIONAL SYSTEMS: COMPENSATORY MECHANISMS

Jacek PASIECZNY

University of Warsaw, Faculty of Management; jpasieczny@wz.uw.edu.pl, ORCID: 0000-0002-9405-3861

Purpose: The purpose of this paper is to analyze organizational dysfunctions as an inherent element of organizational functioning and to identify mechanisms that enable organizations to compensate for or balance such dysfunctions. The study seeks to explain how organizations maintain operational capacity despite structural, process, and behavioral disturbances and to identify mechanisms that limit their negative consequences.
Design/methodology/approach: The study adopts a qualitative research approach due to the exploratory nature of the problem. Empirical data were collected through in-depth interviews with representatives of organizations and their stakeholders. The study included employees and clients of both private and public organizations operating in different sectors. In total, more than sixty respondents participated in the research, and fifty-one interviews were recorded and transcribed.
Findings: Identified dysfunctions include excessive centralization, autocratic management styles, excessive bureaucracy and reporting, conflicts between departments, unclear division of responsibilities, and problems related to outsourcing and labor cost reduction strategies. Despite these problems, organizations continue to function by balancing structural and process tensions. Key compensatory mechanisms include experienced employees, informal cooperation networks, and organizational resources such as reputation or market position.
Research limitations/implications: The study is based on purposive sampling and qualitative interview data, which limits statistical generalization. Future research could extend the analysis through comparative or quantitative studies examining relationships between organizational dysfunctions, resilience, and adaptive capabilities.
Practical implications: The findings highlight the importance of balancing formalization and flexibility in organizational structures and supporting mechanisms of cooperation and organizational learning. Informal relationships and experienced employees play a key role in maintaining organizational effectiveness.
Originality/value: The paper contributes to the literature by treating organizational dysfunctions not only as pathologies but also as inherent elements of complex organizational systems and by identifying compensatory mechanisms that enable organizations to maintain operational capacity despite disturbances.
Keywords: organizational dysfunctions; compensatory mechanisms; organizational resilience; organizational learning; organizational structures.
Category of the paper: Research paper.

1. Introduction

The issue of organizational dysfunctions constitutes an important area of research in management sciences, as organizations – understood as complex social systems – operate under conditions of uncertainty, bounded rationality of decision-makers, and often conflicting interests among organizational participants. Under such conditions, organizational processes rarely proceed in a fully rational and optimal manner, and various disturbances, tensions, and inefficiencies constitute a natural element of the functioning of organizational structures. Classical studies on organizations already indicated that decisions made within organizations are often the result of compromises, organizational routines, and adaptive processes rather than purely rational calculation (March, Simon, 1958). Consequently, various types of organizational dysfunctions may be treated not only as manifestations of inefficiency but also as an inherent element of the functioning of complex organizational systems. Interest in the issue of organizational dysfunctions has a long tradition in organization theory. Classical analyses of bureaucracy indicated that organizational solutions designed to increase operational efficiency may simultaneously generate unintended consequences. An example is provided by analyses of bureaucratic dysfunctions, which showed that excessive formalization and orientation toward procedures may lead to a loss of organizational flexibility and the emergence of rigid patterns of action (Merton, 1940). These analyses were further developed in studies of the functioning of bureaucratic structures, which demonstrated that mechanisms of control and formalization may contribute to the persistence of inefficient organizational practices and limit the organization's ability to introduce change (Crozier, 1964). An important contribution to the development of research on organizational functioning was also made by the behavioral theory of the firm. According to this perspective, organizations are perceived as systems of coalitions composed of different groups of stakeholders whose goals are not always aligned. Under such conditions, decision-making processes within organizations have a negotiated and adaptive character, and the decisions made are often the result of bounded rationality and the availability of information (Cyert, March, 1963). Consequently, organizations develop various routines and procedures that stabilize their functioning but may simultaneously lead to the emergence of specific organizational dysfunctions. Contemporary research on organizational pathologies also focuses on the analysis of phenomena such as organizational misconduct, corruption, or unethical behavior within organizations. The literature indicates that such phenomena may have a systemic character and result from specific organizational, cultural, or institutional conditions. In particular, it is emphasized that processes of institutionalization of certain organizational practices may lead to the normalization of undesirable or unethical behaviors (Ashforth, Anand, 2003). Studies on the phenomenon of organizational wrongdoing indicate that organizational irregularities may result both from individual decisions made by members of organizations and from broader organizational mechanisms that facilitate the reinforcement

of particular patterns of action (Palmer et al., 2016). At the same time, organizations are not merely passive victims of their own dysfunctions. In many cases they develop adaptive mechanisms that allow them to limit the negative consequences of disturbances and maintain their operational capacity in a changing environment. These mechanisms may include, among others, processes of organizational learning, the development of informal networks of cooperation, or the use of excess organizational resources (Argote, Miron-Spektor, 2011). In this context, particular importance is attributed to the concept of organizational resilience, which refers to the ability of organizations to adapt and maintain operational effectiveness under conditions of disturbances or crises (Duchek, 2020). Research indicates that organizations characterized by a high level of resilience are able not only to respond to crises but also to use them as impulses for organizational change and for the development of new adaptive capabilities (Hillmann, Guenther, 2021). The literature also emphasizes the role of learning processes based on organizational errors and failures. Analyses show that experiences related to failures may constitute an important source of organizational knowledge, enabling the identification of organizational weaknesses and the introduction of changes in structures and processes (Desai, 2016). From this perspective, organizational dysfunctions may paradoxically serve as stimuli for organizational learning and for increasing the adaptive capabilities of organizations. The issue of organizational dysfunctions has also been addressed in the context of analyses of organizational pathologies and their impact on the effectiveness of organizational functioning. Research indicates that organizational dysfunctions may result from structural, cultural, or institutional factors, and their consequences may include decreased operational effectiveness, organizational conflicts, or limitations in the adaptive capacity of organizations (Pasieczny, 2016, 2017). Despite the growing interest in the issue of organizational dysfunctions in the management literature, relatively few studies focus on the analysis of mechanisms that enable organizations to function despite the occurrence of such disturbances. Most studies concentrate on identifying the sources of organizational pathologies or analyzing their negative consequences. Much less frequently analyzed, however, are the processes that enable organizations to compensate for or balance dysfunctions over the long term. In particular, attempts to integrate research on organizational dysfunctions with concepts related to organizational resilience, organizational learning, and organizational adaptive mechanisms are relatively rare in the literature. Therefore, a research gap can be identified in the insufficient recognition of mechanisms for balancing organizational dysfunctions that enable organizations to maintain their operational capacity despite the occurrence of structural or process disturbances. Of particular interest is the question of how organizations compensate for the negative consequences of dysfunctions through the use of various adaptive mechanisms, such as flexible organizational structures, learning processes, or informal organizational relationships. The aim of this article is to analyze organizational dysfunctions as an element of organizational functioning and to identify mechanisms that enable their balancing. The study aimed to answer the following research questions: What forms of organizational dysfunctions

are most frequently discussed in the literature on organization and management? What mechanisms allow organizations to maintain operational stability despite internal dysfunctions? To what extent can organizational resources, institutional position, and informal practices compensate for organizational dysfunctions?

The article adopts a systemic perspective, according to which organizational dysfunctions are not merely negative phenomena but may constitute an integral element of the functioning of complex organizational systems. In particular, an attempt is made to identify compensatory mechanisms that allow organizations to limit the effects of dysfunctions and maintain their operational capacity under conditions of disturbances. The contribution of this article to the development of the literature can be considered in several dimensions. First, the article proposes an approach that treats organizational dysfunctions not only as negative phenomena but also as elements of the functioning of complex organizational systems that may coexist with adaptive mechanisms within organizations. Such an approach complements the dominant stream of research in the literature, which focuses primarily on identifying the sources of organizational pathologies and analyzing their negative consequences (Ashforth, Anand, 2003; Greve et al., 2010). Second, the article integrates two streams of research that are often analyzed separately in the management literature, namely research on organizational dysfunctions and research on organizational resilience and organizational adaptive capabilities (Duchek, 2020; Hillmann, Guenther, 2021). The adopted perspective makes it possible to indicate that adaptive mechanisms within organizations may function as compensatory mechanisms that limit the negative consequences of organizational dysfunctions. Third, the article develops the discussion on the role of mechanisms for balancing dysfunctions within organizations by emphasizing the importance of processes such as organizational learning, the adaptation of organizational structures, and the use of informal mechanisms for coordinating activities (Argote, Miron-Spektor, 2011; Desai, 2016). Identifying these mechanisms makes it possible to better understand how organizations are able to maintain their operational capacity despite the occurrence of various disturbances in their functioning. As a result, the article contributes to a deeper understanding of the nature of organizational dysfunctions and the mechanisms that enable their balancing in the process of organizational functioning.

2. Dysfunction as an Element of Organizational Functioning

Organizations are complex social systems operating under conditions of uncertainty, multiple stakeholder interests, and bounded rationality of decision-makers. As a result, organizational processes rarely correspond to models of rational design of management structures and procedures. In practice, the functioning of organizations is often associated with the occurrence of various inefficiencies described in the literature as organizational

dysfunctions or organizational pathologies. The issue of organizational dysfunctions constitutes an important area of research in management sciences, particularly in the context of analyzing organizational effectiveness and sustainability. Dysfunctions may be understood as persistent or recurring disturbances in the functioning of organizations that lead to decreased operational efficiency, the generation of losses, or the waste of resources (Pasieczny, Glinka, 2016). The literature indicates that organizational pathologies are not incidental phenomena but often constitute an inherent element of the functioning of organizational systems (Pasieczny, 2017). Research on organizational pathologies has a long tradition in organization theory. Classical analyses of bureaucratic structures already indicated that organizational solutions generate both functional and dysfunctional effects (Merton, 1940). In a similar vein, scholars analyzed the phenomenon of unintended consequences of organizational actions, which may lead to the emergence of rigid procedures and excessive formalization (Crozier, 2009). Contemporary research indicates that organizational dysfunctions may take various forms, such as inefficient organizational structures, conflicts of interest, decision-making errors, opportunistic behavior, pathological phenomena in social relations, corrupt practices, and others (Ashforth et al., 2008; Ashforth, Anand, 2003; Greve et al., 2010; Treviño et al., 2014). From a systemic perspective, organizations should be perceived as complex adaptive systems in which dysfunctions are often the result of tensions between different elements of the system (Anderson, 1999). In such an approach, organizations are not fully rational structures but rather dynamic systems in which both adaptive and disorganizing mechanisms emerge (Weick, Sutcliffe, 2011). Various classifications of organizational dysfunctions have been proposed in the literature. One of the most frequently cited typologies includes structural, process, and behavioral dysfunctions (Vaughan, 1999). Structural dysfunctions result from an inadequate fit between the organizational structure and the organization's environment or strategy (Donaldson, 2001). They may lead to excessive centralization, conflicts of competence, or a lack of coordination of activities. Process dysfunctions refer to inefficiencies in the implementation of fundamental organizational processes, such as decision-making, communication, or knowledge management (Argote, Miron-Spektor, 2011). Research indicates that particularly in complex organizations problems often arise related to the flow of information and the coordination of activities between organizational units (Gulati et al., 2012). Behavioral dysfunctions, in turn, result from the behaviors of individuals and groups within organizations, such as opportunism, abuse of power, or unethical conduct (Ashforth, Anand, 2003). The sources of organizational dysfunctions can be analyzed at different levels: individual, organizational, and institutional. At the individual level, a key role is played by the cognitive limitations of decision-makers and decision-making errors resulting from heuristics and cognitive biases (Bazerman, Moore, 2012). At the organizational level, structures of power, incentive systems, and control mechanisms are of significant importance (Ocasio, 1997). Improper design of these elements may lead to the emergence of dysfunctional behaviors, such as manipulation of information or excessive risk-taking (Sitkin, Pablo, 1992).

At the institutional level, dysfunctions may result from environmental pressures (Pfeffer, Salancik, 1878) and mechanisms of institutional isomorphism (DiMaggio, Powell, 1983). Organizations often adopt organizational solutions not because they are effective but because they are socially legitimized. Contemporary systemic approaches indicate that dysfunctions do not always lead to organizational failure. In many cases, organizations develop adaptive mechanisms that allow them to compensate for the negative consequences of disturbances (March, Simon, 1958). One such mechanism is the phenomenon of loose coupling, which enables the limitation of the spread of problems within the organizational system (Weick, 1976). As a result, dysfunctions occurring in one area of an organization do not necessarily lead to destabilization of the entire system. A similar role is played by organizational slack, which increases an organization's ability to absorb shocks and adapt to changing conditions (Bourgeois, 1981; Cyert, March, 1963). These resources may take various forms, such as financial surpluses, personnel reserves, or excess organizational competencies. The importance of organizational learning processes is also emphasized, as they allow organizations to adapt to emerging dysfunctions (Argote, Miron-Spektor, 2011). In this context, dysfunctions may serve as stimuli for organizational change and innovation. Compensatory mechanisms may be understood as processes and structures that enable organizations to maintain operational effectiveness despite the occurrence of disturbances or inefficiencies in certain areas of activity (Lengnick-Hall et al., 2011). In the management literature, this phenomenon is increasingly analyzed in the context of organizational resilience, which refers to the ability of organizations to survive and adapt under conditions of disturbances (Duchek, 2020). Compensatory mechanisms may take both formal and informal forms. Formal mechanisms include, among others, crisis management procedures, control systems, and risk management structures (Sitkin, Pablo, 1992). Informal compensatory mechanisms, in turn, include social relationships, organizational norms, and networks of cooperation. Organizational resilience is one of the key compensatory mechanisms enabling organizations to function under conditions of dysfunction (Lengnick-Hall et al., 2011). Resilient organizations are characterized, among other things, by the ability to learn quickly, the flexibility of organizational structures, and well-developed networks of cooperation (Duchek, 2020). These mechanisms allow organizations not only to survive crises but also to use them as opportunities for development (Vogus, Sutcliffe, 2007). One of the most important compensatory mechanisms is the design of organizational structures in a way that enables the limitation of the effects of dysfunctions. An example is the decentralization of decision-making, which makes it possible to increase organizational flexibility and shorten response times to changes in the environment (Mintzberg, 1983). Another mechanism is organizational modularity, which makes it possible to isolate problems within specific parts of the organization (Schilling, 2000). Social mechanisms such as trust, cooperation, and social capital also play an important role in compensating for organizational dysfunctions (Nahapiet, Ghoshal, 1998). Social relationships may enable informal problem-solving and limit the consequences of formal organizational dysfunctions. The literature

indicates that in many organizations informal networks of cooperation play a key role in ensuring effective functioning (Krackhardt, Hanson, 1993).

3. Research Methodology

Due to the exploratory nature of the research problem and the limited state of knowledge concerning mechanisms for balancing organizational dysfunctions in the practice of organizational functioning, a qualitative approach was applied in the study. Qualitative research is particularly useful in the analysis of complex organizational phenomena in which context, the interpretations of organizational participants, and the processual nature of the studied phenomena are of key importance (Denzin et al., 2023). This approach makes it possible to achieve a deeper understanding of the mechanisms of organizational functioning and to identify relationships that are difficult to capture using quantitative methods. The study employed the method of in-depth interviews with representatives of organizations and their stakeholders. Interviews are one of the fundamental qualitative research techniques in management sciences, enabling the collection of detailed information about the experiences, interpretations, and organizational practices of the studied individuals (Kvale, Brinkmann, 2009). In particular, they make it possible to identify organizational mechanisms that may not be directly visible in formal documents or organizational structures. The selection of the studied organizations was purposive. The aim of such a selection was to include in the study employees of organizations diversified in terms of size, industry, and organizational form, which made it possible to capture different contexts in which organizational dysfunctions occur as well as different ways of compensating for them. In qualitative research, purposive sampling is a commonly used strategy that enables the selection of cases that are particularly useful for analyzing the studied phenomenon (Patton, 2015). The study included employees and clients of both private and public organizations. The respondents included, among others, employees and clients of: a large decentralized public institution responsible for phytosanitary control, a housing cooperative, a university, a private primary school, an international automotive corporation, a private medical clinic, an internet service provider, a large retail chain, and a catering company. Such diversity of cases made it possible to analyze organizational dysfunctions in different types of organizations and in different institutional contexts. In total, interviews were conducted with more than 60 respondents. The respondents included employees occupying various organizational positions, including representatives of management, operational employees, and – in some cases – clients of the studied organizations. Including the perspective of clients made it possible to obtain a more diverse picture of organizational functioning and to identify dysfunctions visible from the perspective of external stakeholders. Among the conducted interviews, 51 were recorded and subsequently transcribed (table 1). The transcripts

constituted the primary empirical material used in further data analysis. The remaining interviews were documented in the form of detailed research notes prepared immediately after the interview. The material derived from these interviews formed part of a broader research process. However, it was not subjected to coding and is not drawn upon in the present article.

Table 1.
List of interlocutors

Company/Sector	Size	Respondent type/Number of Interlocutors
Phytosanitary Control	Over 2000 employees	President – 1 Branch directors – 3 Inspectors - 12
University – 1	Over 5000 employees	Dean – 1 Professors - 3
University – 2	Over 3000 employees	Dean – 1 Professor - 1
Housing cooperative	100 employees	Technical Specialist – 1 Secretary - 1
Primary school	60 employees	Teacher - 1
International automotive corporation (local branch)	150 employees	HR specialist – 1 Controlling specialist - 2
Medical Clinic – 1	Over 1000 employees	HR Specialist - 1
Medical Clinic – 2	30 employees	President - 1
Internet provider	100 employees	President – 1 Finance director – 1 Technical manager - 1 Organizational specialist – 1
Retail chain	Over 1000 employees	Procurement specialist – 1 Secretary - 1
Catering company	50 employees	Quality manager - 1
Producer of seedlings	20 employees	Owner – 1 Export manager - 1
Handling company – 1	Over 200 employees	Operations manager -1
Handling company – 2	Over 300 employees	Operations manager - 1
Construction company	70 employees	Owner – 1 Operations manager - 1
Manufacturer of rehabilitation equipment	80 employees	Finance specialist - 1
Manufacturer of household appliances (local branch)	40 employees	Sales representative – 1 Secretary - 1
Shoe manufacturer	200 employees	President – 1 Chief accountant – 1 Quality manager - 1
Merchant ship	20 employees	First officer – 1 Sailor motorist - 1

Source: own elaboration.

The analysis of the collected empirical material was conducted using qualitative data coding procedures. This process involves the systematic identification and categorization of fragments of empirical data in order to extract key themes and interpretative patterns (Saldaña, 2013). Coding enables the gradual transition from raw empirical data to more general analytical categories. The data analysis proceeded in several stages. In the first stage, open coding was conducted, which involved identifying basic categories appearing in the respondents' statements. In the next stage, thematic coding was applied, which allowed the identified

categories to be grouped into broader analytical areas related to the occurrence of organizational dysfunctions and mechanisms for their compensation. Such an approach is widely used in qualitative research concerning organizations (Miles et al., 2014). The data analysis process had an iterative character, which means that the interpretation of the empirical material was gradually developed as the analysis of subsequent interviews deepened. Such an approach allows for a more in-depth understanding of the studied phenomena and for the identification of new analytical categories emerging during the process of data analysis. In order to increase the credibility of the research results, several procedures characteristic of qualitative research were applied. One of these was the triangulation of data sources, which involved the use of information obtained from different categories of respondents, including employees of organizations as well as their clients. Triangulation is a commonly used strategy for increasing the reliability of qualitative research because it enables the confrontation of different interpretative perspectives (Denzin, 2012). Additionally, case triangulation was applied, consisting of the analysis of different types of organizations operating in various sectors of the economy. The analysis of multiple cases makes it possible to identify both similarities and differences in the mechanisms of organizational functioning and increases the potential for generalizing analytical conclusions (Yin, 2018). An additional element increasing the credibility of the research was the systematic procedure of coding the empirical material and documenting subsequent stages of the data analysis. The transparency of the analytical process is one of the key criteria of quality in qualitative research in the social sciences (Miles et al., 2014). When interpreting the results, it is necessary to take into account the limitations typical of qualitative methods. The research strategy applied was based on purposive case selection, which means that the obtained results are not statistically representative of the entire population of organizations. In qualitative research, however, the objective is not statistical representativeness but rather a deeper understanding of the analyzed phenomena and the identification of mechanisms and processes occurring within organizations (Patton, 2015). Another limitation concerns the nature of the empirical data based on interviews with respondents. Data of this type have a declarative character and rely on the individual interpretations of organizational participants. This means that the opinions presented by respondents may be partially conditioned by their experiences, organizational roles, or subjective interpretations of the organizational situation (Kvale, Brinkmann, 2009). For this reason, in qualitative research it is important to take into account different perspectives and to confront information obtained from different respondents. The diversity of the studied organizations in terms of industry, size, and organizational form may also be considered a limitation. On the one hand, this made it possible to analyze organizational dysfunctions in different institutional contexts; on the other hand, it makes direct comparison of certain aspects of organizational functioning more difficult. However, case diversity is often used in qualitative research in order to increase the analytical potential of studies and to identify common mechanisms occurring in different organizational contexts (Yin, 2018). Finally, it should be

emphasized that the analysis of the data was based on an interpretative process characteristic of qualitative research. Although the use of systematic coding procedures and the documentation of subsequent stages of data analysis increase the transparency of the research process, the interpretation of empirical material always depends to some extent on the perspective of the researcher (Miles et al., 2014). In order to limit this type of risk, the analysis employed an iterative character of data coding and confronted interpretations with different fragments of the empirical material.

4. Results

The study revealed a number of phenomena recurring in many of the analyzed organizations, although they are not always evaluated in the same way.

Centralization of power and the importance of headquarters. Centralization and decentralization are key parameters of organizational structures. Extreme centralization means that the most important strategic decisions are made by a central decision-making body, which limits the autonomy of lower organizational levels.

At the beginning of the 2000s the managers were French and they came here to manage the company. There was no possibility that a Pole could be a director. Poles could be managers or rank-and-file employees. [FMP01]

The final decisions were made by the board in France, while in Poland decisions belonged to the directors and ultimately to the president, who in any case acted according to the guidelines from France. [FMP01]

However, in another institution centralization is perceived differently by both its clients and employees.

We consulted the first shipment with the inspection (…).

Q: With the local branch or with the headquarters? With the main office. They were the ones who learned the regulations of the destination country and told us what the requirements were. [KFK02]

It should be more unified so that all branches operate in a similar way. (…) Sometimes everyone interprets the regulations a little differently. [KFP02]

In many analyzed organizations the source of dysfunction is excessive centralization. However, as the above quotations indicate, problems may also arise from the lack of central coordination and control. Therefore, the source of dysfunction seems to be deviations from the desired level of centralization, which is specific to each organization.

Autocratic and bureaucratic management style. The hierarchical structure of organizations leads to multi-stage decision-making processes and the dominance of procedures.

The management style was certainly bureaucratic, but it could also be said that it was autocratic, because everything had to be approved at successive levels. [FMP01]

First the order was prepared by an employee in SAP, then approved by the manager, later by the director, who often did not even technically know how to use the system. [FMP01]

All final decisions were practically made by the owner. [FIP01]

The president could change his mind by 180 degrees at the last moment and no one could oppose it. [FIP01]

All of this then goes to the rector and it takes an incredibly long time…. [UP01]

A consequence of an autocratic, but also highly hierarchical, structure of power is a large power distance within the organization and, consequently, difficulties in correcting erroneous decisions.

Misalignment of decisions with local realities. Decisions made by managers at headquarters do not always take into account the local market or cultural context.

Very often decisions were made by people who came here and had little understanding of our market and the realities of how the company operates. [FMP01]

They came here from headquarters, basically they didn't know anything, but they were the most important… And they pushed their own suppliers. [SSWP01]

The misalignment of decisions with local realities often causes irritation among employees, but it may also significantly affect work efficiency and become a strongly dysfunctional factor.

Symbolic projects and superficial changes. Some organizational changes primarily serve to build the image of managers or institutions.

This move to the new office was supposed to show that the president had completed a major reorganization project that would bring savings. In reality, it turned out that the office was more expensive, worse located, and more difficult for employees to commute to. [FMP01]

We changed the name so that it would sound better in English for accreditation purposes. But our students are mostly from Poland, and in Polish it sounds terrible. [UP02]

Introducing changes is associated with the necessity of incurring costs, although these costs are not always easy to estimate. In the case of superficial changes, these costs are particularly burdensome, as such changes do not bring the expected organizational benefits.

Excessive bureaucracy, reporting, and data manipulation. A large number of reports and analyses sometimes become more important than real operational activities. Employees sometimes demonstrate considerable creativity in creating a false but management-approved picture of reality.

Over time there were more and more reports coming from headquarters and we had to prepare monthly, quarterly, semi-annual, and annual forecasts. At some point the reports became more important than the client itself. [FMP01]

If the targets were unrealistic, we had to adjust the data so that it looked as if they were achievable. [FMP01]

We took data from the THIN AIR system, but we often called this system by a more expressive name. [FMP02]

We prepare these 12-page syllabi, but everyone knows that it cannot really be used in practice. [UP01]

The phenomenon outlined here has an extremely dysfunctional character not only because it essentially describes work without value. It also creates an organizational fiction that deepens when decisions in an organization are made on the basis of foundations that are completely detached from reality.

Organizational chaos and unclear division of responsibilities. An important problem is the lack of clearly defined roles and responsibilities.

It was not clear who was responsible for what. In the initial period there was a substitution table, but later it completely faded away. [FMP01]

An unclear division of responsibilities creates another risk.

If someone was very committed and coped well with their work, they were given even more responsibilities. [FMP02]

We had such an irreplaceable employee. When he died there was chaos for a long time. [UP01]

An unclear division of responsibilities leads to employee dissatisfaction and the overburdening of certain parts of the organization. It generates conflicts, results in professional burnout, and leads to excessive exploitation of valuable organizational resources.

Conflicts between departments. Tensions between departments hinder cooperation. The more complex the organizational structure becomes, the more visible the tensions are, and sometimes even conflicts arise between different parts of the organization.

Between finance and accounting it was not cooperation, but rather a tug of war. [FMP01]

Accounting recorded documents according to its own rules, and controlling later had to correct the data. [FMP01]

The administrative division was constantly fighting with the technical division. [SM01]

There was constant shifting of responsibility between the HR department and accounting. [FIP01]

A problem for many organizations is the silo structure, which is characterized by weak information flow between divisions that are simultaneously interdependent because they are connected by organizational processes.

Outsourcing and control problems. The outsourcing of functions leads to the loss of organizational knowledge and the loss of control over selected areas. Another problem is often a poorly functioning internal control system resulting from an improperly designed structure or simply a lack of supervision.

Accounting was first moved to Slovakia and later to India, and this made communication very difficult. Our employees had to explain every accounting operation in detail. [FMP01]

When an inspection came, it discovered that an employee had entered the refrigerator temperature for the entire day in advance on the sheet. And he was supposed to check it every two hours… [FKM01]

In some situations, the possibilities for controlling employees are limited, and the cost of operating a control system may be very high. However, in cases involving the introduction of changes, high complexity, or safety concerns, strict control is necessary, which in practice does not always occur.

Labor cost reduction strategy. Companies sometimes minimize employment costs at the expense of organizational stability.

Students were employed under civil-law contracts because the company did not have to pay social security contributions. [FMP01]

Instead of hiring a new employee, the duties were distributed among the remaining employees. [FMP02]

The president said that instead of the workshop manager he would hire several workers from the Far East and save money on that. [FIP01]

The director does not want to dismiss him because although he is weak, he has a low salary. [SP01]

Attempts to reduce labor costs are common regardless of the type of organization or the industry in which it operates. However, they often lead to the loss of valuable organizational knowledge resources and weaken employees' engagement and their attachment to the organization.

Compensatory factors and mechanisms. One of the compensatory factors within an organization is experienced and committed employees. They constitute a specific form of organizational memory of the company.

A person working in the HR department for many years knew the history of the company and could find the necessary documents within a few minutes. With such employees it was much easier to solve problems. [FMP01]

It is difficult to negotiate with doctors. But they must be taken care of because they are the most important for us. [KMM01]

As organizations grow, organizational culture changes. Organizations move from a relational culture to a corporate culture. This is not always accepted by employees, but at the same time it provides greater predictability and repeatability of organizational behaviors.

At the beginning the company functioned somewhat like a family business and employees helped each other. Over time the atmosphere changed and corporate formalization began to dominate. [FMP02]

Our university is practically a corporation – indicators, procedures, standards, slots… [UP01]

Informal actions of employees that allow the organization to function despite dysfunctions may also serve as a compensatory mechanism. On the other hand, strong formalization keeps the organization at a stable level and makes it predictable, although not very innovative.

We operate somewhat by inertia, while at the same time trying to patch holes and put out fires. The old guard of employees knows the company and tries to ensure that it somehow continues to function despite everything. [FMP01]

If we do not know something, we call another region. We activate our private contacts. [KFP01]

Moreover, some dysfunctions can be compensated by organizational resources.

The company has a nice brand that some people associate positively with. They come back to the company. [FMP01]

We were the first such supermarket in the country. [SSWP01]

They may also be compensated by a monopolistic position combined with a sense of mission.

Our task is control. Someone has to do it for the good of consumers. [KFP02]

The results of the study are presented in a synthetic form in Table 2.

Table 2.
Main types of organizational dysfunctions and compensatory mechanisms

Area of dysfunction	Mechanism of the problem	Main consequences	Compensatory mechanisms
Centralization / lack of coordination	Mismatch of the level of centralization	delays, inconsistency of decisions	local improvisation, informal consultations
Autocracy and bureaucracy	Multi-level approval processes, high power distance	slow decisions, difficulty correcting errors	experienced employees bypassing system constraints
Misalignment with local realities	Decisions detached from local practice	frustration, decline in efficiency	employees' local operational knowledge
Superficial changes	Symbolic projects instead of functional ones	costs without benefits, deterioration of work	everyday operational adjustments
Excessive reporting	Dominance of indicators over reality	organizational fiction, erroneous decisions	informal knowledge, bottom-up corrections
Unclear division of responsibilities	Diffusion of responsibility	overload, conflicts, risk of knowledge loss	key employees as organizational memory
Conflicts between departments	Silo structure and weak horizontal coordination	tensions, correction of errors, decline in efficiency	personal relationships between employees
Outsourcing and cost cutting	Loss of knowledge and weakening of supervision	communication problems, lower quality, instability	brand, market position, engagement of part of the staff

Source: own elaboration.

5. Discussion

The results of the conducted study indicate that organizational dysfunctions are a widespread phenomenon and occur in different types of organizations regardless of their size, sector, or ownership structure. At the same time, the analysis of the empirical material shows that organizations rarely operate under conditions of full organizational efficiency. In practice, their functioning rather consists of balancing various structural and process tensions that may lead to the emergence of dysfunctions. These findings are consistent with the assumptions of the behavioral theory of the firm, according to which organizations operate under conditions of bounded rationality, incomplete information, and diverse interests of organizational participants (Cyert, March, 1963; March, Simon, 1958). Contemporary research on organizations also emphasizes that decision-making processes in organizations often have an adaptive and incremental character rather than a fully rational one (Felin et al., 2015; Gavetti et al., 2012).

The empirical findings can be interpreted through the three analytical categories: structural, process, and behavioral dysfunctions. Structural dysfunctions concern the design of organizational arrangements, including centralization, hierarchy, unclear division of responsibilities, and silo structures. Process dysfunctions relate to the way organizational activities are coordinated and controlled, including reporting systems, decision-making procedures, outsourcing, and coordination mechanisms. Behavioral dysfunctions concern managerial and employee behaviors, such as autocratic leadership, data manipulation, symbolic actions, and informal practices developed to compensate for organizational shortcomings. Although these categories are analytically distinct, the empirical material demonstrates that they frequently overlap and reinforce one another.

The issue of centralization illustrates primarily a structural dysfunction, although its consequences extend to organizational processes. One of the important conclusions resulting from the study is that many organizational dysfunctions arise from tensions between different principles of organizing activities, such as centralization and decentralization, formalization and flexibility, or control and employee autonomy. The results indicate that both excessive centralization and too low a level of central coordination may lead to organizational problems. On the one hand, excessive centralization limits the autonomy of local units and slows down decision-making processes; on the other hand, the lack of central coordination may lead to inconsistency of actions and divergent interpretations of procedures. The literature emphasizes that the effectiveness of organizational structures depends primarily on their fit with the context of organizational activity, including the complexity of the environment, strategy, and the nature of the processes being carried out (Burton et al., 2020; Donaldson, 2001). Research on organizational design also indicates that organizations often operate under conditions of persistent structural tensions that cannot be completely eliminated but can only be managed through appropriate coordination mechanisms (Smith, Lewis, 2011).

The findings concerning extensive hierarchy and autocratic management represent an interaction between structural and behavioral dysfunctions. An important area of dysfunction revealed in the study concerns the functioning of extensive hierarchical structures and an autocratic management style. In many analyzed organizations, decision-making processes were highly centralized and multi-stage, which led to longer decision-making times and increased power distance between management and employees. These findings are consistent with earlier analyses concerning dysfunctions of bureaucratic structures, which indicate that excessive formalization and extensive hierarchy may lead to a loss of organizational flexibility and limit the organization's ability to adapt (Crozier, 2009; Merton, 1940). At the same time, contemporary research on organizational structures indicates that hierarchical control mechanisms still play an important role in coordinating activities in large organizations, especially under conditions of high complexity and institutional responsibility (Puranam et al., 2014). This means that the problem is not hierarchy itself but rather its excessive expansion or its improper fit with the nature of organizational activities.

Excessive reporting is primarily a process dysfunction, as it affects the way organizational information is generated, interpreted, and used in decision-making. In some cases, reporting and generating indicators became an end in itself rather than a tool supporting management processes. This phenomenon may be interpreted in the context of research on the institutionalization of organizational practices and so-called organizational rituals, which involve formally fulfilling institutional requirements without having a real impact on the functioning of the organization (Bromley, Powell, 2012; Meyer, Rowan, 1977). Contemporary research also indicates that in organizations strongly oriented toward indicator and audit systems there may occur the phenomenon of the performativity of indicators, in which organizational actions become subordinated to the logic of reporting rather than to the actual improvement of results (Espeland, Sauder, 2016).

Conflicts between departments constitute a structural dysfunction that subsequently generates process inefficiencies by disrupting coordination and information flows. The empirical material analyzed also clearly revealed conflicts between organizational departments and problems resulting from silo organizational structures. In many organizations, individual organizational units functioned to a large extent autonomously, which hindered the flow of information and the coordination of activities. These findings are consistent with earlier research indicating that functional structures may contribute to the emergence of communication barriers between departments and hinder cooperation between organizational units (Gulati et al., 2012). At the same time, research on organizational design indicates that this problem is particularly visible in organizations with a high degree of functional specialization, where individual units develop different logics of action and different systems for interpreting information (Puranam et al., 2014).

Outsourcing and labor cost reduction strategies illustrate process dysfunctions associated with the organization of work, although they also produce behavioral consequences such as declining engagement and knowledge sharing. The results of the study also point to the importance of dysfunctions related to outsourcing and labor cost reduction strategies. In some of the analyzed cases, outsourcing led to the loss of organizational knowledge and the deterioration of communication between organizational units and external entities. The management literature indicates that outsourcing may bring benefits in the form of cost reduction and increased organizational flexibility; however, it is also associated with the risk of losing key competencies and weakening control over organizational processes (Holcomb, Hitt, 2007; Lahiri, 2016). Similar problems may arise in the case of strategies strongly oriented toward reducing labor costs, which may lead to decreased employee engagement and the loss of organizational knowledge (Kalleberg, 2011).

Importantly, compensatory mechanisms were observed across all three categories of dysfunctions. Experienced employees, informal networks, and organizational resources reduced the negative consequences of structural, process, and behavioral deficiencies rather than eliminating their underlying causes. One of the most important conclusions from the study, however, is that despite numerous dysfunctions organizations do not cease to function. The analysis of the empirical material indicates that in many cases organizations develop compensatory mechanisms that enable them to limit the negative effects of dysfunctions. Particularly important in this context are experienced employees who serve as carriers of organizational knowledge and help solve problems resulting from the inefficiency of formal organizational structures. The management literature emphasizes the importance of tacit knowledge and employee experience for the functioning of organizations, especially under conditions of uncertainty and organizational complexity (Argote, Miron-Spektor, 2011; Felin et al., 2015).

Another important compensatory mechanism is the existence of informal networks of cooperation among employees. In many analyzed cases, employees used private contacts and interpersonal relationships to solve organizational problems that could not be effectively resolved within formal procedures. These findings confirm earlier research on informal organizational structures, which indicates that networks of social relations play a key role in the flow of knowledge and in solving organizational problems (Krackhardt, Hanson, 1993; Nahapiet, Ghoshal, 1998). Contemporary research on social capital in organizations also indicates that informal relationships between employees may increase the organization's ability to adapt and solve problems under conditions of uncertainty (Adler, Kwon, 2002; Soda et al., 2018).

The compensatory mechanisms revealed in the study may also be interpreted in the context of the concept of organizational resilience. The literature indicates that organizational resilience refers to the ability of organizations to maintain operational effectiveness despite disturbances and to adapt in the face of crises and uncertainty (Duchek, 2020). Resilient organizations are

characterized, among other things, by the ability to learn from experience, flexible organizational structures, and well-developed networks of cooperation (Hillmann, Guenther, 2021). The results of the present study suggest that compensatory mechanisms may constitute one of the key elements in building such organizational resilience, as they enable organizations to maintain their operational capacity despite the occurrence of various dysfunctions.

The results of the study also fit into the broader discussion on organizational paradoxes. The literature emphasizes that organizations often operate under conditions of persistent tensions between conflicting logics of action, such as stability and change, control and autonomy, or efficiency and flexibility (Smith, Lewis, 2011). From this perspective, organizational dysfunctions may be perceived not only as manifestations of organizational inefficiency but also as side effects of attempts to balance different organizational requirements. The results of the present study indicate that the ability of organizations to function despite the occurrence of such tensions depends largely on the development of compensatory mechanisms and the adaptive capabilities of organizations. Taken together, the findings suggest that organizational dysfunctions rarely occur in isolation. Structural arrangements shape organizational processes, while process failures often stimulate dysfunctional behaviors or informal adaptive responses. This interdependence explains why the empirical cases are best understood as configurations of mutually reinforcing structural, process, and behavioral dysfunctions rather than as isolated organizational problems.

6. Conclusions

This study contributes to the literature on organizational dysfunctions by demonstrating that such dysfunctions are neither isolated phenomena nor exclusive to particular sectors or organizational forms. The empirical findings show that dysfunctions emerge across private companies, public institutions, and non-profit organizations, suggesting that they are an inherent feature of complex organizational systems rather than exceptional cases of organizational failure. The study also highlights that organizational dysfunctions rarely occur independently. Instead, they form interconnected configurations in which structural arrangements shape organizational processes, while process failures frequently reinforce dysfunctional managerial and employee behaviors. The findings further indicate that organizations continue to function despite the presence of numerous dysfunctions because they develop compensatory mechanisms. Experienced employees, informal networks of cooperation, organizational memory, and valuable organizational resources help maintain operational continuity even when formal structures or processes prove inadequate. These mechanisms increase organizational resilience, but they should not be interpreted as solutions to the underlying organizational problems. Rather, they temporarily mitigate the consequences of structural and process deficiencies.

The study also offers several managerial implications. Managers should recognize experienced employees and informal collaboration networks as valuable organizational assets and actively support them through knowledge-sharing practices, mentoring, succession planning, and the systematic documentation of organizational knowledge. At the same time, organizations should avoid becoming overly dependent on individual employees or informal workarounds. Recurring reliance on informal solutions should be treated as a diagnostic signal indicating deficiencies in organizational structures, coordination mechanisms, or decision-making processes that require formal organizational improvement. In this sense, compensatory mechanisms should complement, rather than substitute for, continuous organizational redesign.

The study has several limitations. The findings are based on qualitative interviews conducted in organizations operating in different sectors and institutional contexts. Although this diversity made it possible to identify recurring patterns of dysfunction, the results are not intended to provide statistical generalization. Future research could examine the relationships between structural, process, and behavioral dysfunctions using comparative case studies or quantitative approaches, as well as investigate the conditions under which compensatory mechanisms contribute to long-term organizational resilience rather than merely sustaining ineffective organizational arrangements.

Overall, the study suggests that understanding organizational dysfunctions requires moving beyond the analysis of isolated organizational problems toward examining the interactions between organizational structures, processes, and behaviors. Such an integrated perspective provides a more comprehensive explanation of why dysfunctions persist and how organizations are nevertheless able to maintain operational effectiveness over time.

7. Summary

The aim of the article was to analyze organizational dysfunctions as an element of organizational functioning and to identify mechanisms that enable their balancing. The results of the conducted research indicate that organizational dysfunctions are a widespread phenomenon and take various forms, including structural, process, and behavioral problems. Among the most frequently occurring phenomena identified were excessive centralization or lack of central coordination, an autocratic management style, excessive bureaucracy, conflicts between departments, an unclear division of responsibilities, and problems resulting from outsourcing and labor cost reduction strategies. At the same time, the results of the study indicate that organizations rarely operate under conditions of a complete absence of dysfunctions. In practice, their functioning rather consists of balancing various structural and process tensions and developing compensatory mechanisms that make it possible to maintain operational capacity despite the occurrence of organizational disturbances. In particular,

an important role is played by experienced employees who serve as carriers of organizational knowledge, informal networks of cooperation among employees, and organizational resources such as the reputation or market position of the organization. The results of the present study contribute to the literature on organizational dysfunctions by indicating that these phenomena should be analyzed not only in terms of organizational pathologies but also as elements of the functioning of complex organizational systems. From this perspective, it is particularly important to take into account compensatory mechanisms that allow organizations to limit the effects of dysfunctions and maintain their operational capacity in a changing and uncertain environment. The obtained results also have practical implications for the management of organizations. They indicate the importance of maintaining a balance between formalization and flexibility in organizational structures, as well as the need to support mechanisms of cooperation and organizational learning. In particular, it is important to appreciate the role of informal organizational relationships and the experience of employees in ensuring the effective functioning of organizations. At the same time, it should be emphasized that the presented results are exploratory in nature and result from qualitative analysis conducted on a limited number of organizational cases. In future research, it would be worthwhile to consider deepening the analysis of mechanisms for balancing organizational dysfunctions through the use of comparative studies or quantitative methods that would enable the analysis of relationships between organizational dysfunctions and organizational resilience. A particularly interesting direction for further research may be the analysis of the role of compensatory mechanisms in organizational learning processes and in building the adaptive capabilities of organizations under conditions of increasing environmental complexity.

References

1. Adler, P.S., Kwon, S.-W. (2002). Social Capital: Prospects for a New Concept. *Academy of Management Review*, *27*(1), 17-40. https://doi.org/10.5465/amr.2002.5922314
2. Anderson, P. (1999). Perspective: Complexity Theory and Organization Science. *Organization Science*, *10*(3), 216-232. https://doi.org/10.1287/orsc.10.3.216
3. Argote, L., Miron-Spektor, E. (2011). Organizational Learning: From Experience to Knowledge. *Organization Science*, *22*(5), 1123-1137. https://doi.org/10.1287/orsc.1100.0621
4. Ashforth, B.E., Anand, V. (2003). The Normalization of Corruption in Organizations. *Research in Organizational Behavior*, *25*, 1-52. https://doi.org/10.1016/S0191-3085(03)25001-2

5. Ashforth, B.E., Gioia, D.A., Robinson, S.L., Treviño, L.K. (2008). Re-Viewing Organizational Corruption. *Academy of Management Review*, *33*(3), 670-684. https://doi.org/10.5465/amr.2008.32465714
6. Bazerman, M.H., Moore, D.A. (2012). *Judgment in Managerial Decision Making*. John Wiley & Sons.
7. Bourgeois, L.J. (1981). On the Measurement of Organizational Slack. *Academy of Management Review*, *6*(1), 29-39. https://doi.org/10.5465/amr.1981.4287985
8. Bromley, P., Powell, W.W. (2012). From Smoke and Mirrors to Walking the Talk: Decoupling in the Contemporary World. *The Academy of Management Annals*, *6*(1), 483-530. https://doi.org/10.1080/19416520.2012.684462
9. Burton, R.M., Obel, B., Håkonsson, D.D. (2020). *Organizational Design*. Cambridge University Press. https://doi.org/10.1017/9781108681162
10. Crozier, M. (2009). *The Bureaucratic Phenomenon*. Routledge.
11. Cyert, R.M., March, J.G. (1963). *A behavioral theory of the firm*. Prentice Hall.
12. Denzin, N.K. (2012). Triangulation 2.0. *Journal of Mixed Methods Research*, *6*(2), 80-88. https://doi.org/10.1177/1558689812437186
13. Denzin, N.K., Lincoln, Y.S., Giardina, M.D., Cannella, G.S. (2023). *The SAGE Handbook of Qualitative Research*. SAGE Publications Inc.
14. Desai, V. (2016). Learning to learn from failures: the impact of operating experience on railroad accident responses. *Industrial and Corporate Change, Oxford University Press and the Associazione ICC, 25*(2), 199-226.
15. DiMaggio, P.J., Powell, W.W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. *American Sociological Review*, *48*(2), 147. https://doi.org/10.2307/2095101
16. Donaldson, L. (2001). *The Contingency Theory of Organizations*. SAGE Publications, Inc. https://doi.org/10.4135/9781452229249
17. Duchek, S. (2020). Organizational resilience: a capability-based conceptualization. *Business Research*, *13*(1), 215-246. https://doi.org/10.1007/s40685-019-0085-7
18. Espeland, W., Sauder, M. (2016). *Engines of Anxiety: Academic Rankings, Reputation, and Accountability*. Russell Sage Foundation.
19. Felin, T., Foss, N.J., Ployhart, R.E. (2015). The Microfoundations Movement in Strategy and Organization Theory. *Academy of Management Annals*, *9*(1), 575-632. https://doi.org/10.5465/19416520.2015.1007651
20. Gavetti, G., Greve, H.R., Levinthal, D.A., Ocasio, W. (2012). The Behavioral Theory of the Firm: Assessment and Prospects. *The Academy of Management Annals*, *6*(1), 1-40. https://doi.org/10.1080/19416520.2012.656841
21. Greve, H.R., Palmer, D., Pozner, J. (2010). Organizations Gone Wild: The Causes, Processes, and Consequences of Organizational Misconduct. *The Academy of Management Annals*, *4*(1), 53-107. https://doi.org/10.1080/19416521003654186

22. Gulati, R., Puranam, P., Tushman, M. (2012). Meta-organization design: Rethinking design in interorganizational and community contexts. *Strategic Management Journal*, *33*(6), 571-586. https://doi.org/10.1002/smj.1975
23. Hillmann, J., Guenther, E. (2021). Organizational Resilience: A Valuable Construct for Management Research? *International Journal of Management Reviews*, *23*(1), 7-44. https://doi.org/10.1111/ijmr.12239
24. Holcomb, T.R., Hitt, M.A. (2007). Toward a model of strategic outsourcing. *Journal of Operations Management*, *25*(2), 464-481. https://doi.org/10.1016/j.jom.2006.05.003
25. Kalleberg, A.L. (2011). *Good Jobs, Bad Jobs: The Rise of Polarized and Precarious Employment Systems in the United States, 1970s-2000s*. Russell Sage Foundation.
26. Krackhardt, D., Hanson, J.R. (1993). Informal networks: The company behind the chart. *Harvard Business Review*, *71*(4), 104-111.
27. Kvale, S., Brinkmann, S. (2009). *InterViews: Learning the craft of qualitative research interviewing* (2nd ed.). Sage Publications, Inc.
28. Lahiri, S. (2016). Does Outsourcing Really Improve Firm Performance? Empirical Evidence and Research Agenda. *International Journal of Management Reviews*, *18*(4), 464-497. https://doi.org/10.1111/ijmr.12075
29. Lengnick-Hall, C.A., Beck, T.E., Lengnick-Hall, M.L. (2011). Developing a capacity for organizational resilience through strategic human resource management. *Human Resource Management Review*, *21*(3), 243-255. https://doi.org/10.1016/j.hrmr.2010.07.001
30. March, J.G., Simon, H.A. (1958). *Organizations*. Wiley.
31. Merton, R.K. (1940). Bureaucratic Structure and Personality. *Social Forces*, *18*(4), 560-568. https://doi.org/10.2307/2570634
32. Meyer, J.W., Rowan, B. (1977). Institutionalized Organizations: Formal Structure as Myth and Ceremony. *He American Journal of Sociology, 83*(2), 340-363.
33. Miles, M.B., Huberman, A.M., Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook*. SAGE.
34. Mintzberg, H. (1983). *Structure in Fives: Designing Effective Organizations*. Prentice Hall.
35. Nahapiet, J., Ghoshal, S. (1998). Social Capital, Intellectual Capital, and the Organizational Advantage. *The Academy of Management Review*, *23*(2), 242. https://doi.org/10.2307/259373
36. Ocasio, W. (1997). Towards an attention-based view of the firm. *Strategic Management Journal, 18*(S1), 187-206.
37. Palmer, D., Smith-Crowe, K., Greenwood, R. (Eds.) (2016). *Organizational Wrongdoing*. Cambridge University Press. https://doi.org/10.1017/CBO9781316338827
38. Pasieczny, J. (2017). Organisational Pathologies Under Conditions of Economic Downswing. *Economics and Culture*, *14*(1), 21-30. https://doi.org/10.1515/jec-2017-0002

39. Pasieczny, J., Glinka, B. (2016). Organizational Dysfunctions: Sources and Areas. *Entrepreneurial Business and Economics Review*, *4*(4), 213-223. https://doi.org/10.15678/EBER.2016.040413
40. Patton, M.Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice* (4th ed.). Sage Publications.
41. Pfeffer, J., Salancik, G.R. (1878). *The External Control of Organizations: A Resource Dependence Perspective*. Harper & Row.
42. Puranam, P., Alexy, O., Reitzig, M. (2014). What's "New" About New Forms of Organizing? *Academy of Management Review*, *39*(2), 162-180. https://doi.org/10.5465/amr.2011.0436
43. Saldaña, J. (2013). *The coding manual for qualitative researchers*. SAGE.
44. Schilling, M.A. (2000). Toward a General Modular Systems Theory and Its Application to Interfirm Product Modularity. *The Academy of Management Review*, *25*(2), 312. https://doi.org/10.2307/259016
45. Sitkin, S.B., Pablo, A.L. (1992). Reconceptualizing the Determinants of Risk Behavior. *The Academy of Management Review*, *17*(1), 9. https://doi.org/10.2307/258646
46. Smith, W.K., Lewis, M.W. (2011). Toward a Theory of Paradox: A Dynamic Equilibrium Model of Organizing. *Academy of Management Review*, *36*(2), 381-403. https://doi.org/10.5465/AMR.2011.59330958
47. Soda, G., Tortoriello, M., Iorio, A. (2018). Harvesting Value from Brokerage: Individual Strategic Orientation, Structural Holes, and Performance. *Academy of Management Journal*, *61*(3), 896-918. https://doi.org/10.5465/amj.2016.0123
48. Treviño, L.K., den Nieuwenboer, N.A., Kish-Gephart, J.J. (2014). (Un)Ethical Behavior in Organizations. *Annual Review of Psychology*, *65*(1), 635-660. https://doi.org/10.1146/annurev-psych-113011-143745
49. Vaughan, D. (1999). The Dark Side Of Organizations: Mistake, Misconduct, and Disaster. *Annual Review of Sociology*, *25*(1), 271-305. https://doi.org/10.1146/annurev.soc.25.1.271
50. Vogus, T.J., Sutcliffe, K.M. (2007). Organizational resilience: Towards a theory and research agenda. *2007 IEEE International Conference on Systems, Man and Cybernetics*, 3418-3422. https://doi.org/10.1109/ICSMC.2007.4414160
51. Weick, K.E. (1976). Educational Organizations as Loosely Coupled Systems. *Administrative Science Quarterly*, *21*(1), 1. https://doi.org/10.2307/2391875
52. Weick, K., Sutcliffe, K.M. (2011). *Managing the Unexpected: Resilient Performance in an Age of Uncertainty*. John Wiley & Sons.
53. Yin, R.K. (2018). *Case Study Research and Applications: Design and Methods*. SAGE.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

FLEXIBILITY, LEARNING, AND BUSINESS CONTINUITY AS DETERMINANTS OF MICROENTERPRISE RESILIENCE IN POLAND

Kornelia PRZEDWORSKA

University of Economics in Katowice; kornelia.przedworska@uekat.pl, ORCID: 0000-0003-2714-4066

Purpose: The article aims to establish which internal adaptive capabilities — diversification and proactive adaptation, business continuity planning (BCP), and flexibility and learning culture — are most strongly associated with the organizational resilience of micro and small solid-fuel distribution firms, and to estimate the incremental contribution of each.
Design/methodology/approach: The study draws on a nationwide survey of 175 firms. Resilience was measured with a thirteen-item composite index (B1–B13); second-order confirmatory factor analysis and reliability analysis were applied, together with hierarchical OLS regression using HC3 robust standard errors.
Findings: Flexibility and learning culture showed the strongest association with resilience ($b = 0.391$; $p < 0.001$). BCP is significant ($b = 0.549$; $p = 0.003$), with the effect driven by informal and planned arrangements (no formal-plan group was observed). Diversification is significant at the block level, but its standalone effect disappears in the final model. The final model explains 48.6% of the variance.
Research limitations/implications: The cross-sectional design and self-reported data limit causal inference and raise a common-method-variance risk. Resilience, moreover, rests on several co-occurring adaptive practices rather than on any single instrument.
Practical implications: Microfirms stand to gain more from investing in operational flexibility, post-crisis learning, and minimal continuity routines than in elaborate formal plans.
Originality/value: The study offers a rare account of the internal determinants of resilience among solid-fuel microdistributors in the context of the energy transition.
Keywords: organizational resilience; dynamic capabilities; operational flexibility; microenterprises; energy transition.
Category of the paper: research paper.

1. Introduction

The energy crisis of 2021-2022 and the long-run pressure of the energy transition constitute a double, partly overlapping shock for small solid-fuel distributors (Emiliozzi et al., 2025; Goldthau, Youngs, 2023; Sokołowski, Bouzarovski, 2022). Given their limited internal

resources, the survival of these firms depends largely on their adaptive capabilities (Duchek, 2020; Eggers, 2020). Even so, the internal determinants of resilience at the micro scale remain poorly understood empirically, which constitutes a substantial research gap.

A second gap concerns the size class of the entities themselves. Microenterprises account for more than 97% of firms in Poland and generate nearly 28% of GDP (PARP, 2025), yet they remain under-researched in many areas — excluded from empirical studies or aggregated into the broader SME category (Saarela, Simunaniemi, 2025).

The aim of this article is to establish which internal adaptive capabilities are most strongly associated with the organizational resilience of solid-fuel distribution microfirms in Poland, and to estimate the incremental contribution of each once control variables are taken into account. Three research questions were posed: (RQ1) to what extent diversification and proactive adaptation, BCP, and flexibility and learning are associated with resilience; (RQ2) what incremental contribution each block makes once controls and earlier predictors have been entered; (RQ3) which mechanism proves dominant once the others are accounted for, and how this should be interpreted theoretically.

2. Literature review

2.1. Organizational resilience as a capability construct

Organizational resilience is increasingly understood not as a fixed trait but as a developable capacity to anticipate, absorb, and adapt to adversity — and to learn from it (Lengnick-Hall et al., 2011; Williams et al., 2017; Duchek, 2020). Literature reviews consistently point to a multidimensional structure that combines elements of preparedness, adaptive capacity, and learning and leadership (Hillmann, Guenther, 2021; Linnenluecke, 2017). This three-part structure underpins the measurement model adopted here. Operationally, it draws on the validated Benchmark Resilience Tool (Lee, Vargo, Seville, 2013) and on capability-based conceptualizations of resilience (Kantur, İşeri-Say, 2012; Duchek, 2020), from which the three dimensions of the adopted scale derive.

In small firms the construct is particularly salient: a limited resource buffer makes them at once more vulnerable to shocks and more dependent on managerial agility (Sullivan-Taylor, Branicki, 2011; Herbane, 2019). Crisis research emphasizes that smaller organizations rely less on formalized systems and more on flexible, owner-led routines (Eggers, 2020; Branicki et al., 2018).

2.2. The dynamic capabilities perspective

The three mechanisms under study were framed as manifestations of dynamic capabilities, that is, the firm's capacity to sense, seize, and reconfigure resources under conditions of change (Teece et al., 1997; Teece, 2007; Eisenhardt, Martin, 2000). This perspective treats diversification, continuity planning, and flexibility and learning as elements of a single capability system. It also yields the expectation that the article puts to an empirical test: capabilities most closely tied to ongoing reconfiguration — flexibility and learning — should carry more explanatory weight than discrete, episodic actions.

2.3. Diversification and proactive adaptation

Strategic responses to hostile and shifting environments often emphasize diversification and proactiveness as routes to reducing dependence and improving adaptive fit (Miller, 1983; Covin, Slevin, 1989; Lengnick-Hall et al., 2011; Ortiz-de-Mandojana, Bansal, 2016). In small firms, proactive environmental scanning and offer renewal can buffer demand shocks and open up new customer segments. Research shows that small and medium-sized firms that broadened their offer during a crisis outperformed firms whose profile remained unchanged (Clauss et al., 2022; Puumalainen et al., 2023). Hypothesis H1 therefore posits that firms that responded concretely to the post-2021 energy crisis — by introducing new fuels, online sales, or advisory services — display measurably higher resilience than those that made no changes to their offer. Diversification, however, tends to be a component of a broader proactive posture rather than a standalone action, which the article treats as part of the interpretive context for the results.

H1. Microenterprises that diversified their offer (e.g., by introducing alternative fuels, e-commerce, or advisory services) after 2021 display significantly higher organizational resilience than firms without diversification.

2.4. Business continuity planning

What can help a firm maintain continuity of operations during a crisis is a plan that anticipates a range of event scenarios. This role is played by the business continuity plan (BCP), defined as documented procedures that guide an organization in responding to disruption and in recovering, resuming, and restoring operations to a predefined level (ISO 22301:2019). More broadly, business continuity management is conceived as a holistic process of identifying threats and building a response capacity that protects an organization's key operations and stakeholders (Herbane, Elliott, Swartz, 2004). Business continuity management is traditionally framed as a formalized practice, yet small-firm research indicates that microfirms rarely adopt formal written plans, relying instead on informal arrangements (Herbane, 2010). Decisions are taken as events unfold and demand a response, and that response is often largely intuitive (Fasth et al., 2022). Formal written plans were therefore to be expected only rarely in the studied population, which is why the hypothesis was framed broadly to include informal arrangements.

The question that matters for this sector is thus whether any continuity routine — formal, intended, or informal — is associated with higher resilience.

H2. Microenterprises with a business continuity plan (BCP — formal or informal) display significantly higher organizational resilience, and the effect is stronger when the plan is complete and tested.

2.5. Flexibility and learning culture

What The third mechanism under study is flexibility and learning culture. Operational flexibility — the capacity to reconfigure resources quickly, switch suppliers and channels, and adjust prices — together with a learning orientation that treats shocks as opportunities for improvement, is central to adaptive capacity (Volberda, 1996; March, 1991; Sutcliffe, Vogus, 2003). Duchek (2020), in turn, conceives of resilience as a three-stage process (anticipation, coping, adaptation) in which learning from crises underpins the adaptation stage.

Empirical research on small firms is consistent with a mechanism in which flexibility and learning enable adaptation, which in turn raises firm resilience. For instance, the capacity to reconfigure resources and a proactive posture supported firm performance after a natural disaster (Battisti, Deakins, 2017); organizational ambidexterity — combining exploitation of the current model with exploration of new solutions — explained SME resilience during the financial crisis (Iborra et al., 2020); and small firms in recession proved adaptable despite lacking formal crisis-management structures (Smallbone et al., 2012). Resilience capability is, moreover, built through everyday cognitive and behavioural practices, not solely through formalized procedures (Lengnick-Hall et al., 2011; Duchek, 2020). It can therefore be expected that flexibility and learning are associated with resilience regardless of whether a firm holds a formal BCP or how far it has diversified its offer — that they constitute an independent predictor rather than a derivative of the other mechanisms.

H3. Higher operational flexibility and a stronger learning culture are associated with significantly higher organizational resilience in microenterprises, regardless of formal BCP adoption and the scale of diversification.

3. Data and methods

3.1. Sample and selection

The target population comprised active solid-fuel distributors (fuel depots) operating in Poland. Purposive sampling was applied; 175 complete questionnaires from firm representatives across all Polish macroregions ultimately qualified for analysis. The sampling frame was drawn from the ciepło.gov.pl database and from registers of firms distributing solid

fuels from Polish hard-coal mines. Invitations to an online survey (Google Forms) were sent to the 3022 enterprises identified in this way. The study was conducted in April and May 2026. This corresponds to a response rate of 5.8% (175 of 3022), a level consistent with the low response rates repeatedly documented for unsolicited online surveys of small-firm owner-managers, who are a notoriously hard-to-reach group (Newby, Watson, Woodliff, 2003). Because participation was voluntary, a degree of self-selection cannot be excluded: firms that were more actively managed or more strongly affected by the energy crisis may have been more inclined to respond, which would tend to bias the resilience estimates upward rather than downward. The estimates should therefore be read as conditional on participation.

The sample structure was dominated by microenterprises — 74.9% of firms employ fewer than ten people (15.4% are sole proprietorships and 48.0% employ two to five workers) — which mirrors the structure of the sector (UOKiK, 2022). The predominance of the smallest entities is thus a feature of the studied population, not a sampling flaw. In the UOKiK (2022) market study, firms employing up to nine people likewise dominated the sector (2072 of the entities examined, of which 1408 employed no more than three), and more than 97% of sellers operated no more than three depots, so the size profile of the present sample closely tracks that of the population. The sample was nonetheless assembled through purposive, voluntary sampling rather than random selection; its findings therefore support analytical generalization to firms of similar size and market position rather than statistical generalization to the entire population of Polish solid-fuel distributors. The ten-employee threshold corresponds to the definition of a microenterprise adopted in EU law (Commission Recommendation 2003/361/EC). Respondents were primarily owners and co-owners (74.3%), that is, people with direct knowledge of the firm's situation, which strengthens informant validity (Kumar et al., 1993). The studied population is therefore overwhelmingly small-scale and personally run by its owners.

Coal remains the core product (offered by 90.9% of firms), although 60.6% already sell wood pellets or briquettes, lower-emission fuels. The scale of the demand decline over the studied period is illustrated by revenue change: comparing 2023 with 2021, 47.4% of firms reported a decline, including 27.4% reporting a drop of more than 30%.

3.2. Variable measurement

The dependent variable is organizational resilience, operationalized as the mean of thirteen items rated on a five-point Likert scale (B1-B13). The items were adapted from the validated Benchmark Resilience Tool (Lee, Vargo, Seville, 2013) and from capability-based models of resilience (Kantur, İşeri-Say, 2012; Duchek, 2020), from which the three-dimensional structure adopted here derives. The items span three related dimensions of resilience — preparedness for disruption, adaptive capacity, and learning and leadership — ranging from holding reserves sufficient to weather a period of disturbance, through the speed of response to changing conditions, to drawing lessons from past crises.

Three predictors correspond to the three mechanisms under test. Diversification and proactive adaptation were captured as a composite index (hereafter DIV_composite) combining the introduction of a new offer, the count of changes actually implemented, the revenue share from new products or services, and a four-item proactivity scale. Business continuity planning was in turn captured as an index (BCP_composite) combining plan status (none, planned, or informal), the number of plan elements, and the perceived value of continuity planning. Plan-quality items were assessed only in firms that hold a plan; zeros produced by this filtering were treated as the absence of a plan and not interpreted as genuine Likert disagreement. Flexibility and learning culture were measured with a six-item scale (FLEX_index) covering, among other things, learning from difficulties, market monitoring, knowledge sharing, and fast operational reconfiguration. Its items correspond to the three stages of resilience capability — anticipation, coping, and adaptation — distinguished by Duchek (2020). All three labels (DIV_composite, BCP_composite, FLEX_index) are used throughout the remainder of the text, in the tables, and in the discussion of results.

All models include control variables reflecting firm characteristics: age, employment, breadth of offer, current financial standing, the revenue trajectory in 2023 and 2025 (with separate indicators for "don't know" responses), and macroregion.

3.3. Analytical strategy

The analysis proceeded in three steps. First, descriptive statistics were computed and the reliability and structure of the resilience index were evaluated — using Cronbach's alpha and second-order confirmatory factor analysis (with the WLSMV estimator, appropriate for ordinal Likert indicators; Li, 2016; Rosseel, 2012) — to ensure that the thirteen items can defensibly be combined into a single index. Second, bivariate relationships between each mechanism and resilience were examined, with tests selected after their assumptions had been checked and a robust variant applied where variances proved unequal. Third, a hierarchical regression model was estimated in which predictors entered in successive blocks — controls, diversification (DIV_composite), continuity planning (BCP_composite), and flexibility (FLEX_index) — making it possible to assess the incremental contribution of each mechanism over and above the variables entered earlier and thereby to settle their relative importance. Inference was based on HC3 robust standard errors, a conservative heteroskedasticity-consistent estimator; all computations were performed in R (R Core Team, 2025).

4. Results

4.1. Descriptive statistics and measurement credibility

Mean resilience in the studied population is 3.49 on the five-point scale (SD = 0.68), with marked variation across firms (from 1.69 to 4.85). This variation is sufficient to support an analysis of its determinants. Descriptive statistics for the dependent variable and the three predictors are reported in Table 1. The distribution of continuity planning matters for the analyses that follow: no firm holds a formal written plan, so the empirical contrast runs between no plan (62.9%), a planned BCP (23.4%), and an informal BCP (13.7%).

Table 1.
Descriptive statistics for the dependent variable and predictors

Variable	Mean	SD	Min	Max
Organizational resilience	3.49	0.68	1.69	4.85
Diversification and proactivity (DIV_composite)	0.34	0.27	0.00	0.87
Business continuity planning (BCP_composite)	0.19	0.21	0.00	0.89
Flexibility and learning (FLEX_index)	3.57	0.71	1.00	5.00

The resilience index proved reliable, and the second-order confirmatory factor analysis supported its three-dimensional structure (CFI = 0.94; TLI = 0.92; SRMR = 0.08; RMSEA = 0.10, 90% CI [0.085; 0.120]). Fit is not uniform: the incremental indices favour the three-block structure and SRMR sits close to conventional thresholds, whereas RMSEA exceeds them — a pattern common in compact ordinal survey scales with moderate sample sizes. The CFA result was therefore treated as supportive rather than definitive evidence; together with the high reliability, however, it justifies combining the thirteen items into the single index used as the dependent variable. The reliability of the three key scales — the dependent variable and the two predictor scales relevant to hypotheses H1 and H3 — is summarized in Table 2.

Table 2.
Reliability of the key scales

Scale	Number of items	Cronbach's α
Organizational resilience (dependent variable)	13	0.86
Proactive adaptation (part of H1)	4	0.85
Flexibility and learning (H3)	6	0.76

4.2. Internal determinants of resilience

The hierarchical regression, with predictors entered in successive blocks, revealed a clear hierarchy of importance. Controls alone explained 28% of the variance in resilience; adding diversification raised this share only marginally, continuity planning moderately, and the largest incremental gain — thirteen percentage points — came with the addition of flexibility and

learning. The final model explains nearly half of the variance in resilience ($R^2 = 0.49$). Final-model coefficients are presented in Table 3.

Table 3.
Hierarchical resilience model — final-model coefficients (HC3 robust standard errors)

Predictor	b	SE	p
Flexibility and learning (FLEX_index)	0.39	0.07	< 0.001
Business continuity planning (BCP_composite)	0.55	0.18	0.003
Diversification and proactivity (DIV_composite)	0.23	0.15	0.118

In the final model, flexibility and learning remain the strongest and a highly significant predictor, continuity planning retains its significance, and the standalone contribution of diversification disappears once the other mechanisms are included. The model satisfies its assumptions: the Breusch–Pagan test sits at the edge of conventional significance ($p = 0.057$), which further justifies the use of robust standard errors, and multicollinearity does not distort the estimates (maximum adjusted GVIF = 1.35).

4.3. Hypothesis testing

Hypothesis H1 posited that firms that made concrete changes to their offer after 2021 — introducing alternative fuels, online sales, or advisory services — display significantly higher resilience than firms without such changes. The test did not yield unambiguous confirmation. A one-way ANOVA across the three diversification-status groups (no change, planning, implemented) showed no significant difference between them ($F(2, 172) = 0.90$; $p = 0.41$), meaning that the mere fact of having or not having introduced new products and services does not separate firms by resilience level. At the level of the continuous measure, the Spearman correlation between the composite diversification index and resilience is admittedly significant ($\rho = 0.35$; $p < 0.001$), yet in the final model — once BCP and flexibility are accounted for — the diversification coefficient loses statistical significance ($b = 0.23$; $p = 0.118$). Hypothesis H1 was therefore not confirmed in its assumed form: diversification as a discrete, standalone action does not differentiate resilience levels. The association visible at the bivariate level appears to reflect an adaptive orientation shared with flexibility and proactivity rather than an effect of the change in offer itself.

Hypothesis H2 entailed two conditions: first, that firms with any business continuity plan (formal or informal) display higher resilience; second, that the effect is stronger when the plan is complete and tested. The first part was confirmed. Resilience rises monotonically from firms with no plan at all (mean 3.33), through firms with a planned BCP (3.62), to those with informal arrangements (3.95), and the differences are statistically significant (Welch's $F(2, 75.91) = 20.02$; $p < 0.001$); BCP_composite also remains a significant predictor in the final model ($b = 0.55$; $p = 0.003$). The second part — the stronger effect of a complete, tested plan — could not be tested because of the structure of the data: no firm in the sample holds a formal written

BCP, and the concept itself was new to 76.6% of respondents. The variation in plan quality and testing assumed by the hypothesis thus had no basis in the data for estimation. This is not, however, a negative result. The absence of formal plans is itself informative about the sector: business continuity here is built bottom-up, through informal managerial routines rather than formalized procedures. Testing the second part of H2 remains an open research question that requires a differently structured sample.

Hypothesis H3 posited that flexibility and learning are associated with resilience independently of BCP adoption and the scale of diversification — that is, that they constitute a freestanding predictor once the other mechanisms are controlled for. This hypothesis received full confirmation. FLEX_index shows the strongest bivariate association of all the predictors ($r = 0.57$; $p < 0.001$) and — crucially for the test — remains a highly significant predictor in the final model containing both BCP_composite and DIV_composite ($b = 0.39$; $p < 0.001$). The hierarchical regression shows that flexibility delivers the largest incremental gain in explained variance ($\Delta R^2 = 0.13$) of all three predictor blocks, even after controls, diversification, and BCP have been entered. The independence condition written into the hypothesis is therefore met: the effect of flexibility and learning culture neither disappears nor loses significance once the other mechanisms are taken into account.

The outcomes for all three hypotheses are gathered in Table 4.

Table 4.
Hypothesis testing

Hypothesis	Outcome
H1 — diversification and proactive adaptation	Not supported (group difference non-significant; the bivariate effect disappears in the final model)
H2 — business continuity planning	Partially supported: the effect of holding a BCP is confirmed; the completeness-and-testing condition is untestable (no formal-plan group in the sample)
H3 — flexibility and learning culture	Supported (effect significant after controlling for BCP and diversification)

5. Discussion

The resilience of the studied microenterprises rests on a handful of everyday adaptive practices rather than on a single formalized instrument. Flexibility and learning culture show the strongest association with it. In the realities of a small fuel depot run personally by its owner this makes sense — decisions are made quickly and close to the market, not within a formalized procedure. The result is consistent with the dynamic capabilities perspective: firms that learn from difficulties, monitor the market, reconfigure operations quickly, and retain their customers report higher resilience.

The BCP effect, though significant, is driven by informal and planned arrangements rather than formal plans — none were recorded in the sample. This also means that the second part of H2, positing a stronger effect for a complete and tested plan, remained empirically untestable. The questionnaire did include items on plan completeness and testing; the answers were simply absent, because in the studied firms continuity management runs through the owner's informal habits rather than written procedures. Variation in plan completeness and testing will only become assessable in a differently structured sample that includes firms with more formalized management. Diversification, in turn, did not confirm H1 in its assumed form: firms that broadened their offer after 2021 do not differ significantly in resilience from those that did not. The bivariate effect is real, but it disappears once flexibility and BCP are accounted for, suggesting that diversification is a manifestation of a broader proactive adaptive orientation rather than a mechanism independently linked to resilience.

The strength of the association between flexibility and resilience sits well with earlier research on small firms under shock conditions. Battisti and Deakins (2017), studying firms after earthquakes, identified a proactive posture and the capacity to integrate resources as factors supporting performance in highly uncertain environments; in the present study these correspond to the FLEX_index items on fast operational reconfiguration and market monitoring. A similar picture emerged from Iborra et al. (2020), where organizational ambidexterity explained the resilience of Spanish SMEs during the financial crisis. The present study shows that the same pattern also holds in far smaller entities that lack the organizational back-up typical of medium-sized enterprises. The picture likewise matches Duchek's (2020) process view: if learning from crises forms the core of the adaptation stage, the scale measuring this capacity should show the strongest association with resilience — and that is precisely the configuration visible in the data.

The continuity-planning pattern both confirms and extends prior findings. The complete absence of formal written plans is more extreme than in studies of British SMEs, where formal crisis planning was practised by a minority of firms (Herbane, 2010), and close to the picture from Sweden, where most SMEs maintained no crisis structure at all and decisions were taken intuitively, in the rhythm of events (Fasth et al., 2022). What that literature did not show, however, is the association between informal continuity routines and resilience: captured in BCP_composite, they remain a significant correlate of resilience even after controlling for flexibility. The value of continuity management thus lies not in the document itself but in the thinking-through of scenarios and safeguards that the owner carries "in their head". This conclusion resonates with Sullivan-Taylor and Branicki's (2011) argument that resilience frameworks designed for large organizations fit poorly with the realities of small firms, and with Herbane's (2019) proposal to view small-firm resilience through the lens of strategic renewal rather than procedures.

The diversification result calls for separate comment, since at first glance it contradicts pandemic-era studies in which a change of business model went hand in hand with better performance (Clauss et al., 2022; Puumalainen et al., 2023). At least three sources of this divergence are visible. Those studies measured financial performance or growth, whereas the dependent variable here is resilience understood as a capability, and a change of offer may improve revenues well before it translates into deeper organizational capabilities. Puumalainen et al. (2023) further noted that the pivot in operating model was strongly tied to entrepreneurial orientation — a broader posture whose counterpart in this study is flexibility and proactivity. The correlation structure in the present data supports this interpretation: proactivity correlates with resilience ($r = 0.62$) more strongly than the composite diversification index does ($\rho = 0.35$) and is clearly related to flexibility ($r = 0.49$), so part of the variance that diversification shares with resilience overlaps with flexibility and learning culture. The third reason is sector-specific: 60.6% of the studied firms already sell pellets or briquettes, so broadening the offer by itself differentiates firms only weakly, and a few years on from the 2021–2022 crisis may simply be too short for new revenue lines to have taken hold.

Against this literature, the contribution of the study is twofold. First, it adds to the modest stock of empirical knowledge on microenterprises, whose under-representation in management research is well documented (Saarela, Simunaniemi, 2025), and it does so in a sector under a double burden — the energy crisis and the transition. Second, it furnishes an argument for the thesis advanced in Section 2.2: under continuous change, capabilities of ongoing reconfiguration carry more explanatory weight than episodic actions, which corresponds to the distinction between dynamic capabilities and discrete strategic decisions (Teece, 2007; Eisenhardt and Martin, 2000). The results also sharpen the boundary conditions of this theory at the micro scale: the sensing, seizing, and reconfiguring functions are not distributed across procedures and specialized roles but concentrated in the person of the owner, so resilience depends more strongly on the owner's learning habits and flexibility than on the degree of managerial formalization. This suggests that formalization is not a necessary condition for building resilience capabilities in microfirms, and that the value of continuity practices may also be realized in informal form.

6. Conclusions, limitations, and implications

The study shows that flexibility and learning matter most for the resilience of the firms examined — independently of BCP and diversification, which was the key condition of hypothesis H3. Informal business continuity planning also proved a significant predictor, confirming the first part of H2. Diversification of the offer, by contrast and against H1, does not differentiate firms by resilience in its own right — its effect is visible only indirectly, through its link with the broader proactive posture.

The author is aware of the study's limitations. The findings should be read as associations rather than causal relationships: the data are cross-sectional and self-reported, and because the predictors and the dependent variable come from the same questionnaire, the estimates cannot be regarded as free of common-method-variance risk (Podsakoff et al., 2003). This risk is partly mitigated by the construction of the predictors themselves: the diversification and continuity indices combine items of different formats (status declarations, counts of implemented changes, revenue shares), not Likert ratings alone. Because the flexibility scale shares its response format with the dependent variable, common-method variance was assessed directly with Harman's single-factor test: the first unrotated factor accounted for 33.9% of the variance — well below the 50% threshold — and five factors had eigenvalues above one, indicating that no single factor dominates the covariance among items. This reduces, though does not eliminate, the common-method-variance concern. A particular limitation is the absence in the sample of firms with a formal written BCP, which precludes testing the second part of H2 on the stronger effect of a complete and tested plan. Hypothesis H1, in turn, was not confirmed in its assumed form — which need not mean that diversification is irrelevant; it may instead indicate that its effect operates through indirect channels that call for a different analytical model or longitudinal data. In practical terms — and bearing in mind that these conclusions apply most directly to small, owner-run solid-fuel distributors of the kind sampled here — the results indicate that such a microfirm gains most by developing operational flexibility, post-shock learning, and minimal business continuity routines; extending them to larger or more formalized firms, or to other branches of the energy sector, would require confirmation on a differently structured sample. In the author's view, future research should draw on longitudinal data and objective measures, extend to other sectors affected by the energy transition, and sample firms with a higher degree of managerial formalization.

References

1. Battisti, M., Deakins, D. (2017). The relationship between dynamic capabilities, the firm's resource base and performance in a post-disaster environment. *International Small Business Journal, Vol. 35, Iss. 1*, pp. 78-98, doi: 10.1177/0266242615611471
2. Branicki, L.J., Sullivan-Taylor, B., Livschitz, S.R. (2018). How entrepreneurial resilience generates resilient SMEs. *International Journal of Entrepreneurial Behavior & Research, Vol. 24, Iss. 7*, pp. 1244-1263, doi: 10.1108/IJEBR-11-2016-0396
3. Brown, T.A. (2015). *Confirmatory Factor Analysis for Applied Research (2nd ed.).* New York: Guilford Press.
4. Clauss, T., Breier, M., Kraus, S., Durst, S., Mahto, R.V. (2022). Temporary business model innovation – SMEs' innovation response to the Covid-19 crisis. *R&D Management, Vol. 52, Iss. 2*, pp. 294-312, doi: 10.1111/radm.12498

5. Commission Recommendation 2003/361/EC of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises, OJ L 124, 20.05.2003, pp. 36-41 (2003).
6. Covin, J.G., Slevin, D.P. (1989). Strategic management of small firms in hostile and benign environments. *Strategic Management Journal, Vol. 10, Iss. 1*, pp. 75-87, doi: 10.1002/smj.4250100107
7. Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, Vol. 16, Iss. 3*, pp. 297-334, doi: 10.1007/BF02310555
8. Duchek, S. (2020). Organizational resilience: a capability-based conceptualization. *Business Research, Vol. 13*, pp. 215-246, doi: 10.1007/s40685-019-0085-7
9. Eggers, F. (2020). Masters of disasters? Challenges and opportunities for SMEs in times of crisis. *Journal of Business Research, Vol. 116*, pp. 199-208, doi: 10.1016/j.jbusres.2020.05.025
10. Eisenhardt, K.M., Martin, J.A. (2000). Dynamic capabilities: what are they? *Strategic Management Journal, Vol. 21, Iss. 10-11*, pp. 1105-1121, doi: 10.1002/1097-0266(200010/11)21:10/11<1105::AID-SMJ133>3.0.CO;2-E
11. Emiliozzi, S., Ferriani, F., Gazzani, A. (2025). The European energy crisis and the consequences for the global natural gas market. *The Energy Journal, Vol. 46, Iss. 1*, pp. 119-145, doi: 10.1177/01956574241290640
12. Fasth, J., Elliot, V., Styhre, A. (2022). Crisis management as practice in small- and medium-sized enterprises during the first period of COVID-19. *Journal of Contingencies and Crisis Management, Vol. 30, Iss. 2*, pp. 161-170, doi: 10.1111/1468-5973.12371
13. Goldthau, A.C., Youngs, R. (2023). The EU energy crisis and a new geopolitics of climate transition. *JCMS: Journal of Common Market Studies, Vol. 61*, pp. 115-124, doi: 10.1111/jcms.13539
14. Hayes, A.F., Cai, L. (2007). Using heteroskedasticity-consistent standard error estimators in OLS regression. *Behavior Research Methods, Vol. 39*, pp. 709-722, doi: 10.3758/BF03192961
15. Herbane, B. (2010). Small business research: time for a crisis-based view. *International Small Business Journal, Vol. 28, Iss. 1*, pp. 43-64, doi: 10.1177/0266242609350804
16. Herbane, B. (2019). Rethinking organizational resilience and strategic renewal in SMEs. *Entrepreneurship & Regional Development, Vol. 31, Iss. 5-6*, pp. 476-495, doi: 10.1080/08985626.2018.1541594
17. Herbane, B., Elliott, D., Swartz, E.M. (2004). Business continuity management: Time for a strategic role? *Long Range Planning, Vol. 37, Iss. 5*, pp. 435-457, doi: 10.1016/j.lrp.2004.07.011
18. Hillmann, J., Guenther, E. (2021). Organizational resilience: a valuable construct for management research? *International Journal of Management Reviews, Vol. 23, Iss. 1*, pp. 7-44, doi: 10.1111/ijmr.12239

19. Iborra, M., Safón, V., Dolz, C. (2020). What explains the resilience of SMEs? Ambidexterity capability and strategic consistency. *Long Range Planning, Vol. 53, Iss. 6*, 101947, doi: 10.1016/j.lrp.2019.101947
20. ISO (2019). *ISO 22301:2019 Security and resilience – Business continuity management systems – Requirements*. Geneva: International Organization for Standardization.
21. Kantur, D., İşeri-Say, A. (2012). Organizational resilience: a conceptual integrative framework. *Journal of Management & Organization, Vol. 18, Iss. 6*, pp. 762-773, doi: 10.5172/jmo.2012.18.6.762
22. Kumar, N., Stern, L.W., Anderson, J.C. (1993). Conducting interorganizational research using key informants. *Academy of Management Journal, Vol. 36, Iss. 6*, pp. 1633-1651, doi: 10.2307/256824
23. Lee, A.V., Vargo, J., Seville, E. (2013). Developing a tool to measure and compare organizations' resilience. *Natural Hazards Review, Vol. 14, Iss. 1*, pp. 29-41, doi: 10.1061/(ASCE)NH.1527-6996.0000075
24. Lengnick-Hall, C.A., Beck, T.E., Lengnick-Hall, M.L. (2011). Developing a capacity for organizational resilience through strategic human resource management. *Human Resource Management Review, Vol. 21, Iss. 3*, pp. 243-255, doi: 10.1016/j.hrmr.2010.07.001
25. Li, C.-H. (2016). Confirmatory factor analysis with ordinal data. *Behavior Research Methods, Vol. 48*, pp. 936-949, doi: 10.3758/s13428-015-0619-7
26. Linnenluecke, M.K. (2017). Resilience in business and management research: a review of influential publications and a research agenda. *International Journal of Management Reviews, Vol. 19, Iss. 1*, pp. 4-30, doi: 10.1111/ijmr.12076
27. March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science, Vol. 2, Iss. 1*, pp. 71-87, doi: 10.1287/orsc.2.1.71
28. Miller, D. (1983). The correlates of entrepreneurship in three types of firms. *Management Science, Vol. 29, Iss. 7*, pp. 770-791, doi: 10.1287/mnsc.29.7.770
29. Newby, R., Watson, J., Woodliff, D. (2003). SME survey methodology: response rates, data quality, and cost effectiveness. *Entrepreneurship Theory and Practice, Vol. 28, Iss. 2*, pp. 163-172, doi: 10.1046/j.1540-6520.2003.00037.x
30. Ortiz-de-Mandojana, N., Bansal, P. (2016). The long-term benefits of organizational resilience through sustainable business practices. *Strategic Management Journal, Vol. 37, Iss. 8*, pp. 1615-1631, doi: 10.1002/smj.2410
31. PARP (2025). *Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce 2025 [Report on the state of the small and medium-sized enterprise sector in Poland 2025]*. Warszawa: Polska Agencja Rozwoju Przedsiębiorczości.
32. Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y., Podsakoff, N.P. (2003). Common method biases in behavioral research. *Journal of Applied Psychology, Vol. 88, Iss. 5*, pp. 879-903, doi: 10.1037/0021-9010.88.5.879
33. Puumalainen, K., Sjögrén, H., Soininen, J., Syrjä, P., Kraus, S. (2023). Crisis response strategies and entrepreneurial orientation of SMEs: A configurational analysis on

performance impacts. *International Entrepreneurship and Management Journal, Vol. 19, Iss. 3*, pp. 1527-1559, doi: 10.1007/s11365-023-00847-4

34. R Core Team (2025). *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.
35. Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software, Vol. 48, Iss. 2*, pp. 1-36, doi: 10.18637/jss.v048.i02
36. Saarela, M., Simunaniemi, A.-M. (2025). Microenterprises – underrepresented in research? A call for a more connected research field. *Journal of Entrepreneurship and Public Policy*, ahead-of-print, doi: 10.1108/JEPP-10-2024-0185
37. Smallbone, D., Deakins, D., Battisti, M., Kitching, J. (2012). Small business responses to a major economic downturn: Empirical perspectives from New Zealand and the United Kingdom. *International Small Business Journal, Vol. 30, Iss. 7*, pp. 754-777, doi: 10.1177/0266242612448077
38. Sokołowski, J., Bouzarovski, S. (2022). Decarbonisation of the Polish residential sector between the 1990s and 2021: A case study of policy failures. *Energy Policy, Vol. 163*, 112848, doi: 10.1016/j.enpol.2022.112848
39. Sullivan-Taylor, B., Branicki, L. (2011). Creating resilient SMEs. *International Journal of Production Research, Vol. 49, Iss. 18*, pp. 5565-5579, doi: 10.1080/00207543.2011.563837
40. Sutcliffe, K.M., Vogus, T.J. (2003). Organizing for resilience. In: K.S. Cameron, J.E. Dutton, R.E. Quinn (Eds.), *Positive Organizational Scholarship: Foundations of a New Discipline* (pp. 94-110). San Francisco: Berrett-Koehler.
41. Teece, D.J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, Vol. 28, Iss. 13*, pp. 1319-1350, doi: 10.1002/smj.640
42. Teece, D.J., Pisano, G., Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, Vol. 18, Iss. 7*, pp. 509-533, doi: 10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z
43. UOKiK (2022). *Kto prowadzi składy węgla w Polsce? [Who runs coal depots in Poland?]*. Retrieved from: https://uokik.gov.pl/download/26866, 20.12.2022.
44. Volberda, H.W. (1996). Toward the flexible form: how to remain vital in hypercompetitive environments. *Organization Science, Vol. 7, Iss. 4*, pp. 359-374, doi: 10.1287/orsc.7.4.359
45. White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator. *Econometrica, Vol. 48, Iss. 4*, pp. 817-838, doi: 10.2307/1912934
46. Williams, T.A., Gruber, D.A., Sutcliffe, K.M., Shepherd, D.A., Zhao, E.Y. (2017). Organizational response to adversity. *Academy of Management Annals, Vol. 11, Iss. 2*, pp. 733-769, doi: 10.5465/annals.2015.0134

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

CHATBOT OR HUMAN? CUSTOMER SERVICE PREFERENCES IN THE COURIER INDUSTRY

Szymon PRZYBOREK[1], Roman DOMAŃSKI[2*]

[1] Faculty of Engineering Management; Poznan University of Technology; szymon.przyborek@student.put.poznan.pl
[2] Faculty of Engineering Management; Poznan University of Technology; roman.domanski@put.poznan.pl, ORCID: 0000-0001-5861-4978
*Correspondence author

Purpose: Continuous development in logistics and e-commerce compels companies to implement AI–based solutions in customer service to optimize cost, although consumer acceptance remains a challenge. This paper identifies and assesses customer preferences regarding customer service in the courier industry, regarding the choice between interacting with a chatbot and interacting with a human.
Design/methodology/approach: A quantitative research approach was applied. Data was collected using an online questionnaire, with responses rated on a five-point Likert scale. The survey was distributed in February and March 2026 among individuals using courier services in Poland, yielding 200 correctly completed questionnaires.
Findings: The research show a strong correlation between the chosen contact form and the complexity of the delivery issue. For simple issues, respondents are moderately willing to use chatbots. However, in crisis situations, they reject automated options, expecting human support. Complete automation is currently unacceptable in the Polish courier market.
Research limitations/implications: The main limitation of the study is its exclusive focus on the Polish courier industry and the overrepresented of young people in the research sample. Nevertheless, the identified barriers can serve as a benchmark for the broader e-commerce market, highlighting the need for further research as AI-powered customer service system continue to evolve.
Practical implications: The study provides valuable guidance for businesses, indicating that a hybrid customer service model is the most effective development direction. Courier companies should implement combine the speed of chatbots for routine tasks with the guarantee of immediate delegation to a human representative for difficult-to-solve issues.
Social implications: The study reveals that society still considers the humans factor irreplaceable, primarily due to the need for empathy and a "human touch" that AI bots currently lack. Consequently, consumer strongly reject complete automation in customer service and expect guaranteed access to human agent when dealing with complex or problematic issues.
Originality/value: The paper fills a gap in the existing literature by addressing automated forms of customer service in the previously under-researched Polish courier industry. It provides original insights into consumer preferences and AI-based form implementation barriers, offering value to logistics managers, researchers, and customer experience designers.
Keywords: chatbot, customer service, courier services, e-commerce, survey.
Category of the paper: Research paper.

1. Introduction

The dynamic growth of the e-commerce industry has placed pressure on courier companies providing last-mile services, which represents the final stage of courier delivery to the customer. With the increase in shipment volume, the availability and quality of customer service, alongside price and delivery time, have become important factors in building competitive advantage. To address the growing number of inquiries regarding, for example, parcel status or complaints, companies are increasingly implementing solutions supported by artificial intelligence, such as chatbots and virtual assistants.

Implemented technologies enable the optimization of operating costs and provide 24/7 support, but their effectiveness from the consumer perspective is questionable. Customer service requests in the courier industry often concern problematic situations that require not only fast data processing but also empathy and flexibility in resolving non-standard issues. In this context, research is emerging on the reception of automated forms of customer service. While the benefits for businesses are widely discussed in the literature, the actual preferences and consumer trust in artificial intelligence in everyday practice in this specific sector requires further investigation.

The main goal of this article is to identify and assess customer service preferences in the courier industry, specifically considering the choice between interaction with a chatbot and contact with a human representative. A complementary goal is to identify key trends and challenges in implementing new technologies based on artificial intelligence. This requires answering the following research questions:

RQ1: How does the complexity of a shipment issue determine the choice of the preferred form of customer service contact in the courier industry?

RQ2: What are the current shortcomings and obstacles that prevent consumers from using AI-powered bots to resolve their issues?

RQ3: What development directions for AI bots are identified as key to improving the quality of customer service in last-mile logistics?

The structure of this article includes the following parts: a literature review, a description of the research, a presentation of the research results and their discussion, and a summary containing synthetic conclusions.

2. Literature review

A literature review was conducted in March 2026 using the Scopus database of scientific articles, which contains numerous peer-reviewed publications. The primary search was based on the terms "chatbots" and "courier". This resulted in three related articles, only one of which was directly relevant to the topic. To expand the theoretical background, a broader search was conducted using the terms "chatbots", "e-commerce," "human agents", and "customer service", yielding an additional 32 results, 15 of which directly relate to customer service and chatbots.

In the context of the topic of this article, the growing ubiquity of AI-based chatbots in the e-commerce sector as a replacement for human consultants is observed (Mahajan, Chauhan, 2026). This is linked to the increased interest in improving the efficiency of services provided by AI bots (Xu, Yan, Cao, 2022).

Chatbots are defined in various ways in the literature – as systems designed to communicate with users using natural language, supported by AI (Adam, Wessel, Benlian, 2021), or as intelligent systems using artificial intelligence algorithms and natural language processing (Singh, Manju, Jatain, 2024). Authors also describe chatbots as an outstanding and versatile application of artificial intelligence, a possible link enabling effective communication between humans and machines (Sasikala, Kavitha, 2026), or as customer service agents that help consumers make decisions (Xu, Yan, Cao, 2022).

Among the research methods, many authors used surveys (Baabdullah et al., 2022; Chen, Wang, Wood, 2025; Chen, Salahuddin, Khamarudin, 2026; Mahajan, Chauhan, 2026). Other tools used in the research included a 2x2 factorial experiment in which participants conversed with a human agent or chatbot, during which the conversational style was alternately fact-based or highly emotional (Kim, 2025), and an experiment involving simulated conversations between half of the research group and a "raw" bot, while the other group communicated with a chatbot with human characteristics (Klein, Martinez, 2023). The research focused on factors shaping virtual customer experiences during conversations with AI bots (Baabdullah et al., 2022), differences in customer behaviour when served by a chatbot and a live human (Mahajan, Chauhan, 2026), the main components of customer satisfaction (Antonio et al., 2022), and factors influencing the willingness to use chatbot services instead of a human consultant (Chen, Wang, Wood, 2025).

Among the results, the authors point to the need to implement chatbots that solve simple problems based on a database by answering standard questions, while simultaneously operating in a hybrid model or a strict mechanism that delegates the resolution of difficult problems to humans (Wang et al., 2023; Deepak, Dumka, Mazumdar, 2025; Zhang et al., 2025). Furthermore, it has been noted that giving human characteristics significantly increases customer satisfaction, which simultaneously increases the chance of success in handling cases (Adam, Wessel, Benlian, 2021; Klein, Martinez, 2023).

A significant gap identified in the literature is the lack of studies conducted in the Polish context, particularly those examining consumer preferences regarding customer service in the courier industry.

The authors of this paper use a survey as a methodological approach to identify and assess customer service preferences in the courier industry, with particular emphasis on the choice between interaction with a chatbot and human contact. Understanding these attitudes is crucial in identifying current trends and challenges in customer service. This issue has been previously addressed in other publications, but the research has not yet been directed at customers of the courier industry in Poland.

3. Methods

To assess consumer preferences regarding customer service in the courier industry and verify their attitudes toward AI-based solutions, a survey was conducted (like other scientists - Baabdullah et al., 2022; Chen, Wang, Wood, 2025; Chen, Salahuddin, Khamarudin, 2026; Mahajan, Chauhan, 2026). A proprietary survey was created using Google Forms. The form was divided into six thematic sections, including: an introduction to the research, the respondent's demographic profile, preferences regarding the form of contact depending on the complexity of the problem, an assessment of previous experiences with chatbots, expectations regarding the future of customer service automation in the courier industry, and the identification of trends and challenges in the implementation of AI bots.

The questions included in the questionnaire were intended to examine customers' willingness to use AI-powered virtual assistants and identify factors influencing trust in this form of customer service. The questionnaire consisted of single- and multiple-choice closed-ended questions. A five-point Likert scale was used to examine respondents' opinions. This study structure was intended to facilitate the collection of transparent and standardized data that would enable further quantitative analysis.

The survey was aimed at people who use courier services in Poland. However, no reports were found specifying the number of people utilizing this industry. The "E-commerce in Poland 2025" report stated that the number of people shopping online in Poland in 2025 was approximately 24 million (Gemius, 2025), which is directly related to the need to use courier services. Therefore, it was assumed that the number of people using courier services at least once a year is 24 million.

During the study, 200 correctly completed surveys were obtained. Assuming a significance level of $\alpha = 5\%$ and a permissible error of $e = 7\%$, the minimum sample size for the finite population studied is 196. The number of responses obtained meets this requirement, which allows the results to be considered reliable.

The survey was distributed via social media in February and March 2026. The survey were completely voluntary and anonymous. The collected data was analysed, the results of which are presented in the next chapter of this article.

4. Results and discussion

The primary goal of the study was to identify and assess customer preferences regarding customer service in the courier industry, with a particular focus on choosing between chatbot and human interaction. The collected data allowed us to verify consumer expectations and identify their concerns regarding the future of customer service. The study collected 200 correctly completed questionnaires.

The sample consisted of 66% women, 33% men, and 1% respondents who selected “other gender”. The dominant age group in the study aged 19-25, accounting for 60% of the sample group. The second largest group aged 26-40, representing 15%. Analysis of the respondent profile shows that the majority of respondents were young and actively using modern technologies.

Respondents were first asked about their most recent contact with customer service. The smallest group was those who had contacted customer service more than six months ago – 13%. The largest group was those whose most recent contact occurred within the previous week – 35%. This suggests that respondents' opinions are based on recent market experiences.

In the next question, respondents were asked about their preferences regarding the choice of customer service channel depending on the complexity of the issue. In the case of simple and routine matters, such as checking the status of a shipment, preferences are relatively evenly distributed (Figure 1) – the largest group (44.5%) still prefers contact with a consultant, but overall, over half of respondents choose a chatbot (26.5%) or indicate indifference to the choice (29%).

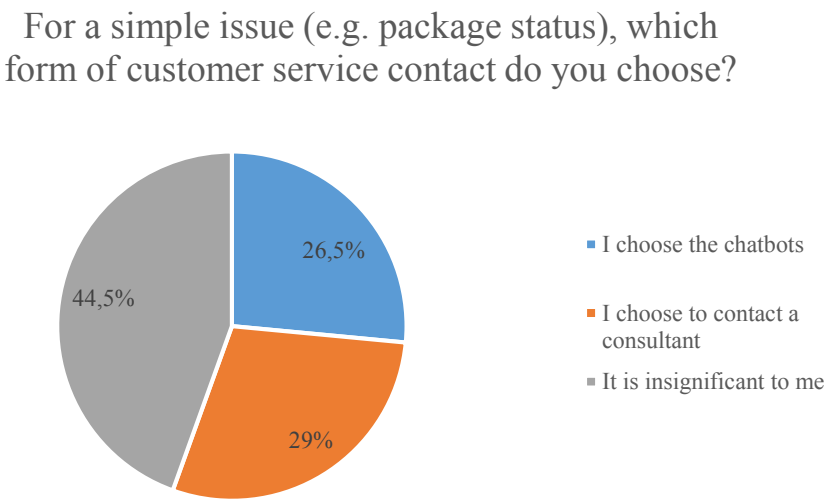


Figure 1. Customer service contact preferences for simple issues.

Source: own study – results of a proprietary questionnaire.

However, a substantial shift can be observed in the case of more complex issues, such as filing a complaint (Figure 2). In such situations, as many as 86% of respondents choose a human consultant, while only 5% of respondents express a desire to use a chatbot, and 9% remain indifferent.

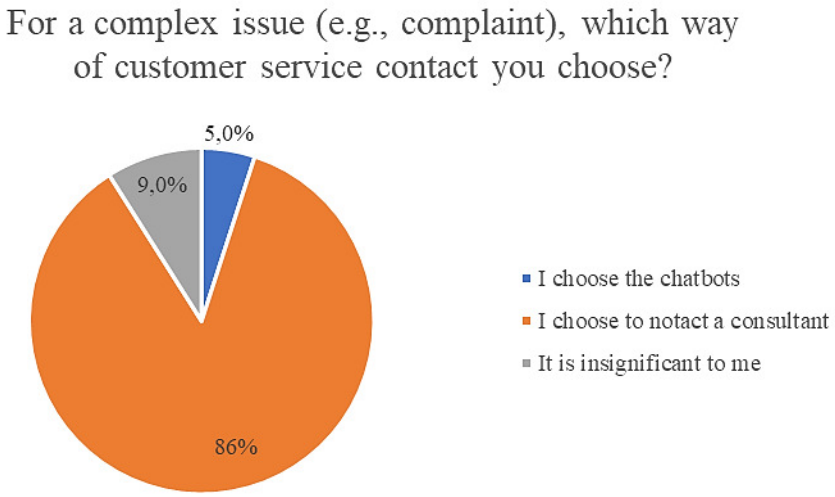


Figure 2. Customer service contact preferences for complex issues.

Source: own study – results of a proprietary questionnaire.

When asked about the importance of minimizing waiting time, 64% of respondents provided affirmative answers, indicating they would choose the option involving the shortest waiting time in every situation (Figure 3). Only 2% of respondents always choose a chatbot. Human contact is always chosen by 34% of respondents, regardless of waiting time.

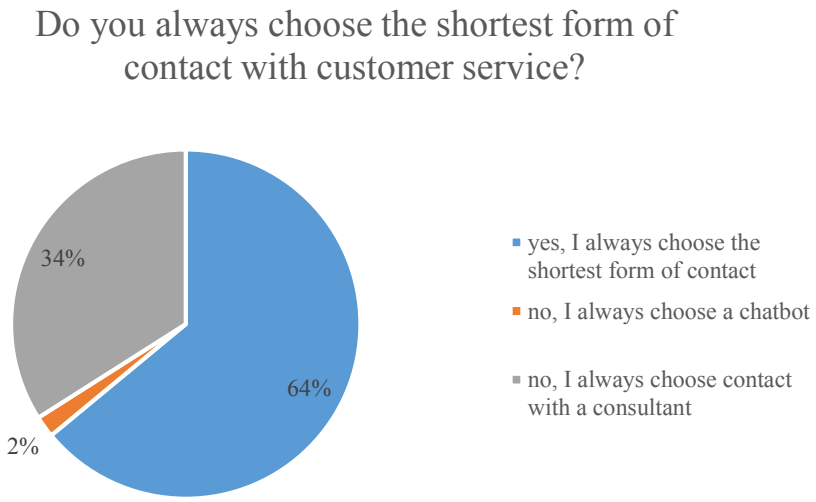


Figure 3. Customer service contact preferences depending on waiting time.

Source: own study – results of a proprietary questionnaire.

The results show that customers demand that more complex issues be resolved by a human. For simpler queries, they prioritize speed of resolution, not paying much attention to the form of contact. The above results answer the first research question (RQ1). The results we obtained are confirmed by the publications of other scientists (Wang et al., 2023; Deepak, Dumka, Mazumdar, 2025; Zhang et al., 2025).

The next section of the survey focused on experiences with chatbots (Figure 4). As many as 65% of respondents believe that chatbots lack a "human touch". Only 26% of respondents consider chatbots competent and helpful. This indicates a generally sceptical attitude toward chatbots.

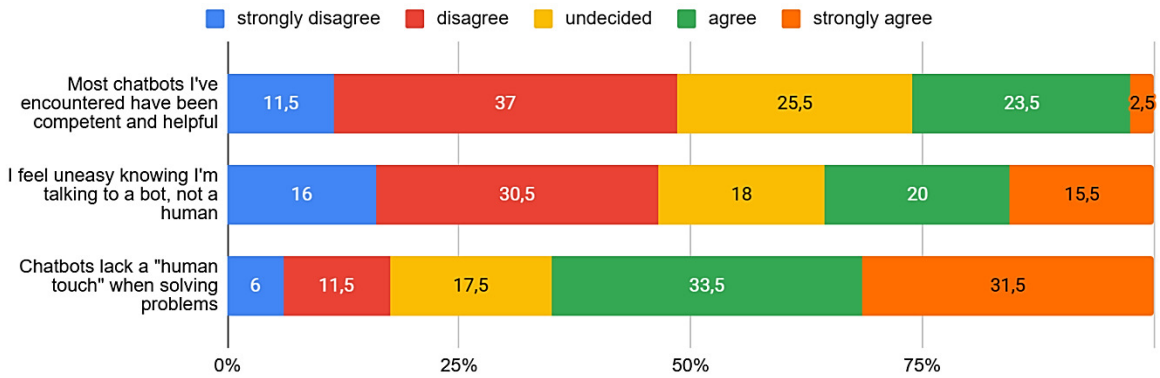


Figure 4. Evaluation of consumer experiences with chatbots.

Source: own study – results of a proprietary questionnaire.

While 35.5% of respondents say they have no problem with automated contact, and 18% have no opinion on the matter, 46.5% of respondents indicate that the awareness of a conversation with a bot makes them uncomfortable (Figure 4). These results show that, in addition to technical accessibility, human connection and empathy are key factors, which

chatbots still lack. Assessing consumer experiences reveals what currently hinders them in using AI bots, which provides an answer to the second research question (RQ2). The results we obtained are similar to the information in the publications of other scientists (Baabdullah et al., 2022; Chen, Wang, Wood, 2025; Mahajan, Chauhan, 2026).

Analysis of respondents' expectations regarding the future development of chatbots reveals significant customer resistance to the complete automation of customer service (Figure 5). The vast majority of respondents completely reject the vision of a bot dominating customer service (76% of respondents), of which 49% strongly disagree with the possibility of being served exclusively by an advanced AI chatbot without human involvement within the next five years. This result is directly related to their disagreement with the statement that AI bots will be able to completely replace humans in the future – as many as 60% of respondents disagree with this thesis.

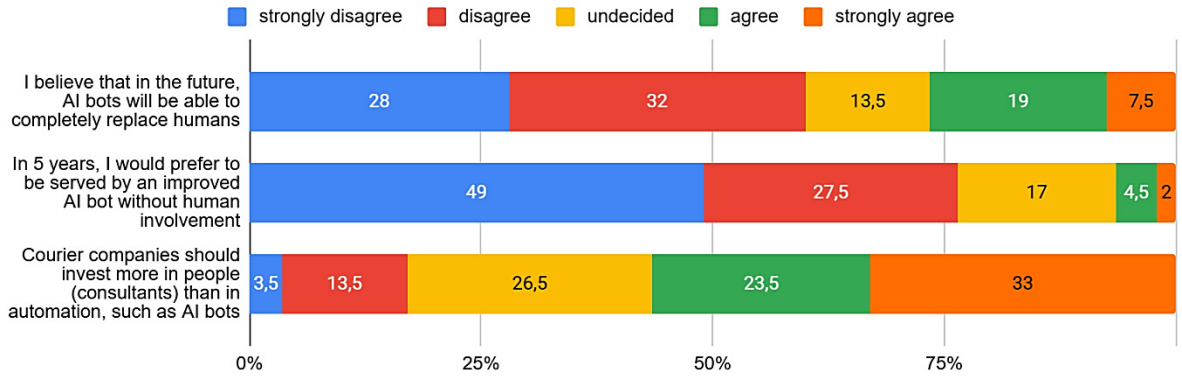


Figure 5. Future expectations regarding chatbots as assessed by consumers.

Source: own study – results of a proprietary questionnaire.

In light of all the above, the results are understandable, as they show that 56.5% of respondents agree with the statement that courier companies should prioritize investing in people (consultants) rather than fully automating the customer service process based on AI bots (Figure 5). The collected results clearly demonstrate that despite the rapid development and increasing digitization of the e-commerce sector, Polish consumers consider humans to be an irreplaceable component of service quality, indicating that their role cannot be eliminated in the future.

The identification of implementation barriers shows (Figure 6) that the main obstacles are not technical issues, such as complicated operation (16.5%) or technical difficulties (31%). Respondents clearly point to AI bots' lack of understanding of complex problems (80.5%), as well as the low quality and precision of responses (61%) as the most significant barriers.

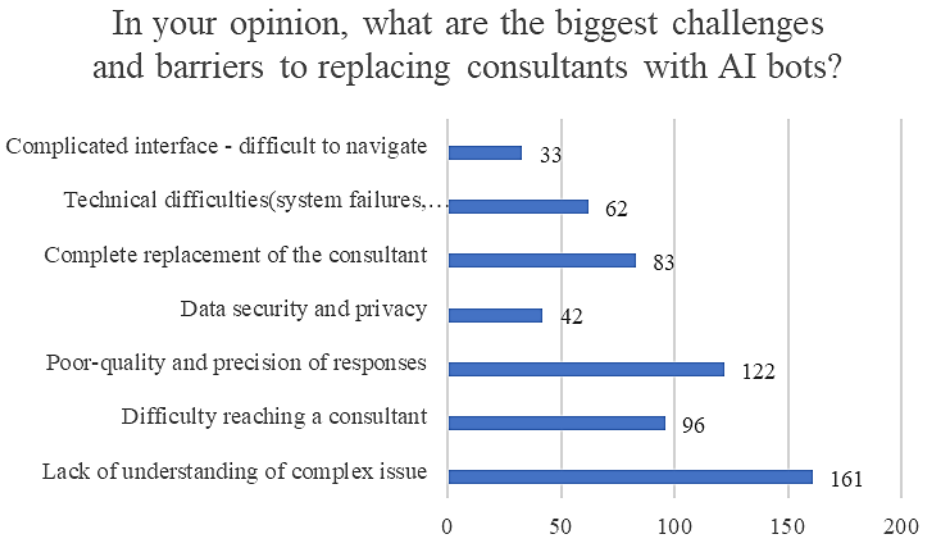


Figure 6. Barriers and challenges related to replacing consultants with AI bots.

Source: own study – results of a proprietary questionnaire.

The key directions for the development of automated customer service in the form of AI bots are strongly linked to consumer experience (Figure 7). Respondents indicated the ability to immediately redirect to a consultant in difficult cases as the most important development direction (79%). Faster and more precise responses ranked second (57.5%), while improved language models ranked third (43%). These results answer the third research question (RQ3). The results we obtained are confirmed by the publications of other scientists (Adam, Wessel, Benlian, 2021; Antonio et al., 2022; Xu, Yan, Cao, 2022; Klein, Martinez, 2023).

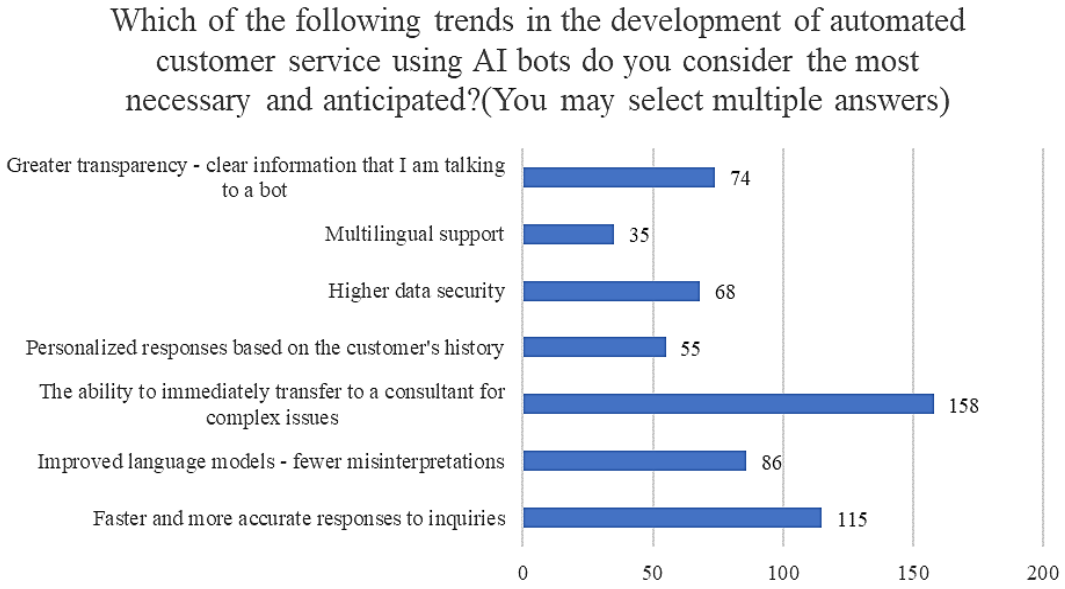


Figure 7. Key directions of development of automated customer service in the form of AI bots.

Source: own study – results of a proprietary questionnaire.

The results of the survey's section on trends and challenges indicate that Polish consumers don't reject AI bot technology, but they do point to its current shortcomings. The acceptance of automation in the courier industry could gain traction under a model that guarantees constant and seamless access to a consultant in challenging situations.

5. Summary

The main goal of this article was to identify and assess customer service preferences in the courier industry, particularly the choice between interaction with a chatbot and human contact. The survey allowed us to identify preferences regarding the choice of a specific channel for customer service communication, assess the functioning of chatbots, define expectations regarding them in the future, and identify key barriers and directions for the development of automated customer service. The results are consistent with conclusions emerging from the literature.

Based on the results, it's noticeable that the reception of chatbots depends on the complexity of the reported issue. For simple queries, customers show moderate willingness to interact with a chatbot, but for more complex issues, they strongly reject the possibility of using this solution (RQ1).

The results clearly indicate the impossibility of implementing complete automation in customer service processes. A fundamental obstacle is the inability of AI bots to understand complex problems and the low quality of the responses they generate. Additionally, consumers point to a lack of a "human touch" on the part of AI bots, which causes discomfort during service (RQ2).

Courier companies should be aware of consumers' resistance to fully digitizing the customer service process. For AI chatbot-based systems to succeed, a working hybrid strategy is essential. AI bots should support the solution of simple, routine problems. In the event of a difficult problem, the service system should ensure that the matter is delegated to a consultant (RQ3).

The conducted survey focused on customer service in the courier industry. However, the identified preferences and barriers can serve as a benchmark for other e-commerce market sectors. It is crucial to continue research in this area as automated customer service systems employing among others AI bots continue to evolve and improve.

Acknowledgements

This research was funded by the by the Polish Ministry of Science and Higher Education – project No. 0812/SBAD/4237 and project No. 0812/SBAD/4240.

References

1. Adam, M., Wessel, M., Benlian, A. (2021). AI-based chatbots in customer service and their effects on user compliance, *Electronic Markets*, *31(2),* pp. 427-445, DOI: 10.1007/s12525 020-00414-7.
2. Antonio, R., Tyandra, N., Nusantara, L.T., Anderies, A., Gunawan, A.A.S. (17-18.09.2022). *Study Literature Review: Discovering the Effect of Chatbot Implementation in E-commerce Customer Service System Towards Customer Satisfaction*. International Seminar on Application for Technology of Information and Communication (iSemantic), Semarang, Indonesia: IEEE, pp. 296-301, DOI: 10.1109/iSemantic55962.2022.9920434
3. Baabdullah, A., Alalwan, A., Algharabat, R., Metri, B., Rana, N. (2022). Virtual agents and flow experience: An empirical examination of AI-powered chatbots. *Technological Forecasting and Social Change*, *181*, 121772, pp. 1-15, DOI: 10.1016/j.techfore.2022.121772.
4. Chen, S., Wang, P., Wood, J. (2025). Exploring the varying effects of chatbot service quality dimensions on customer intentions to switch service agents. *Scientific Reports*, *15(1),* 22559, pp. 1-16, DOI: 10.1038/s41598-025-06490-z
5. Chen, Y., Salahuddin, N., Khamarudin, M. (2026). From Failure to Satisfaction: How AI Chatbot Language Affects Service Recovery in Chinese E-Commerce. *International Research Journal of Multidisciplinary Scope*, *7(1),* pp. 1199-1213, DOI: 10.47857/irjms.2026.v07i01.07511
6. Deepak, Dumka, A., Mazumdar, B. (2025). Establishing Communication in Agent Based E Commerce Platforms. In: Naithani, K., Tiwari, S., Kumari, S. (Eds.), *AI for Product Development* (pp. 1-17), 1st edition. Boca Raton: CRC Press, DOI: 10.1201/9781003536901-5
7. Gemius (2026). E-commerce w Polsce 2025 (E-commerce in Poland 2025). Warszawa: Gemius S.A. Retrieved from: https://gemius.com/documents/81/RAPORT_E-COMMERCE_2025.pdf, 15.03.2026.
8. Kim, H. (2025). Chatbots vs. Human Agents: Emotional Aspects and Trust in Customer Service Interactions. *International Journal of Electronic Commerce Studies*, *16(3),* pp. 1-22, DOI: 10.7903/ijecs.2480.

9. Klein, K., Martinez, L. (2023). The impact of anthropomorphism on customer satisfaction in chatbot commerce: an experimental study in the food sector. *Electronic Commerce Research*, *23(4),* pp. 2789-2825, DOI: 10.1007/s10660-022-09562-8
10. Mahajan, S., Chauhan, V. (2026). AI and human interaction in e-commerce platforms: analysing the consequential effects through empirical investigation. *International Journal of Electronic Marketing and Retailing*, *17(1),* pp. 80-103, DOI: 10.1504/IJEMR.2026.150311
11. Sasikala, S., Kavitha, V. (2026). Exploring of AI-Powered Application in Chatbots for Future Development. In: Raj, P., Sundaravadivazhagan, B., Kavitha, V., Rao, B.N.K., Vijaykumar, H. (Eds.), *Real-Time Artificial Intelligence (AI): Key Motivations, Technologies, Platforms and Use Cases* (pp. 1-34)*,* 1st edition. New York: Apple Academic Press, DOI: 10.1201/9781998511358-10
12. Singh, D., Manju, D., Jatain, A. (2024). Artificial Intelligence and Natural Language Processing Inspired Chatbot Technologies. *Recent Advance in Computer Science and Communications*, *17(1),* pp. 11-20, DOI:10.2174/2666255816666230712141148
13. Wang, C., Li, Y., Fu, W., Jin, J. (2023). Whether to trust chatbots: Applying the event-related approach to understand consumers' emotional experiences in interactions with chatbots in e-commerce. *Journal of Retailing and Consumer Services*, *73*, 103325, pp. 1-11, DOI: 10.1016/j.jretconser.2023.103325
14. Xu, Q., Yan, J., Cao, C. (2022). Emotional Communication Between Chatbots and Users: An Empirical Study on Online Customer Service System. In: Degen, H., Ntoa, S. (Eds.), *Artificial Intelligence in HCI* (pp. 513-530), Lecture Notes in Computer Science, 13336, Cham: Springer, DOI: 10.1007/978-3-031-05643-7_33
15. Zhang, Y., Ding, Z., Sun, J., Zhao, X., Hu, X., Yang, Z. (2025), Optimizing AI strategies in e-commerce customer service: An agent-based simulation. *Electronic Markets*, *35(1),* pp. 1-22, DOI: 10.1007/s12525-025-00821-8

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

ESSENTIAL FUNCTIONALITIES OF A DECISION SUPPORT SYSTEM FOR SMALL FARMS: A QUALITATIVE APPROACH

Jacek PUCHAŁA

Hugo Kołłątaj University of Agriculture in Krakow, Department of Statistics and Social Policy;
jacek.puchala@urk.edu.pl, ORCID: 0000-0002-7671-411X

Purpose: The purpose of this article is to determine to which extent young farmers from small farms use information technology (IT) solutions in farm management, to document the expectations of the surveyed group of farmers regarding this type of software, and to identify the management functions that should be prioritized in the design of digital decision-support tools. The third research question concerns the management functions to which digital solutions for farm management should be dedicated.
Design/methodology/approach: The study was conducted using the Computer-Assisted Personal Interviewing (CAPI) method among a group of 37 farmers aged 40 or younger who had received funding to start their agricultural businesses.
Findings: According to the results, one in two young farmers reports using innovations in production, technology, or management; six out of ten respondents use a computer for farm management. Online information retrieval, government agency communication, financial-flow recording, and market-seeking activities are characterized as operational-record-keeping tasks focused on day-to-day work organization, administrative duties, and financial control. Only one farmer—operating a larger agricultural enterprise—employed herd-management software and dedicated farm-management software. Farmers' expectations regarding an IT system for farm management are primarily linked to the implementation of planning and control functions in the management process, with particular emphasis on financial performance monitoring, plant protection product application, animal-production deadline tracking, and regulatory compliance.
Research limitations/implications: The Agency for Restructuring and Modernization of Agriculture (ARiMR) did not provide the contact information of young farmers, citing personal data protection regulations; this decision—cited by the agency—limited the size of the research sample.
Practical implications: The expectations of the surveyed group regarding software supporting the management of small farms are useful for IT companies. It is reported that every second farmer surveyed would be willing to pay no more than 200 PLN per year for a program supporting farm management, and the program should be designed for installation on a computer, not for running in a browser. In addition, the system is expected to incorporate geospatial layers for plot-level mapping, to collate yield data, and, in the context of ongoing climate change, to automate the collection of temperature and precipitation records, thereby supporting data-driven adaptation strategies.

Originality/value: The results presented here are based on pilot studies conducted across a diverse sample of smallholder operations. No comparable studies in the literature focus exclusively on young farmers—identified as a key group determining the future of European agriculture (European Commission, 2020).
Keywords: Farm Management Information System (FMIS), agricultural software, agricultural decision-support systems (DSS), information management in agriculture.
Category of the paper: Research Article.

1. Introduction

With the declining proportion of young farmers among farm owners, it would be advisable to increase the use of digital decision support systems (DDSS), which would not only improve farm productivity but also encourage young people to engage in agricultural activities. In the European Union (EU), approximately 11% of all farms are run by farmers under the age of 40, which represents a decline compared to 14% according to earlier data from the review of the Common Agricultural Policy (CAP) reform for 2014-2020 (Figurek et al., 2023). In light of ongoing demographic transitions, the widespread adoption of IT solutions supporting decision-making is particularly important for young farmers, who do not have as much farming experience as their parents. A well-considered response to the documented demographic aging and the limited appeal of agriculture to young people is the promotion of agricultural software among the latter. Digital management support in agriculture—by integrating sensor networks, cloud-based analytics, and predictive modeling—not only increases productivity but also proves to be a strategic mechanism for attracting and retaining young people in rural areas (Ronzhin et al., 2025). Young people, generally eager to adopt digital devices, can be effectively targeted by agricultural advisory services that promote decision-support systems, and the digitization of agriculture (Agri-Tech) thus occupies a central position within global trends in agricultural development.

Precision agriculture (PA) and digital technologies—here treated as synonymous with information and communication technologies (ICTs)—are identified as a key direction for the development of modern agricultural production on large farms that possess the financial resources to invest in new, innovative technologies. Within this digitalization trend, technologies deployed in crop production—yield-mapping systems, drones for monitoring and spraying, soil-moisture sensors, and automated-machine control—are undergoing transformation, as are livestock-production tools such as automated-milking systems, feeding robots, and animal-welfare monitoring devices. Data management plays a key role in the digitization of agriculture, and DDSS is an integral part of this.

Small farms lack the funds for such investments, although non-commercial IT solutions exist. According to Gacek et al. (2025), the deployment of these solutions not only helps improve the profitability of agricultural operations by reducing the use of fertilizers and plant protection products but also contributes to environmental protection by reducing the risk of excessive transfer of chemicals into ecosystems. Given these benefits, free or low-cost digital decision-support systems (DDSS) are recommended for promotion among small farms, which—lacking the capital to purchase drones or soil sensors—can instead utilize service providers that offer digital data. Free decision-support programs, partially non-commercial solutions (e.g., SatAgro), and commercial services—including those provided by harvesters equipped with yield-mapping functions—are therefore reviewed as potential data sources. Young farmers with small farms struggle with insufficient equity capital due to limited cultivated areas and traditional technological equipment, yet their age-related digital proficiency confers a demonstrable capacity to absorb new knowledge and innovations

2. Objectives, materials, and methods

This article is exploratory in nature and serves as groundwork for explanatory research, as well as for the practical goal of organizing an EIP (European Innovation Partnership) operational group based on the needs of farmers. The aim of the article is to determine the extent to which young farmers use digital solutions and to understand their expectations regarding an IT program supporting farm management.

The research sample included 37 farmers who are beneficiaries of an EU program aimed at supporting those starting agricultural activities. These are individuals assessed according to relevant criteria by the Agency for Restructuring and Modernization of Agriculture and selected for public funding as entities with high development potential. The sampled farmers are predominantly drawn from the northern agricultural zones of the Małopolskie Province; their contact details were obtained, with ethical approval, from local village leaders—primarily from the districts of Kraków, Olkusz, and Proszowice.

Computer-Assisted Personal Interviewing (CAPI)—deployed in the present study—was used as the primary data-collection method, thereby increasing the reliability and consistency of the dataset, shortening the overall duration of the study, enabling the deployment of an online questionnaire, and improving quality control of the research process. Descriptive statistical methods were employed for data analysis, including examination of frequency distributions and characterization of the study population's structure.

Literature searches were conducted through "Consensus.app", "Scite.ai", and "Zotero", and the resulting corpus was imported into Zotero for unified management. Subsequent literature screening, conducted through Zotero and complemented by Internet searches, resulted

in the identification of 48 FMIS/DSS solutions; of these, 7 were selected as suitable for small farms, with their characteristics aggregated from manufacturer websites and the existing literature. The aggregated dataset was subjected to statistical processing within the Python environment, with ChatGPT-generated code facilitating data wrangling, and the resulting summary statistics are reported in Table 1; the associated prompt is accessible at https://chatgpt.com/share/69fac8d0-357c-832d-a792-6979364d9a2a. The programs identified through the literature review but not subjected to Python-based analysis are: AfiFarm, Ifarma, FARMnet, Kilo, Fieldtouch, WIDHOC, FARMA, Mark online, SIG AGRO, AGRIMI, Crop360, myCrop, eDWIN "Virtual Farm", and FarmSmart.

3. Innovation of young farmers

Significant milestones in the development of agriculture have been the transition from three-field rotation to crop rotation, as well as the use of synthetic fertilizers and plant protection products. In modern agriculture, such a milestone is precision agriculture—often also referred to as Agriculture 4.0, smart, or digital agriculture—which is an innovative agricultural production system that utilizes information technologies and analytical tools to precisely determine the application rates of inputs—fertilizers, plant protection products, and water. The application rate of these inputs is adjusted to changing environmental conditions and the needs of the crops being grown. In animal production, environmental conditions are adapted to the individual requirements of the stock, thereby enabling the optimization of production processes and the enhancement of animal welfare (Gacek et al., 2025). The non-adoption of Agriculture 4.0 solutions results in decision-making based on incomplete data.

Nearly 80% of farmers in the European Union utilize some form of digital solution on their farms. However, this statistic may be misleading due to the high proportion of young farmers in the sample. According to Tur et al. (approximately 79% of farms in the European Union (EU) have implemented at least one crop-specific digital technology, while only 29% have implemented three or more such technologies. Digital field records are the most commonly used (58%), while the adoption rate of other crop-specific technologies ranges from 3% to 22%. Digital technologies specific to animal husbandry are also used. Approximately 83% of farmers have implemented at least one such solution, while only 17% have implemented three or more (Tur et al., 2025). It is worth noting that the above data comes from a research sample that included a higher proportion of young people than is reflected in statistics on the general population of farmers in Europe; therefore, given the documented age-related innovation gap (Kielbasa, Puchala, 2015), the reported adoption levels may be slightly overestimated.

Small-scale farmers report a knowledge gap concerning precision agriculture (PA) tools, although a substantial majority express interest in acquiring such expertise. An analysis of the CAWI survey results, conducted by the Polish Space Industry Foundation (https://www.pfpk.org.pl, 2025) on a sample of 432 farmers, indicates that, among respondents running farms with an area of ≤20 ha, a lack of awareness regarding precision agriculture is a common phenomenon. Within this same subpopulation, 65.2% of respondents indicated interest in both conceptual training and practical implementation guidance, whereas, across the full sample, only 34.3% demonstrated pre-existing awareness of precision agriculture principles. Only 33.8% of all respondents currently employ precision agriculture (PA) on their farms (Rolnictwo precyzyjne w Polsce, 2021). By comparison, in Germany, over 80% of farmers already use this technology (Gacek et al., 2025). The indicator could be improved through the popularization and enhanced availability of digital solutions in agriculture for small farms.

Digital management support in agriculture needs not be limited solely to precision farming; it also encompasses the utilization of digital technologies available to all stakeholders in the operation of a farm. Young agricultural entrepreneurs in Indonesia, when surveyed, reported using the Internet to identify new markets (52% of respondents), search for information (31% of respondents), and communicate online (20% of responses). The study group consisted solely of farmers aged 20 to 23, who made up 63% of the total sample (the remainder of the sample consisted of individuals from processing and marketing). Young farmers mostly seek information about agriculture and crop production (32%), including land cultivation, fertilization, crop care, and harvesting, followed by market information (29%), prices (20%), and information on agricultural product processing (19%) (Nurlaela et al., 2022). It is worth noting that the respondents were part of a special project called "Young Agricultural Entrepreneurial Growth", which aimed to encourage young people to work in agriculture.

The generation of first-time farmers is characterized by innovative adoption of approaches that combine traditional methods with modern ones. European young farmers are ready to embrace innovation, smart farming, and the adaptation of scientific research findings to practice (Kielbasa, Puchala, 2015). Modern tools for the digitalization of agriculture offering opportunities to harness existing potential for agricultural development, e.g., through the use of the Internet of Things IoT are being deployed in context (Figurek et al., 2023). Connecting "things," for example, can entail the retrofitting of satellite-navigation guidance to legacy tractors – a physically feasible practice already documented on farms managed by young farmers – and such incremental digitization, when applied to existing production means, is expected to safeguard the long-term stability, profitability, and efficiency of European agriculture.

The adoption of these solutions is nonetheless capital-intensive, a barrier that limits uptake by small farms and small non-agricultural enterprises. The Central Statistical Office in Poland (GUS) reports that the highest share of entities using Artificial Intelligence (AI) tools was

recorded among large entities (33.0%), while the lowest was among small entities (4.0%) (https://naukawpolsce.pl, 2025). The situation is similar regarding the use of digital solutions on farms, as smaller farms are less likely to adopt digital solutions that support decision-making in agricultural operations, and most farmers with farms under 10 hectares were unable to explain what digital and precision agriculture entails. Farmers' awareness of digital and precision agriculture was reported to be the highest among the youngest age cohort under 40 years (Ropek, 2025), and this positive association was confirmed in a separate meta-analysis, an increase in size is consistently accompanied by elevated awareness and utilization of digital technologies. Large farms implement 10% to 84% more digital technologies than small farms (Tur et al., 2025), yet when such young managers operate small holdings, the financial barrier to technology adoption remains prohibitive (Ropek, 2025; Tur et al., 2025). Software suites for yield-and-growing-condition data management are priced between 2000 and 10,000 PLN per year, while aggregated soil-monitoring sensor arrays range from 10,000 to 30,000 PLN (ursus.pl, 2025).

The digitization of businesses has been better studied than that of farms, as an Enterprise Digitization Index (EDI) has been developed, but no such indicator exists for agricultural holdings (https://naukawpolsce.pl/, 2025). The findings underscore that, in the absence of targeted financial incentives, young farmers operating small holdings remain unable to absorb the up-front costs of precision-agriculture suites.

Young farmers' decisions regarding innovative smart farming technologies differ by gender. For example, in Taiwan, young male farmers had a greater intention to use IoT technologies for crop management and solving agricultural problems than young female farmers (Chuang et al., 2020). Unfortunately, similar studies are lacking in Europe.

Despite these knowledge gaps, there remain young women and men who express a desire to remain in agriculture, and many of them adopt an innovative approach to developing and managing their farms; the choices they confront, however, will depend on farm-specific factors – including size, maintenance history, and modernization status – that shape technology adoption trajectories (Rooij, 2006). Greater digital inclusion of rural youth, achieved through the aforementioned infrastructure investments, enables the combination of agricultural work with non-agricultural activities—income diversification—that is particularly important for small farms (Licciardo et al., 2024). With improved digital inclusion, rural youth can combine agricultural work with non-agricultural activities, a crucial step for small farms seeking income diversification.

Current research findings confirm the results of studies from the 1990s, which indicate that younger farmers with higher levels of formal education are more likely to use more advanced Farm Management Information Systems (FMIS) (Lewis, 1998). The findings are consistent with the diffusion theories, which link innovative behavior to younger, better-educated individuals who tend to gather information from scientific, impersonal, and local sources. Conversely, older, more experienced farmers exhibit lower demand for management

information – and, consequently, for digital agricultural support – relative to their younger colleagues (Lewis, 1998). Consequently, further research on digital inclusion among young farmers – who will determine future agricultural digitization trajectories – is recommended.

4. Software for managing farm operations

The literature on farm-management software (FMS) employs numerous abbreviations that require initial clarification, a task undertaken at the outset of this section. The analyzed articles reference FMS - Farm Management Software (Nikkilä et al., 2010; Carrer et al., 2015, 2017; Munz et al., 2020; De Souza Filho et al., 2023) and FMIS - Farm Management Information Systems (Lewis, 1998; Nikkilä et al., 2010; Fountas et al., 2015; Tummers et al., 2019; Ammann et al., 2022).

Another commonly used term related to IT-based management support is DSS (Decision Support System), which also plays a key role in digital and "smart" agriculture (Hayman, Easdown, 2002; Verleye, De Marez, 2005; Wenkel et al., 2013; Sampurno et al., 2014; Giusti, Marsili-Libelli, 2015; Navarro-Hellín et al., 2016; Aiello et al., 2018; Nestel et al., 2019; Rupnik et al., 2019; "AgroDSS", 2019).

According to a systematic literature review conducted by Cavazza et al. (2023), DSS is identified as the most frequently discussed topic regarding digital technologies deployed in agriculture, and, according to that analysis, 19 out of 37 articles on the state of the art in artificial intelligence (AI) in agriculture refer to it. DSS represents the predecessor to the latest solutions, such as BI (Business Intelligence) applications, some of which already offer artificial intelligence (AI) support.

Within the context of sustainable precision agriculture, FMIS (Farm Management Information Systems) are defined as integrated software platforms that aggregate data from fields, machinery, markets, and financial ledgers into a unified decision-support environment. The primary goal of these systems is to reduce costs, improve yields and quality, and assist farmers in meeting regulatory standards. Initially, FMIS were not fully computerized and did not always utilize digital media or the Internet.

In the early phase of digital agriculture, the first comprehensive system that assisted farmers in decision-making was the Canadian program Canfarm, which was developed in the 1970s and which organized services into three categories - cash flow control, cost management, and production planning – thereby linking recording and planning functions within a single framework. These systems were not always fully computerized or based on digital data storage and the Internet. Decision-support logic was executed on the basis of data and records transmitted to the central facility in Guelph via traditional mail or telephone – the Internet was not yet operational, although the Advanced Research Projects Agency Network (ARPANET)

was already in use. The Guelph center maintained a central computer-data-processing system for analyzing data sets, and feedback was therefore provided only after about 15 days (Thompson, 1976).

The next, more advanced program was CALEX, an early, innovative computer system for its time that integrated data and expert knowledge to manage agricultural operations. It ran on personal computers (IBM-compatible PCs) and was developed as part of work on artificial intelligence (Plant, 1989). This first solution, Canfarm, represents the Agriculture 2.0 era; the Agriculture 3.0 era, spanning the 1990s to 2010, encompasses the CALEX program. Agriculture 4.0 – discussed since 2010 – has been associated with a dynamic development of FMIS. By 2015, 141 FMIS solutions were already available, commercially offered by 75 providers from the United Kingdom, the United States, Canada, Australia, France, Germany, and Italy (Fountas et al., 2015).

In the early stages of DSS development, information from farmers was collected by telephone or mail; the agricultural advisor then utilized software that generated indicators based on the entered data to aid in rational decision-making. A streamlined DSS, in which farmers manually enter data via a web portal, could – given appropriate data-validation routines – calculate decision-relevant indicators and their interpretations, thereby reducing cost barriers for small holdings. Such a configuration, although representing a deliberate step back to previous technologies, aligns with the resource constraints typical of small holdings that lack Internet of Things (IoT) sensors, farm-data-collection software, or the financial capacity to deploy complex systems.

Farm management software (FMS) is a centralized platform that integrates data from various sources, allowing farmers to remotely monitor their entire farm and optimize operations for efficient resource use. These tools provide real-time analytics and support decision-making (Tilak et al., 2024).

According to the scientific literature, the main functions of FMS/FMIS are: collecting, storing, analyzing, planning, and documenting data related to the management of crops, fields, machinery, and finances (Fountas et al., 2015; Saiz-Rubio et al., 2020; Tummers et al., 2019) Typical FMS/FMIS modules include: record keeping, crop planning, inventory, machinery utilization, traceability, quality and compliance, finance, and decision support. Advanced systems – integrating sensor-driven data pipelines – include additional precision-agriculture features, such as variable-rate irrigation/fertilization and yield-mapping capabilities, alongside predictive models (Baseca et al., 2019; Nikkilä et al., 2010; Rupnik et al., 2019; Zhang et al., 2022).

In addition, the expectations of small farm owners regarding FMS/FMIS functions, as well as the funds available for investment in DSS, are reported to be lower than those of larger farms, a finding that, when coupled with targeted functionality reduction, may permit a corresponding decrease in system pricing.

The development trajectory of agriculture has been nonlinear and systemic, encompassing parallel changes in land-use organization – from slash-and-burn agriculture, through three-field rotation, to crop rotation – as well as in technology and means of production. The current shift primarily concerns the logic of production management, in which decision-making is data-driven (data-driven agriculture). Agriculture 4.0 – often abbreviated as Ag4.0 – paves the way for the next evolution of agriculture, encompassing unmanned operations and autonomous decision-making systems. Agriculture 5.0 (Ag5.0) will be based on robotics and (some form of) artificial intelligence (Digital Farming: what does it really mean?, 2025).

Autonomous agricultural machinery (AAM) – often identified as Agriculture 5.0 – comprises automated tractors with navigation, unmanned aerial vehicles, and agricultural robots, which execute and support services commissioned by farmers. Research is already at the stage of an Autonomous Agricultural Machinery Management Platform (AAMMP) with Internet of Things (IoT) support (Zhang et al., 2022). As a result of this progress, the machine operator is removed from the production process and replaced by AI.

It is impossible to cover all Agriculture 4.0 solutions in a single article; therefore, this paper focuses on software programs that support farm management – understood as monitoring agricultural operations, tracking and counting products, determining production efficiency, financial analysis, energy-consumption analysis, technology integration, and decision implementation – by leveraging Decision Support Systems (DSS). A DSS ¬– an intelligent system that supports decision-making regarding specific requirements and problems – is defined here as a software environment that delivers actionable answers to stakeholders and potential users by extracting useful information from raw data, documents, personal knowledge, and/or models (Figure 1). Such systems can be underpinned by data, models, communication, documents, and knowledge (Abbasi et al., 2022), thereby enabling evidence-based decision-making; nevertheless, the final decision remains with the farmer, who interacts with the platform through the DSS interface.

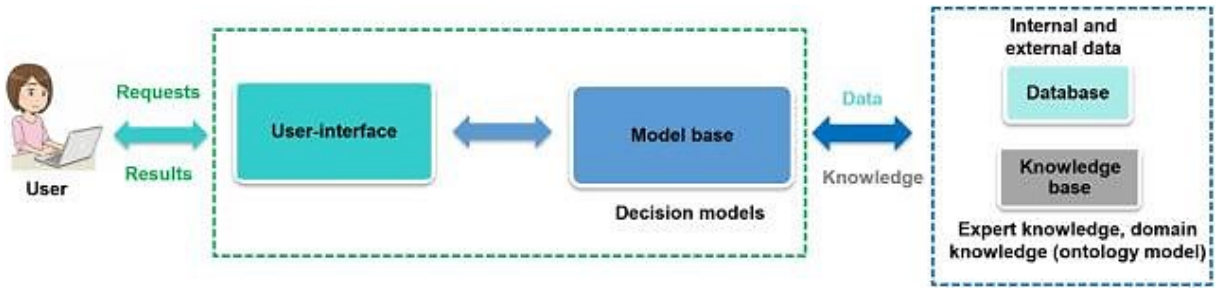


Figure 1. The general architecture of a decision support system.

Source: Abbasi, R., Martinez, P., Ahmad, R. (2022). The digitization of agricultural industry – a systematic literature review on agriculture 4.0. Smart Agricultural Technology, 2, 100042. https://doi.org/10.1016/j.atech.2022.100042.

Modern DSSs tailor their decisions to specific crops and not only collect information from various sensors but also send commands to actuators in the IoT network. Saiz-Rubio et al. (2020) provided a very accessible description of a data-driven management system along with AI-based data analysis. Such a system is grounded in objective field data and in intelligent, AI-augmented decision-making, and its operational framework commences with a specific crop that requires management, exploiting its internal spatial and temporal variability (Figure 2). The platform depicted in Figure 2 – referring to the physical layer through which information is obtained – consists of sensors, the specific components from which objective data are derived. The dataset encompasses information directly collected from parameters measured within the crop, soil, or environment (Figure 2).

Data retrieval from sensors can occur in many ways, ranging from using a USB flash drive to download files to retrieving data from applications synchronized with the Internet. The link between the data and the decision-making stage involves filtering procedures and AI algorithms that allow only relevant data to be obtained and help the farmer make the right decisions.

Actuation – implemented by advanced equipment capable of receiving commands from a computer control unit – constitutes the final layer of the decision-execution stack. The cycle, thus, begins and ends at the crop level (Figure 2), thereby ensuring closed-loop feedback and continuous improvement of management prescriptions. The crop's response to the decision is then recorded by specialized sensors, and the loop repeats systematically until harvest—which marks the end of the crop's life cycle (Figure 2; Saiz-Rubio et al., 2020).

Thus, FMIS have evolved from simple programs used for recording and calculating indicators (Canfarm), when farmers had to wait 15 days for analysis results, to complex systems supporting real-time crop management with AI assistance (for example, in irrigation; Navarro-Hellín et al., 2016).

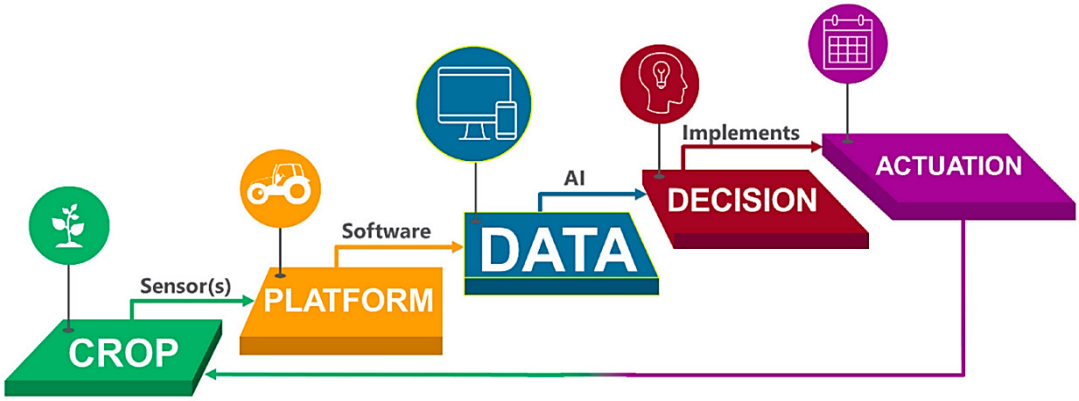


Figure 2. Information-based management cycle for advanced agriculture.
Source: (Saiz-Rubio et al., 2020).

For advanced management systems in precision agriculture to function effectively, standardization of communication protocols within the IoT system is essential. Hence, a key element of agricultural digitization is the Agricultural Industry Electronics Foundation (AEF)—which developed the ISOBUS standard for tractor-to-machine communication, based on

ISO 11783—and which, through its dedicated Farm Management Information Systems (https://www.aef-online.org, 2025).

Equipment manufacturers receive the appropriate certificate of compliance with the ISOBUS standard, and their products are entered into a knowledge database, which, in turn, allows farmers to verify the digital compatibility of equipment – e.g., whether a tractor will communicate digitally with a machine they intend to purchase. For small farms collaborating within a shared machinery pool, investment in machinery that each of the agricultural tractors belonging to the group of agricultural producers can communicate with is essential.

Current digital agriculture solutions can be applied not only to crop production but also to livestock farming, where, with the appropriate software, milk can be analyzed for signs of mastitis in cows, and, in the case of pigs, artificial intelligence can identify sick animals based on their movement patterns. For both livestock and crop production, large amounts of data are collected and summarized in an accessible way so that the farmer can better understand them (Wrzecińska et al., 2023) . Based on the collected data, the farmer can make better production decisions, which translates into the farm's financial performance and product quality.

One company supporting livestock production is Afimilk (Israel). Afimilk's solutions enable farmers to actively detect costly conditions such as mastitis, nutritional issues, and difficult births (https://www.afimilk.com, 2025). The company offers the "AfiFarm" program for managing and automating dairy farms.

In Malawi, a pilot-project deployment – documented in Munthali et al., 2022 –demonstrates a field-ready data-collection workflow whereby agricultural advisors, during on-farm visits, use the "Rapitest 4-in-1 soil tester" to capture soil-health indicators, which are then automatically synchronized with a cloud-based storage platform. Subsequent review of the farm-management portal by extension workers then supports farmers in production decision-making (Munthali et al., 2022).

Module (ProFit), an innovative software component designed to quantify the economic benefits of precision farming applications under varying environmental and operational conditions. In terms of architecture, "ProFit" is embedded in the cloud-based farm-management information system (FMIS) "Ifarma", where it leverages existing functionalities – such as the precision agriculture database provided by other "Ifarma" modules, including "PreFer" (Karydas et al., 2023).

Recently, numerous platforms and technologies for farm management have emerged. Some of the notable options include Climate FieldView, Granular's Farm Management Software (FMS), Farmers Edge, Agworld, Taranis, Trimble, Sentera, Topcon Agriculture, and Raven Industries provide automation solutions, such as guidance and steering systems (Karydas et al., 2023). Additional platforms – listed for comprehensive context – include: FarmWorks, 365FarmNet, Ifarma, FARMnet, Kilo, Fieldtouch, WIDHOC, FARMA, Afimilk, and Mark Online are available (Tummers et al., 2019).

Other solutions supporting farm management include SIG AGRO, (Baseca et al., 2019) and "AgroDSS" (Rupnik et al., 2019). Development of the last mentioned tool was undertaken within the AgroIT project – cofinanced by the European Union under the Information and Communication Technologies Policy Support Programme (CIP-ICT PSP). The "Geofolia" application - developed and deployed in Romania (Geofolia – Program de management agricol - ISAGRI, 2025) – provides farmers with a decision-support dashboard that integrates geospatial layers, crop-management modules, and compliance reporting tools („Software pentru managementul fermei Archives", 2025). Another platform, called "AGRIMI", supports farm decision-making (Geofolia – Agricultural Management Program - ISAGRI, 2025). Furthermore, "Crop360" is another application that facilitates farm management through artificial intelligence and has become one of the most popular tools in Romanian agriculture (Markovits, 2023).

Free, open-source farm-management tools – designed for farmers and available on the market – are identified as a promising means of enhancing sustainability; these tools include information-technology (IT) solutions such as LiteFarm, farmOS, ekilibre, Farm-Simulator (Tribki, 2017/2025), GENMON (SolangeD, 2016/2024), and myCrop (Apostolakis, 2013/2024). Among these, the LiteFarm program deserves special attention. The LiteFarm application – developed by an interdisciplinary team of scientists, researchers, farmers, designers, and software specialists – is highlighted for its comprehensive feature set and its role in facilitating data-driven decision-making. The team – formed at the University of British Columbia (UBC) – has established a data-sharing framework whereby anonymized farm records collected through the platform are utilized for scientific research.

A free option available for small farms in Poland is "eDWIN" (Internet Platform for Advice and Decision Support in Integrated Crop Management), which includes the "Virtual Farm" e-service. One of the features of "Virtual Farm" is its ability to assist farmers in deciding when, where, and how much to apply crop protection products. "FarmSmart" provides a similar solution but is entirely commercial. Other commercially available farm management programs on the Polish market include "xFarm", "eAgronom", "Agroasystent", and "RolnikON" (Dmowski et al., 2024). Notably, "xFarm" offers some basic functions for free, while "eAgronom" provides only a limited free trial period.

"FarmPortal" is widely adopted on small family farms with low automation requirements, as well as on medium- and large-scale operations where full resource control, production optimization, and automation are required. The CropX platform – positioned as a data-aggregation hub – ingests soil analyses and real-time weather telemetry, transforms these streams into actionable insights, and delivers a unified dashboard view of field conditions, thereby supporting proactive crop-health monitoring. These platforms rely on cloud connectivity, Internet of Things (IoT) sensors, and artificial intelligence (AI) to enable real-time monitoring and optimization of agronomic workflows. Across a dataset of representative

holdings, average yield gains of 1.75%, energy-cost reductions of $17-32 per hectare, and irrigation-water savings of 8% have been documented (Saiz-Rubio et al., 2020).

An analysis of 38 articles conducted by Tummers et al. (2019) shows that FMIS offer features such as financial management (found in 17 cases), reporting (14 cases), and data collection (13 cases), which support effective operational decision-making on farms. Mobile and web-based modules – particularly important for young farmers – enable remote monitoring of fields, crops, and resources, thereby aligning with their digital lifestyle. Additional key features include resource and equipment management, as well as operational planning, which help reduce production costs. Less experienced young farmers benefit from simple, mobile FMIS that lower the barrier to entry and reduce costs.

Automated decision-support systems are becoming increasingly important for managing agricultural irrigation, especially in the context of climate change. A notable system developed in Spain uses continuous soil measurements alongside climate data to accurately predict crop water needs. This research aims to demonstrate, within the context of accelerating climate change, the efficacy of an automated decision-support system (ADSS) for irrigation management – a framework that fuses real-time soil-moisture measurements with long-term climate records – thereby enabling data-driven, climate-adaptive water allocation (Navarro-Hellín et al., 2016). Although this conceptual solution has been applied to citrus-tree cultivation, work is underway to adapt the system to other crops. A solution that is already operational and supports farmers' decisions is "IRRINET", an online irrigation system developed in the Emilia-Romagna region (Giusti, Marsili-Libelli, 2015).

"LandCaRe DSS" is an interactive, model-based platform developed in Germany—designed to assess the impact of climate change on agriculture and land management and to analyze potential adaptation strategies at regional and local scales (Wenkel et al., 2013). The primary goal of "LandCaRe DSS" is to provide information on the complex, long-term effects of climate change and to explore possible management options for adaptation by addressing "what-if" scenarios.

An illustrative application of DSS technology is documented in Israeli research on pesticide management in greenhouse cultivation, where, in 2015, greenhouses managed by the DSS received approximately 67% fewer pesticides than control greenhouses (Nestel et al., 2019). A similar initiative, focused on integrated pest management (IPM), was implemented in Italy (Aiello et al., 2018).

SCADA (Supervisory Control And Data Acquisition) denotes a class of industrial control architecture that employs hardware and software to enable organizations to monitor, manage, and control processes, machines, and facilities, both locally and at remote locations. Spanish researchers employed Gensym Corporation's G2 (a model-based, real-time decision-support platform) and SCADA in combination with the LabVIEW (Laboratory Virtual Instrument Engineering Workbench) tool to implement an agriculture-focused decision-support system. The resulting integrated platform – operating in real time – provides producers with

decision-support alerts, delivers additional climate-control data to greenhouse systems, and offers a suite of solutions for issues arising during automatic monitoring of environmental parameters throughout the growth period (Cañadas et al., 2017). As of 2017, the platform remained in the prototype stage.

According to the accepted definitions, "FMIS with DSS components" (Table 1) refers to farm management information systems that include analytical/decision-support elements, and a DSS (in the strict sense) is a system whose primary function is to generate decision recommendations based on models, data, and rules. The FMIS/DSS combination best suited for small farms is presented in Table 1.

Table 1.
FMIS with DSS and the "OneSoil" component designed for small farms

System name	Production planning	Analisys of the costs	Support for operational decisions	Data integration	Paid program	Free period	Free features	Interface languages	Producer
FarmPortal	✓	✓	✓	◐	not	demo	FMIS Basic	PL	Digital Crops
Greenfield	◐	◐	◐	◐	Partly	Free-mium	Poetry	IN	Greenfield Technologies
Harvest Profit	◐	✓	◐	–	not	trial	limit analysis	IN	Bushel / Harvest Profit
OneSoil	◐	–	✓	✓	NO	constant	satellite maps	PL, EN, RU	OneSoil AI
eAgronomist	✓	✓	✓	◐	not	trial	Poetry	PL, EN, inside	eAgronom OÜ
LiteFarm	◐	◐	◐	◐	NO	constant	full	IN, IS	LiteFarm (UBC)
xFarm	✓	◐	✓	✓	Partly	Fre-emium	FMIS	PL, EN, IT	xFarm Technologies

Symbols in the table: ✓– function explicitly declared, ◐ – intermediate/supporting function, – no declaration.

Source: The data collected was analyzed in a Python environment using ChatGPT code. Due to its length, the prompt will be made available by the author upon submitting a query.

The environmental burden is reduced through a decision-support system for herbicide-spraying planning and nozzle-size selection (Sampurno et al., 2014). Scientific research is advancing faster than practical application: complex FMIS concepts are emerging, but office software and basic planning tools still dominate on farms.

Generally, farm management information systems (FMIS) can be categorized as (Fountas et al., 2015):

- "Basic systems" – focused primarily on finances and reports,
- "sales-oriented systems" – strong in sales, inventory, and finances,
- "site-specific systems", geared toward precision agriculture,
- "complete systems", offering the broadest set of functions, including quality management, best-practice frameworks, and, often, precision modules.

In recent years, farm-management systems – including Farm Management Software (FMS) and Farm Management Information Systems (FMIS) – have been gaining importance in the agricultural sector; however, the advisory needs of young farmers in this context remain poorly researched. Much research focuses on precision agriculture technologies and their adoption by

producers, which may suggest the presence of a research gap regarding the specific advisory needs of young farmers regarding FMS and DSS.

5. Training needs of young farmers

A research gap is also evident in understanding the impact of education on the adoption of new technologies, and many studies suggest that educated farmers are more likely to adopt new technologies, meaning that access to education regarding FMS and DSS could significantly increase their practical application (Santiago, Roxas, 2015) The development of tailored training programs, therefore, is proposed as a strategic measure to facilitate technological adaptation by young farmers operating within a rapidly evolving technological environment.

Farmers' insufficient skills represent a barrier to the use of Farm Management Information Systems (FMIS), and, as demonstrated by Tummers et al. (2019), farmers often possess a low level of education, which limits their ability to fully utilize the potential of FMIS. Better education and training for farmers are widely recognized as one of the most important factors facilitating the implementation of sustainable agricultural technologies (Saiz-Rubio et al., 2020). A strong positive correlation has been documented between a farmer's participation in specialized training on digitalization and the number of technologies that are implemented. The cultivation of digital competencies through formal education and targeted training programs is therefore identified as a critical lever for overcoming adoption barriers and realizing the full potential of these digital tools (Tur et al., 2025). Operating advanced software and analyzing data requires specialized knowledge, which is often lacking among farmers.

Public and private agricultural advisory systems have long played a crucial role in transferring knowledge and technology into agricultural practices. As early as the 1970s, during the implementation of early information-technology (IT) systems such as the Canadian "Canfarm", advisory staff were key in educating farmers on the use of new tools (Thompson, 1976). The advisory role – characterized by technology selection, system integration, and data interpretation – remains essential.

Small holdings are anticipated to adopt basic digital tools gradually, whereas large-scale operations are projected to invest in advanced sensor-linked equipment, and intuition-based management, uninformed by data, is expected to decline as the dominant paradigm within professional agriculture. Information-technology (IT) systems that support management are identified as a source of opportunities, especially for the new generation of young farmers who are accustomed to digital technologies, and the offsetting of the negative effects of an aging rural population through the leveraging of innovations is documented (Saiz-Rubio et al., 2020).

However, to fully realize the potential of Agriculture 5.0, the provision of in-depth training to users is necessary; the optimal target group for such training is identified as young farmers eager to learn and apply modern technologies in agriculture (Saiz-Rubio et al., 2020).

Key Features of a Farm Management Support Program for Young Farmers (Fountas et al., 2015):

- Field-operation management – enabling the planning and recording of all tasks (sowing, fertilization, spraying, and harvesting) – facilitates compliance with subsidy requirements, environmental standards, and yield analysis.
- Finance – enables calculation of costs per hectare and per crop, comparison of technology options, and assessment of farm profitability, which is particularly important for young farmers with limited capital.
- Inventory and Inputs – the module facilitates the monitoring of fertilizers, plant protection products, fuel, and seed, thereby establishing a foundation for traceability.
- Reporting – report generation for payment agencies, inspections, and banks (e.g., for investment loans) reduces time spent on administrative tasks.

The findings underscore that, within the context of resource-constrained adoption, barriers to technology uptake among the new generation of farmers can be reduced through systemic support delivered via well-organized advisory services and targeted training programs – so that investments in human capital are accorded the same priority as investments in the technology itself, because competencies ultimately determine implementation effectiveness. Although young farmers are often more open to innovation, they also require professional support to navigate the complex world of digital agriculture.

As early as 2002, it was noted in Australia that adoption rates of farm-management information systems (FMIS) were significantly lower than expected, and that increased computer availability on farms did not automatically result in the use of computers for farm management (Hayman, Easdown, 2002).

A review of the literature indicates that the effective digital transformation of the agricultural sector requires an integrated and systemic approach. The promises of Agriculture 4.0 can only be fulfilled by creating a coherent support ecosystem that will simultaneously:

- Address the skills gap through targeted training programs and the development of professional advisory services.
- Overcome the financial barrier using available financing instruments, such as EU funds and preferential loans, which help cover high initial costs.
- Strengthen trust and infrastructure by ensuring universal access to high-speed internet and establishing a clear legal framework regarding data security and ownership.

Ultimately, the future of Polish and European agriculture depends on the ability to harmoniously combine technological progress with investments in human capital and to create an environment conducive to innovation. Only through such coordinated action can the full potential of digitalization be harnessed to build a resilient, competitive, and sustainable agricultural sector, and digital education is now regarded as being no less essential than instruction in biology, economics, or management.

6. Results – research area, area, and production directions of the surveyed farms

The surveyed farmers are drawn from twenty-four municipalities: Charsznica, Igołomia-Wawrzeńczyce, Jerzmanowice-Przeginia, Kłobuck, Koniusza, Koszyce, Krzeszowice, Limanowa, Lisia Góra, Moszczenica, Nowy Targ, Osiek, Pałecznica, Proszowice, Raciechowice, Racławice, Skała, Sułoszowa, Trzyciąż, Wieprz, Wolbrom, Woźniki, and Zator.

The highest proportion of survey participants was recorded in Proszowice County (35.0%), followed by Kraków County (16.0%), Olkusz County (13.0%), and Miechów County (8.0%). The remaining farmers were recruited from the counties of Oświęcim, Gorlice, Kłobuck, Limanowa, Lubliniec, Myślenice, Nowy Targ, Tarnów, and Wadowice.

The average farm size was recorded as 8.81 ha; the modal class – defined as the interval containing the highest frequency of observations – spanned 10-15 ha (35.0 % of the sample), indicating a predominance of smallholder operations. In second place in terms of frequency were farms up to 5 ha (32.4% of cases), and nine out of ten farms did not exceed 15 ha (91.9% of the surveyed farms).

The average lease size was recorded as 16.7 ha, a figure inflated by a single outlier farm leasing 148 ha; in the majority of cases, lease size did not exceed 80 ha (Table 2). It is worth noting that half of the farms leased no more than 20 ha of land

Two out of three farms grew wheat (73% of the surveyed farms), and more than half of the farms planted no more than 10 ha with wheat (54.1% of the farms), a distribution primarily driven by the preponderance of farms with an area of up to 10 ha.

Barley (Hordeum vulgare) was not cultivated on two out of three surveyed farms (70.3% of respondents), and the most frequently reported sown area for barley was 2 ha (16.2% of responses).

Corn (Zea mays) was cultivated more frequently than barley, although exactly half of the surveyed farms (54.1%) did not grow corn. Additionally, around 70% do not cultivate legumes, and, on one in ten farms, legume area does not exceed 2 ha. Legumes—through a symbiotic association with nodule-forming bacteria of the genus Rhizobium—fix atmospheric nitrogen, thereby acting as natural green manure and enriching the soil with this essential nutrient.

In addition, three out of four farms do not maintain cattle (75.7% of farms), and, when cattle are present, holdings most frequently report 20-30 head (8.1% of farms); swine production is even more limited—only four farms raise pigs. In contrast, four farms reported maintaining herds of 100-200 head, thereby demonstrating the concentration of swine production at a larger scale. Poultry management – characterized by low stocking densities for self-sufficiency – was recorded on seven farms, with flock sizes not exceeding 50 birds; however, one farm maintained a commercial-scale layer operation of 4500 birds, underscoring the presence of specialized poultry production within the study region. Equine holdings were limited to three farms, one of which kept a herd of 20 animals, thus indicating a marginal role for horse husbandry in the local agricultural matrix.

7. Results – gender, age, education, profession of respondents

The survey sample consisted of 5 women and 32 men, and the age structure revealed that the largest cohort—spanning 45.9% of respondents—was concentrated between 25 and 35 years; at the time of data collection, 35.0% of participants were 25 years or younger, whereas 19.1% were aged 35 to 45.

The gender distribution was predominantly male, with men representing 86.5% of the sample (32 individuals) and women constituting 13.5% (5 individuals). The largest percentage of respondents held a secondary education—technical school (45.9% of respondents). The smallest shares consisted of respondents with a high-school education (general secondary school) and a bachelor's degree (approximately 13.5% each); a master's degree was held by 27.0% of the sample.

The occupational profiles of program beneficiaries reveal that 62.2% of respondents report a primary occupation in agriculture; 5.4% combine agricultural work with business management; and 19.9% couple agricultural activities with employment in the private sector. A limited number of respondents combined agricultural labor with employment at the municipal office or in teaching roles. Approximately 8% of respondents reported employment in a private company.

These outcomes indicate that sustaining a livelihood exclusively on farm income—particularly from small, grain-dependent operations—remains challenging, a pattern attributed to persistently low commodity prices.

8. Results – farm labor engagement

The most frequently observed household configuration comprises three members—typically parents and a young farmer (29.7% of respondents)—while four-adult households were also relatively common (27.0% of respondents), and six-person households occurred least frequently (5.4% of respondents). Young farmers participating in the study maintain separate households, and multigenerational families are reported to be declining.

Most surveyed families did not include minor children (54.3% of respondents), one in four families had two children (25.7% of surveyed farmers), and one in six families had only one child (14.3% of respondents).

Most often, farm work is carried out by a single individual (37.8% of responses), followed by two or three individuals (27.0% of responses each), and having four or five individuals engaged in on-farm labor is a very rare occurrence. V. Discussion In the past, there was talk of hidden unemployment in rural areas; however, in the present sample, such a phenomenon appears unlikely to be present.

In one out of every three farms, no one works outside the farm (32.4% of respondents), whereas, in the remaining farms, one person often works outside the farm (37.8% of respondents), and less commonly, two people (21.6% of responses) or three people (8.1% of responses) do so.

9. Results – Young farmers' use of digital technologies

This study investigates the limited uptake of innovations among young farmers and reports that 48.6% of respondents do not employ production, technology, or management innovations, whereas only 13.5% self-identify as users of such solutions (see Figure 3). Among the limited set of adopters, the following technologies are deployed: GPS-guided sprayers with remote section control, GPS navigation, soil maps that reveal site-specific nutrient content, zero-till cultivation systems, and computer-based herd-management software – all of which are implemented at scales that remain below widespread diffusion thresholds (see Figure 3). No-till farming was practiced by two respondents, and herd-management software was employed by one.

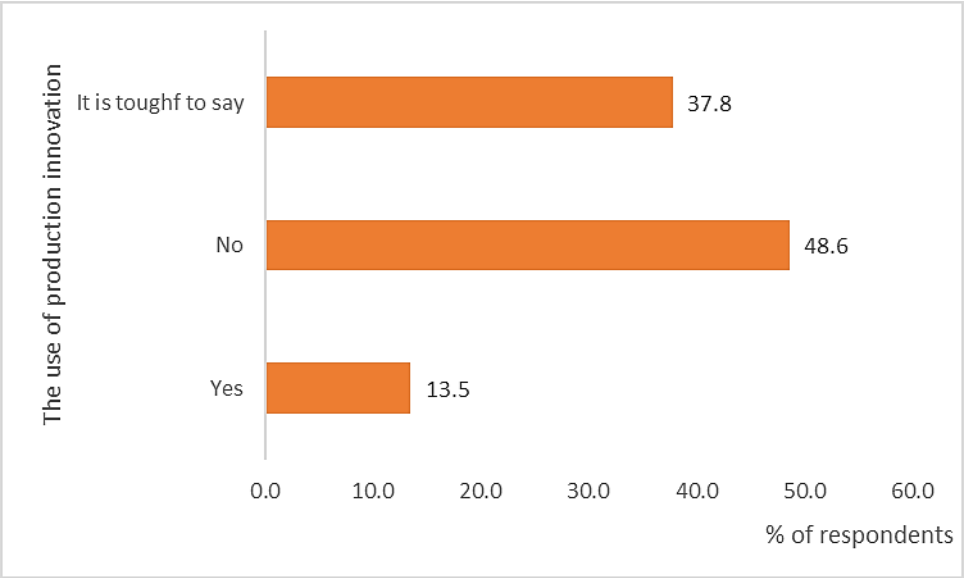


Figure 3. Structure of the answers to the question: Does your farm use production, technological, and management innovations? (%)

Source: own study, N = 37.

Six out of ten surveyed farmers use a computer to support farm management (59.5% of responses—Figure 4). This level of adoption is assessed as satisfactory, although an Excel spreadsheet alone offers significant capabilities for data analysis and decision-making, and the non-use of computers for cost or income recording is noted as anachronistic in the current technological context.

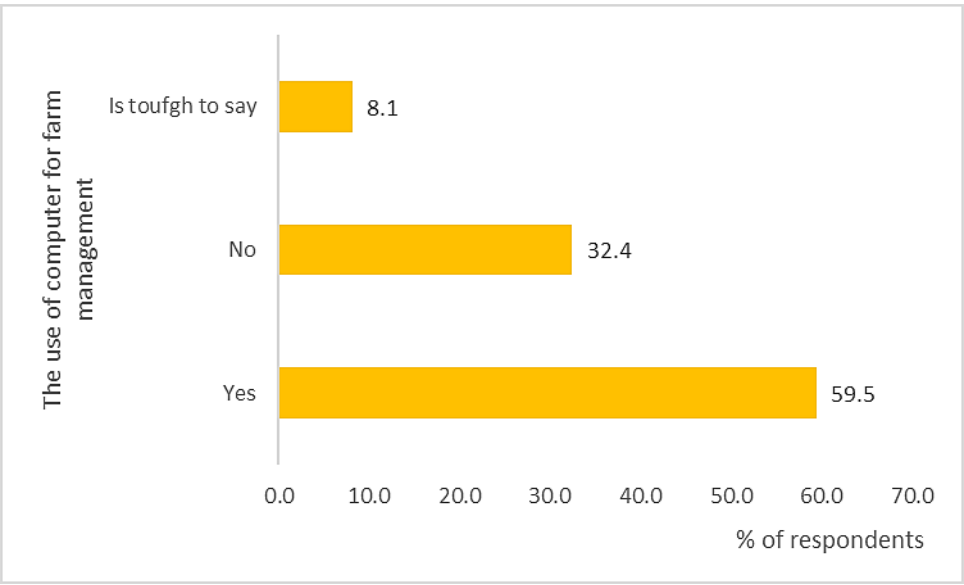


Figure 4. How many of respondents use a computer to support farm management? (%)

Source: own study, N = 37.

Younger producers, operating under intensified data-management pressures, cited specific examples of information-management support: record-keeping of farm income and expenses, animal registration and deregistration, invoice issuance, and e-commerce listing on OLX or Allegro. The machine is further leveraged for the submission of applications to the ARiMR (Agency for Restructuring and Modernization of Agriculture) for direct payments, for the management of official matters, and, in a minority of cases, for the maintenance of agrotechnical treatment records – including the application of plant protection products – within the Excel environment. In Eco-Schemes – where digital recordkeeping is a compliance prerequisite – all treatments are required to be documented, and data are most often entered manually, subsequent to field or barn operations, with only one surveyed young farmer having herd-management software installed.

Most farmers manually input data into their computers, often doing so at home after a day's work in the field or barn. Only one of the surveyed young farmers had herd management software installed on their computer.

Only a few farmers had farm-management software compatible with the GPS navigation system in their tractors, demonstrating that seamless data exchange between in-cab displays and back-office platforms remains limited. The software passively records the application rates of specific plant protection products used on a given plot of land, or the fertilizer application rates used on a given field, thereby enabling retroactive dose verification and regulatory compliance. The date of application is also recorded, and the software – interoperable with the navigation system – permits remote visualization of the entire dataset on a desktop computer.

An Excel add-in (developed by Bogusław Kiedrowski) is employed by some operators to generate a fertilization plan – computational routines calculate the required rates of nitrogen, phosphorus, potassium, and magnesium, and they indicate the need for liming.

Farmers also search for information regarding available plant protection products or new plant varieties, often using a geoportal to find geospatial information and identify agricultural plots. Additionally, farmers communicate through computers, and buyers of agricultural products often look for sales markets online. For a few of the surveyed farmers, electronic mail (email) contact with an advisor or accountant is also considered essential. Online training participation was reported by a minority of respondents.

The most frequently adopted management-support tool was identified as the Excel spreadsheet (51.4% of responses; Figure 5), which was cited as a familiar platform for record-keeping and budget-projection activities.

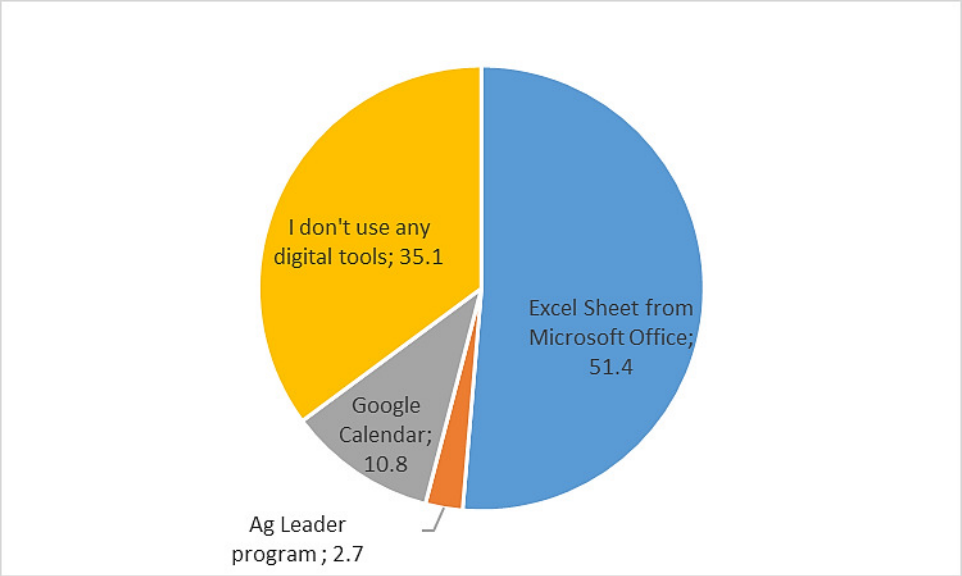


Figure 5. Structure of responses to the question "What tools do you use to support farm management?" (%)

Source: own study, N = 37.

Additional tools cited included Google Calendar for activity planning, and, in a single instance involving a young farmer, a professional farm-management software package from AG Leader – a U.S. firm specializing in precision agriculture solutions.

10. Results – Expectations of young farmers towards an IT program supporting farm management

Farmers were asked to identify management problems that could be addressed by a computer program supporting farm management. In their responses, farmers pointed to "faster implementation of agrotechnical measures and accurate cost and profit accounting". For some, it is important for the software to solve the problem of "recording the plant protection products used on a given field". Keeping records of plant protection products is important because the surveyed farmers maintain these records in paper form, which is time-consuming.

For livestock farmers, it would be important for the software to allow, for example, "calving planning" and a "dry-off schedule". Crop-production specialists, in turn, highlighted the need for modules that would automate fieldwork logging, calculate fertilizer application rates for a given field, determine spraying dates, and enable "analysis of crop-production data". Additional stakeholders emphasized decision-support capabilities – formulated as response-condition pairs (e.g., "At a given temperature, can a plant protection product be applied?" or "Can this product be mixed with another product?") – that are intended to reduce application errors and associated environmental risks.

One farmer, using Ag Leader's software on a daily basis, highlighted its advantages: "The problem is that you don't remember which variety was sown, or how and what you applied. We have everything recorded. We open the field map and everything is recorded there".

Most farmers (62.2% of responses – Figure 6) indicated a preference for a desktop version, although a browser-based solution – accessible on mobile phones, desktop computers, or laptops – was identified as potentially more resilient in field conditions.

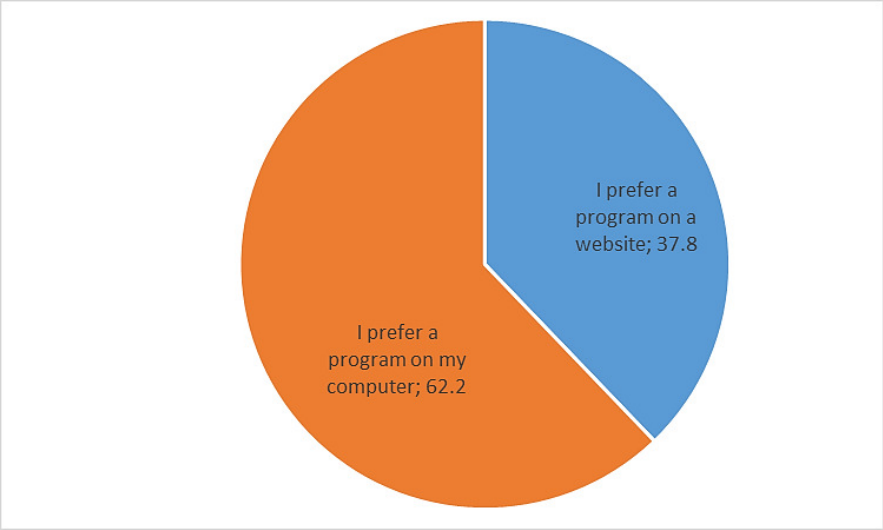


Figure 6. Structure of the answer to the question "Should the farm management support program be in the browser or locally on your computer?" (%)

Source: own study, N = 37.

According to the vast majority of farmers, a program designed to support farm management should include a map on which agricultural plots can be marked (Figure 7).

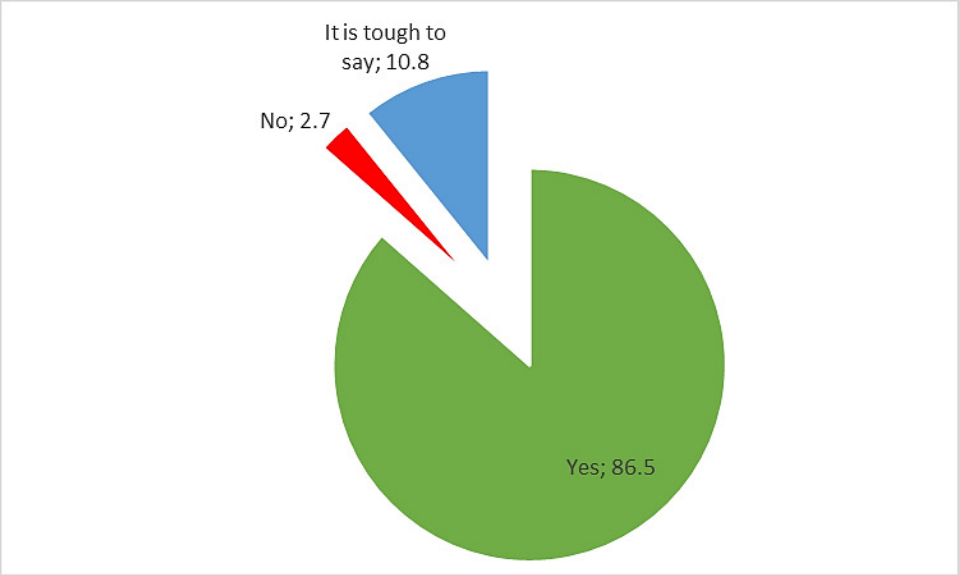
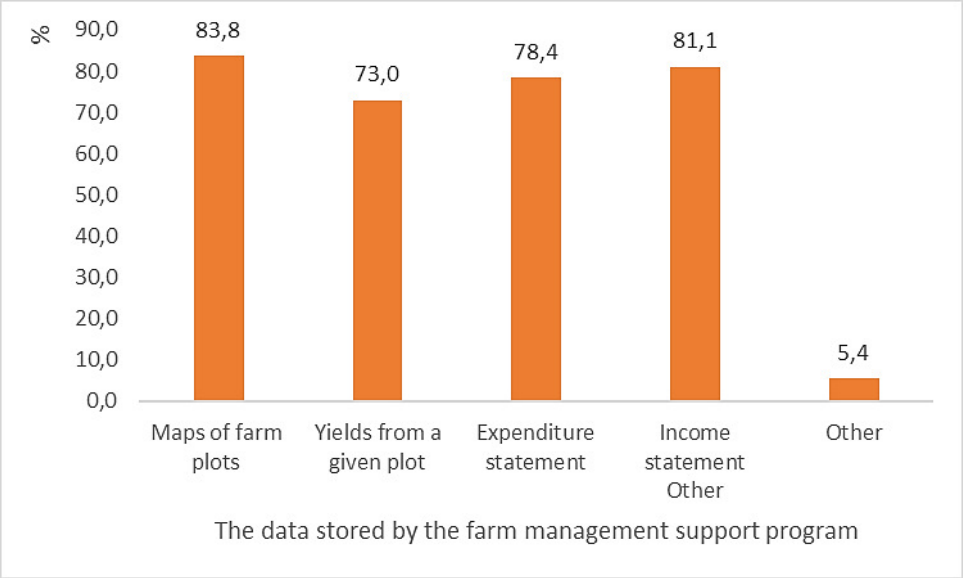


Figure 7. Structure of farmers' responses to the question: "Should the farm management support program include a map to mark your agricultural plots?" (%)

Source: own study, N = 37.

The young farmers surveyed were asked: “What farm data should a program designed to support farm management store?” The highest response frequency was recorded for the storage of farm-plot maps (83.8%); the next most frequently cited item was a revenue summary (81.15%); and the lowest frequency pertained to the storage of plot-level yield data (73%).

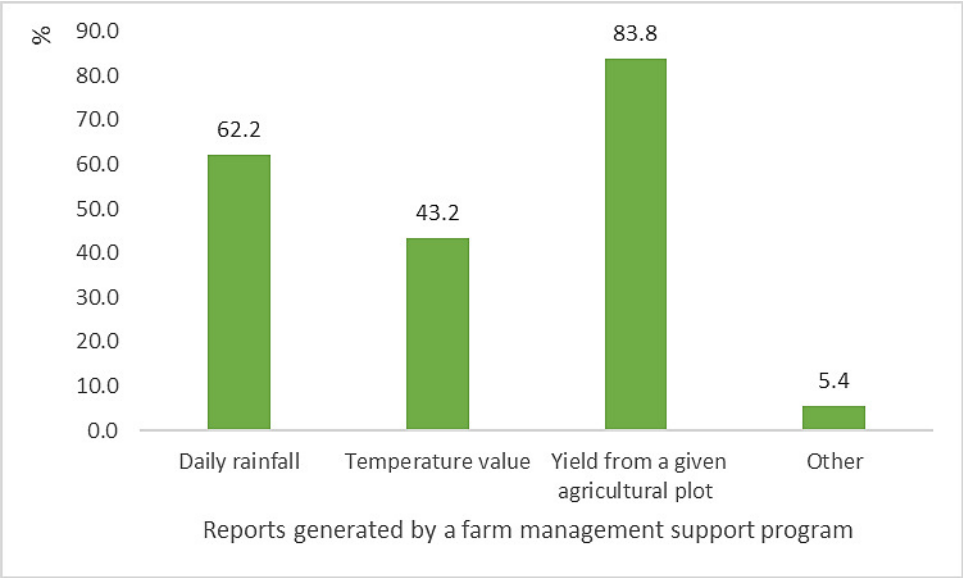


Other answers no mentioned in the figure 8: income statement, treatment dates, plant protection products used, most necessary items for everyone.

Figure 8. Structure of the answer to the question: "What farm data should the farm management support program store?" (multiple answers could be selected; %).

Source: own study, N = 37.

In response to the question “What reports should a farm-management support program generate?” (Figure 9), yield reports for individual farm plots were cited most frequently (83.8% of responses), precipitation summaries were mentioned less often (62.2%), and temperature records were cited least frequently (43.2%); additional requests included a financial report and a precipitation–yield correlation analysis. Daily precipitation was mentioned less frequently (62.2% of responses), and temperature was mentioned least frequently (43.2% of responses); a small proportion of respondents cited additional desired reports, such as a financial report or a report correlating precipitation with crop yields.

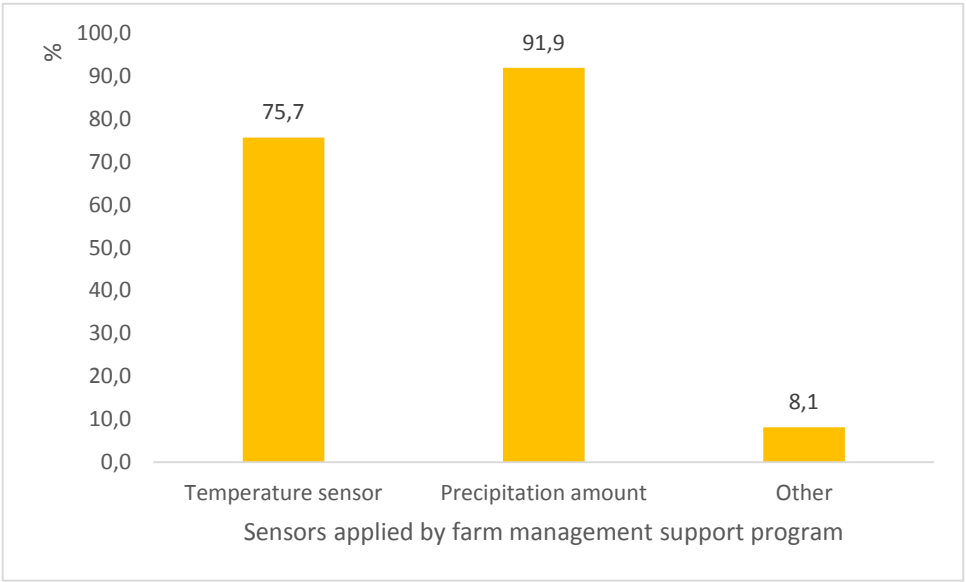


Other responses included: financial report, report on the correlation between rainfall and crop yield.

Figure 9. Structure of the answers to the question: "What reports should a farm management support program generate?" (multiple answers were possible, %).

Source: own study, N = 37.

In addition, the need for direct integration with environmental sensors was emphasized, with data collection from a rainfall sensor (91.9% of responses—Figure 10) and a temperature sensor (75.7% of responses) identified as essential components of the decision-support architecture. Additional requirements, cited by a smaller subset of respondents, included direct integration with the nearest weather station, wind-speed measurement, and Global Positioning System (GPS) navigation interfaces for agricultural machinery.



Other: operate the nearest weather station nearby, measure wind speed, and connect to GPS.

Figure 10. Share of responses to the question: "Should the program support any sensors, e.g., temperature, rainfall?" (%)

Source: own study, N = 37.

Based on the collected responses, it can be concluded that farmers expect a farm-management software program to primarily offer analytical and computational functionalities that will enable more effective planning and assessment of the profitability of agricultural production. The respondents' comments can be grouped into several main themes (Table 2).

Table 2.
Synthesis of farmers' needs and proposed software functionalities for small farms

Category	Farmers' expectations	Functional specification
Maps	Spatial visualization of the farm and marking agricultural plots.	Mapping and Geolocation Module: Interactive maps allowing for defining plot boundaries, storing, and displaying spatial farm data.
Revenue summaries	Accurate cost and profit accounting, and assessing the profitability of various crops.	Financial and Analytical Module: Automated record-keeping of income and expenses, calculation of profit per hectare or crop, break-even point determination, and financial report generation.
Yield data	Storing plot-level yield data for efficiency analysis.	Yield Recording and Reporting Module: Recording harvest quantities assigned to specific plots and automatically generating yield reports for individual farm plots.
Plant protection records	Faster implementation of agrotechnical measures, replacing time-consuming paper records, and avoiding application errors (e.g., due to temperature or improper mixing).	Decision Support and Digital Field Diary: Automated recording of applied products, conditional alerts based on response-condition pairs (e.g., temperature warnings or substance mixing prohibitions), and monitoring maximum permissible rates.
Fertilizer rates	Calculating optimal fertilizer application rates based on crop type, expected yield, and soil test results.	Fertilization Calculator: Nutrient-balance calculation, automatic adjustment to crop requirements, and automatic conversion of fertilizer quantities to the specific field area.
Animal-production deadlines	Scheduling and tracking key events in the livestock life cycle.	Herd Scheduling Module: Calendar and notification system enabling calving planning and setting dry-off schedules.
Weather data	Understanding the impact of weather conditions on crop yield and planning field operations based on weather data.	Environmental Integration Module: Direct integration with environmental sensors (temperature, rainfall) or nearby weather stations, suggesting spraying dates based on weather, and analyzing the correlation between precipitation and crop yields.

Source: own elaboration based on empirical research.

The most frequently mentioned expectations include: the capacity to calculate profit per hectare or per crop; the analysis of production costs (inputs, fuel, labor, etc.); the balancing of income and expenses; the determination of the break-even point and the profitability of various crops; and the automated record-keeping of income and expenses. A substantial proportion of respondents indicated that these calculations are currently executed in spreadsheet applications (e.g., Excel), thereby signifying the need for a simplified, intuitive software module that integrates the aforementioned functions.

The second key area involves functions supporting decisions regarding fertilization and plant protection, including calculating optimal fertilizer rates based on crop type, soil test results, and expected yield. For young farmers, monitoring maximum permissible rates of fertilizers and plant protection products is also important. The software is expected to suggest spraying dates, taking weather conditions (temperature, precipitation, risk of fungal diseases) into account. Nutrient-balance calculation and their automatic adjustment to crop requirements

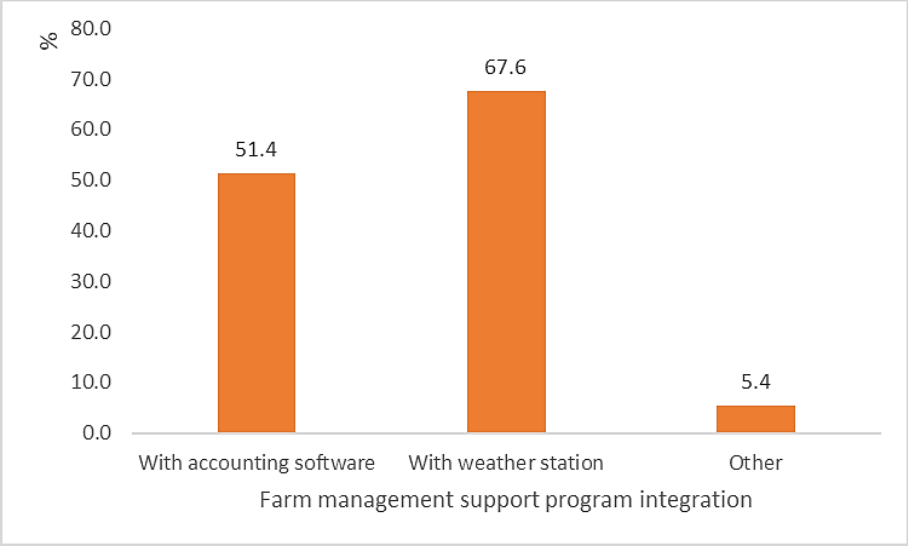
were also cited as essential modules. Automatic conversion of fertilizer or plant-protection-product quantities to field area, thereby eliminating manual calculation, was identified as a critical back-end function.

The integration of environmental data – including average daily temperature and average seasonal precipitation – was identified as essential, because it enables the quantification of feedback loops among fertilization, weather conditions, and crop yield, thereby supporting retrospective efficiency analysis across successive growing seasons.

The need to expand the program's functionality to include the following components is highlighted: inventory management (e.g., grain quantities in silos, breakdown by type), land and crop records, and production planning capabilities (e.g., crop rotation, eligibility for payments under eco-schemes such as "Carbon Farming").

Several respondents indicated that the platform should be comprehensive and integrated—so that it provides everything a farmer might require – and that it should operate intuitively and automatically once foundational data are submitted, thereby supporting widespread adoption.

Young farmers were asked: "Should a program designed to support farm management integrate with anything?" The most frequently cited integration points were weather-station data (67.6% of responses; Figure 11) and accounting-software interfaces (51.4% of responses); additional mentions included SatAgro maps and Global Positioning System (GPS) navigation tools.



Other: with SatAgro maps, with GPS navigation.

Figure 11. Share of responses to the question: "Should the farm management support program be integrated with anything?"; (%)

Source: own study, N = 37.

Nearly half of farmers would be willing to pay no more than 200 PLN per year for a farm-management support program (45.9% of responses—Figure 12), indicating that this group of farmers likely does not fully realize the benefits of this solution and therefore values it so lowly. Between 200 and 400 PLN per year was indicated by 16.2% of respondents, whereas the 400-600 PLN bracket was cited by 8.1% of respondents.

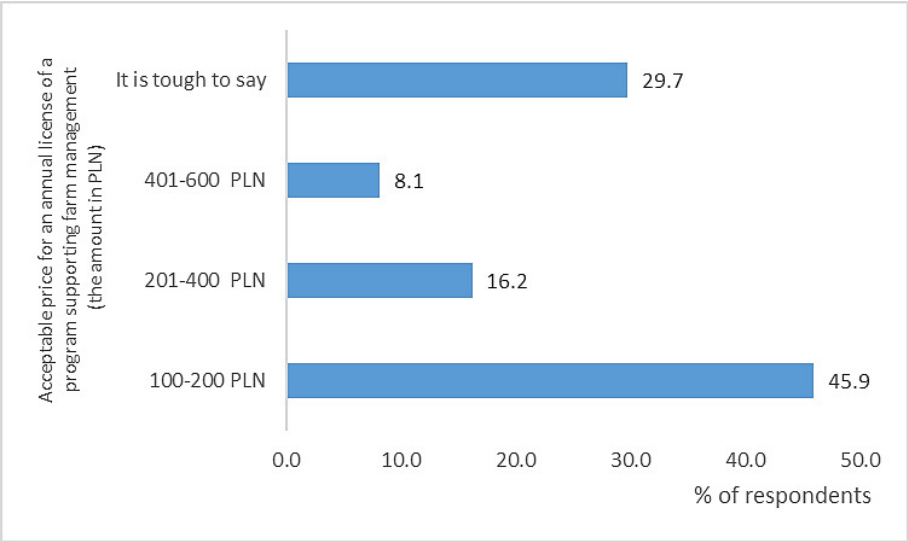


Figure 12. Structure of answers to the question: "What is the acceptable price for an annual license of a program supporting farm management?" (%)

Source: own study, N = 37.

Only 29.7% of young farmers indicated a need for additional farm-management training (Figure 13), underscoring the urgency of targeted extension interventions. One in five young farmers (21.6%) explicitly indicated no such need, whereas nearly half (48.6%) remained undecided, underscoring the ongoing uncertainty regarding the urgency of management training (Figure 13).

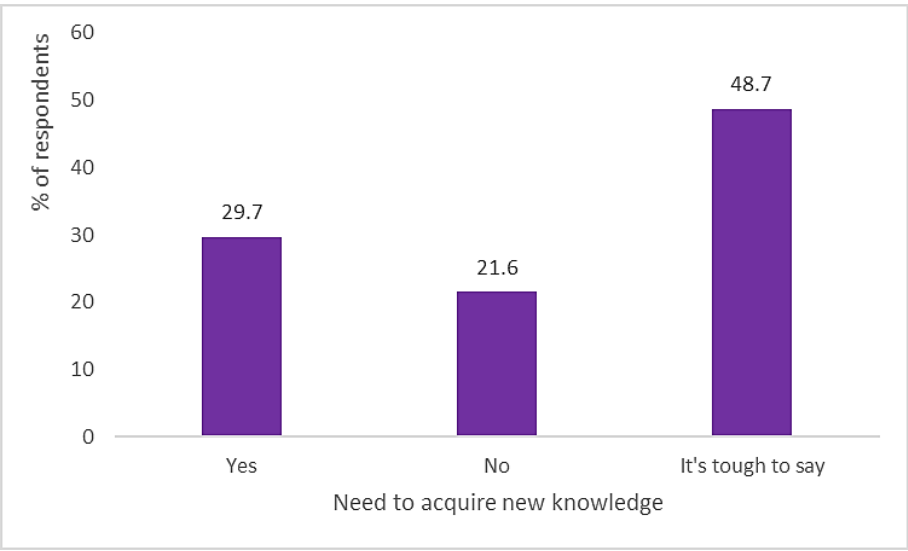


Figure 13. Structure of responses to the question: "Do you feel you need to expand your knowledge of farm management?" (%)

Source: own study, N = 37.

Young farmers were asked to what extent they would like to expand their knowledge. In their responses, they indicated a desire to expand their knowledge regarding crop production, and less frequently regarding livestock production. With regard to crop production, young farmers expect training in the following areas:

- new plant protection products (active ingredients),
- organic plant protection,
- the use of cover crops (instead of fertilizers),
- no-till farming,
- new fertilizers,
- new cereal varietiesEcological plant protection.

In the area of animal production, a need to deepen knowledge of modern veterinary medicines and other issues related to animal husbandry has been highlighted by farmers operating under varying climatic and regulatory pressures. In addition, farmers reported a need to acquire knowledge in the areas of production management and marketing management. They see the main challenges in expanding their knowledge of sales and agricultural economics. In this context, they expressed interest in participating in training under a program supporting farm management.

The "Young Farmer" program – of which the respondents were beneficiaries – requires farmers to participate in training, and under current requirements, a young farmer must have an advisor; farmers stated that they learn primarily from the Internet and most often receive advice from those selling plant protection products.

11. Discussion and conclusions

In crop production, 27.5% of all innovations were related to the modernization of agricultural machinery (Olszańska, Szymańska, 2014). In 95% of the surveyed young farmers' farms, many capital expenditures were financed from European Union (EU) aid funds (Olszańska, Szymańska, 2014). The situation is similar among the farmers surveyed in the present study, who are beneficiaries of the "Young Farmer" program; thus, each of them received investment funds from EU sources. Unfortunately, the acquisition of a tractor or other agricultural machinery does not automatically entail a transition to digital agriculture, including in management; small farms, while incurring the expense of purchasing better agricultural equipment, do not expand their equipment options to include digital solutions enabling automated operation using GPS or the collection of digital data while the machine is in operation.

Survey research conducted in 2024 on a sample of 106 farms shows that the larger the farm, the more frequently it uses management software (Dmowski et al., 2024). The results obtained in this study confirmed this trend and indicate that small farms are foregoing IT solutions because their cost would exceed the benefits they could bring (Da et al., 2025; Dmowski et al., 2024). However, it was not mentioned that there exist information-technology (IT) tools that carry no direct licensing costs beyond the investment required for farmer training. Therefore,

digital education – delivered through regional Agricultural Advisory Centers (AACs) – should be identified as a strategic priority, particularly for small-scale farmers.

Although digital farm-management support technologies are becoming increasingly widespread in agriculture, young farmers' advisory needs regarding FMS, FMIS, and DSS remain unmet. There is a significant gap in research aimed at understanding these needs, which may hinder the adoption of digital management support in agricultural practices. Young farmers require enhanced educational pathways and streamlined information access regarding these systems so that they can fully realize the potential of modern **agriculture**. Results reported indicate that, in a 2021 Swiss survey (Ammann et al., 2022), 43.0% of 109 agricultural students had received no instruction on digital technologies – either during basic training or in farm-management courses – a proportion that, when extrapolated to Polish classrooms, is anticipated to remain comparable or slightly lower. Regarding FMIS, 51% of students indicated that they had never heard of FMIS during their agricultural training (Ammann et al., 2022). It appears that these percentages would be the same among Polish students or – more likely – even slightly lower.

The implementation and use of Farm Management Software (FMS) are, unfortunately, not significant factors in the optimization of agricultural practices among the young farmers surveyed. Although studies indicate that younger users are more inclined to use digital tools and technologies in agricultural activities than their older counterparts (Chuang et al., 2020; Citra Irawan et al., 2023; Figurek et al., 2023; Nurlaela et al., 2022; Rooij, 2006), this pattern holds for owners of large farms; however, the ICT proficiency of young farmers from small farms is reported to be limited, a factor that discourages their engagement in more advanced farming methods. Meanwhile, the integration of interactive technology and data-analysis workflows into cropping systems is projected to raise precision, yield, and profitability for smallholders, to facilitate climate-change preparedness, and to limit adverse environmental externalities (Trendov et al., 2019).

An analysis of survey results from young farmers who utilized EU funds supporting the launch of agricultural operations indicates that, despite owning a computer, four out of ten farmers do not use it in connection with running their farm. In the study region (Małopolskie Province, Poland), where farm sizes are small, this barrier to innovation adoption is particularly pronounced. An analysis of the global literature on information technology (IT) systems for farm management support indicates dynamic growth in their number and quality, and the emergence of nonproprietary decision-support tools that could be localized for smallholders (Trendov et al., 2019). However, during the literature review, non-commercial software programs supporting economic decision-making were identified, and it is recommended that these tools be translated into Polish and promoted among small farm owners. Expanding the knowledge of young farmers is crucial for encouraging even small farms to begin using IT systems for farm management.

Based on the empirical findings, the development of Farm Management Information Systems (FMIS) targeted at small-scale and young farmers must prioritize a streamlined, low-cost approach rather than overly complex Agriculture 4.0 suites. To ensure adoption, IT developers should focus on the following concrete design specifications:

- The system must be highly affordable, as nearly half of the surveyed farmers (45.9%) expect the annual license fee to not exceed 200 PLN. The architecture should be a hybrid model that primarily functions locally but has basic cloud synchronization, avoiding complex IoT dependencies unless requested.
- While mobile browser-based solutions are seen as potentially resilient in field conditions, the clear preference among respondents (62.2%) is for a desktop-based application. Because most farmers manually input data on their computers at home after completing a day's work in the field or barn, robust offline desktop functionality is a mandatory requirement rather than an optional feature.
- A minimum viable product must include the following core modules: mapping (spatial visualization tools, as 83.8% of farmers cited farm-plot maps as the most crucial data to store), financial & yield analytics (modules capable of balancing income and expenses, calculating profit per hectare, and determining break-even points, which are currently the most heavily requested analytical features), environmental integration (direct integration with basic environmental sensors or nearby weather stations to inform agrotechnical decisions).
- Since 51.4% of farmers currently rely on Microsoft Excel for farm management, any new software must mimic its intuitive nature while eliminating the need for manual calculations. The system must operate intuitively and automatically once foundational baseline data (such as plot sizes and crop types) are submitted, significantly reducing the time currently spent on paper-based record-keeping.
- A critical value-add for developers is integrating compliance reporting. Farmers heavily rely on computers to submit applications to the Agency for Restructuring and Modernization of Agriculture (ARiMR) for direct payments. Software must automatically generate treatment records and compliance reports required for EU subsidies and "Eco-Schemes" (e.g., Carbon Farming), which currently force farmers into tedious manual data entry.

Developers must recognize that providing software is insufficient without onboarding. Insufficient skills remain a major barrier to FMIS adoption. While only 29.7% of young farmers explicitly stated a need for training, 48.6% remained undecided, indicating a hidden need for digital education. IT developers should partner with agricultural advisory services to build integrated training modules or accessible tutorials directly into the FMS ecosystem.

12.Limitations and future research

The study, which included only 37 participants, serves as an initial step for more extensive research. Therefore, the results should not be applied to the entire population of young farmers. It would be advisable to conduct similar studies involving a larger group of young farmers. To address the limitations of this research, it would be beneficial for the author to enhance their understanding of the GDPR (General Data Protection Regulation) or consult a lawyer specializing in this area. A well-structured cover letter could effectively address the concerns of the Agency for Restructuring and Modernization of Agriculture regarding the sharing of young farmers' personal data for research purposes.

Currently, there is a research gap concerning the extent to which Polish educational and advisory institutions provide students, including farmers, with updated information about digital technologies that support farm management.

Acknowledgements

The project “Greater Potential of Management and Quality Sciences through Better Utilization of the Capital of the Polish Countryside” (acronym: URK Management), co-financed from the state budget under the Minister of Science’s program titled “Regional Initiative of Excellence”, grant amount: PLN 6,187,000.00; total project value: PLN 6,187,000.00; agreement no.: RID/SP/0039/2024/01. “Funded by a subsidy from the Ministry of Science and Higher Education for the Hugo Kołłątaj University of Agriculture in Krakow for the year 2026”.

References

1. Abbasi, R., Martinez, P., Ahmad, R. (2022). The digitization of agricultural industry – a systematic literature review on agriculture 4.0. *Smart Agricultural Technology, 2*, 100042. https://doi.org/10.1016/j.atech.2022.100042
2. *AEF Online—About the AEF*. Retrieved from: https://www.aef-online.org/about-us/about-the-aef.html#/About, 28.12.2025.
3. Aiello, G., Giovino, I., Vallone, M., Catania, P., Argento, A. (2018). A decision support system based on multisensor data fusion for sustainable greenhouse management. *Journal of Cleaner Production, 172*, 4057-4065. https://doi.org/10.1016/j.jclepro.2017.02.197

4. Ammann, J., Walter, A., El Benni, N. (2022). Adoption and perception of farm management information systems by future Swiss farm managers -An online study. *Journal of Rural Studies, 89*. https://doi.org/10.1016/j.jrurstud.2021.12.008
5. Apostolakis, N. (2024). *Nickapos/myCrop [Java]*. https://github.com/nickapos/myCrop (Original work published 2013).
6. Baseca, C.C., Sendra, S., Lloret, J., Tomas, J., Baseca, C.C., Sendra, S., Lloret, J., Tomas, J. (2019). A Smart Decision System for Digital Farming. *Agronomy, 9(5).* https://doi.org/10.3390/agronomy9050216
7. Cañadas, J., Sánchez-Molina, J.A., Rodríguez, F., del Águila, I.M. (2017). Improving automatic climate control with decision support techniques to minimize disease effects in greenhouse tomatoes. *Information Processing in Agriculture, 4(1),* 50-63. https://doi.org/10.1016/j.inpa.2016.12.002
8. Carrer, M.J., Filho, H., Batalha, M. (2017). Factors influencing the adoption of Farm Management Information Systems (FMIS) by Brazilian citrus farmers. *Comput. Electron. Agric., 138,* 11-19. https://doi.org/10.1016/j.compag.2017.04.004
9. Chuang, J.-H., Wang, J.-H., Liang, C. (2020). Implementation of Internet of Things depends on intention: Young farmers' willingness to accept innovative technology. *International Food and Agribusiness Management Review, 23(2),* 253-266. https://doi.org/10.22434/IFAMR2019.0121
10. Citra Irawan, N., Irham, I., Mulyo, J.H., Suryantini, A. (2023). Unleashing the Power of Digital Farming: Local Young Farmers' Perspectives on Sustainable Value Creation. *AGRARIS: Journal of Agribusiness and Rural Development Research, 9(2),* 316-333. https://doi.org/10.18196/agraris.v9i2.239
11. Da, A., Eo, A., Es, F., Eu, H., & So, H. (2025). A Systematic Review of Management Science Integration in Farm Decision Tools: Advancing Theory for Agricultural Problem-Solving. International Journal of Multidisciplinary Research and Growth Evaluation. https://doi.org/10.54660/.ijmrge.2025.6.4.656-664
12. De Souza Filho, H.M., De Mello Brandão Vinholis, M., Carrer, M.J., Mozambani, C.I. (2023). Adoption of farm management information systems (FMIS): The case of Brazilian sugarcane farmers. *Information Development, 41,* 1131-1145. https://doi.org/10.1177/02666669231177864
13. *Digital Farming: what does it really mean?* Retrieved from: https://www.cema-agri.org/images/publications/position-papers/CEMA_Digital_Farming_-_Agriculture_4.0__13_02_2017_0.pdf, 28.12.2025.
14. Dmowski, K., Bartyna, W., Stępniak, M. (2024). Analysis of Information Technology Adoption in Polish Agriculture. *Studia Informatica. System and Information Technology, 31(2),* 103-115. https://doi.org/10.34739/si.2024.31.08

15. Figurek, A., Morphi, K., Thrassou, A., Figurek, A., Morphi, K., Thrassou, A. (2023). A Sustainable Risk Management Model and Instruments for Young Farmers in EU Agriculture. *Sustainability, 16(1).* https://doi.org/10.3390/su16010283
16. Fountas, S., Carli, G., Sørensen, C.G., Tsiropoulos, Z., Cavalaris, C., Vatsanidou, A., Liakos, B., Canavari, M., Wiebensohn, J., Tisserye, B. (2015). Farm management information systems: Current situation and future perspectives. *Computers and Electronics in Agriculture, 115*, 40-50. https://doi.org/10.1016/j.compag.2015.05.011
17. Gacek, A., Misiąg, J., Misiąg, W., Palimąka, K., Pomianek, T., Rodzinka, J. (2025). *Program przebudowy wsi i rolnictwa w kierunku zmian strukturalnych i zasad zrównoważonego rozwoju*. Wyższa Szkoła Informatyki i Zarządzania z siedzibą w Rzeszowie. https://ksiegarnia.wsiz.pl/strona-glowna/137-program-przebudowy-wsi-i-rolnictwa-w-kierunku-zmian-strukturalnych-i-zasad-zrownowazonego-rozwoju.html
18. *Geofolia – Program de management agricol—ISAGRI*. Retrieved from: https://www.isagri.ro/software/geofolia-program-de-management-agricol-isagri, 28.12.2025.
19. Giusti, E., Marsili-Libelli, S. (2015). A Fuzzy Decision Support System for irrigation and water conservation in agriculture. *Environmental Modelling & Software, 63*, 73-86. https://doi.org/10.1016/j.envsoft.2014.09.020
20. Hayman, P.T., Easdown, W.J. (2002). An ecology of a DSS: Reflections on managing wheat crops in the northeastern Australian grains region with WHEATMAN. *Agricultural Systems, 74(1),* 57-77. https://doi.org/10.1016/S0308-521X(02)00018-5
21. *Ile kosztuje wdrożenie rolnictwa precyzyjnego w gospodarstwie?* Retrieved from: https://e-ursus.pl/ile-kosztuje-wdrozenie-rolnictwa-precyzyjnego-w-gospodarstwie.htm, 21.03.2025.
22. Karydas, C., Chatziantoniou, M., Tremma, O., Milios, A., Stamkopoulos, K., Vassiliadis, V., Mourelatos, S., Karydas, C., Chatziantoniou, M., Tremma, O., Milios, A., Stamkopoulos, K., Vassiliadis, V., Mourelatos, S. (2023). Profitability Assessment of Precision Agriculture Applications—A Step Forward in Farm Management. *Applied Sciences, 13(17).* https://doi.org/10.3390/app13179640
23. Kielbasa, B., Puchala, J. (2015). Innowacyjność młodych rolników i ich postawy wobec zmian na przykładzie gospodarstw rolnych położonych w regionie rozdrobnionego rolnictwa. *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu, 17(1).* https://bibliotekanauki.pl/articles/863726
24. Lewis, T. (1998). Evolution of farm management information systems. *Computers and Electronics in Agriculture, 19(3),* 233-248. https://doi.org/10.1016/S0168-1699(97)00040-9
25. Licciardo, F., Henke, R., Piras, F., Zanetti, B. (2024). The Setting-Up Measure to Support Generational Renewal in Agriculture: The Italian Experience. *World (2673-4060), 5(4),* 1130-1147 (181946719). https://doi.org/10.3390/world5040057

26. Markovits, P.S. (2023). Digitally Enabled Decission Making in Big Crop Farms: Inspiration for a Balanced Decision Making Metaphorical Model. *Proceedings of the International Conference on Business Excellence, 17(1),* 1240-1250. https://doi.org/10.2478/picbe-2023-0111
27. Munthali, E., Munthali, K., Mikeka, C., Kunyenje, G. (2022). Effectiveness of Using Digital Technologies and Digital Labour in Farm Management towards Shaping Precision Farming to Achieve Food Security: A Malawian Perspective. *Mediterranean Journal of Basic and Applied Sciences, 6(2),* 28-35. https://doi.org/10.46382/MJBAS.2022.6204
28. Munz, J., Gindele, N., Doluschitz, R. (2020). Exploring the characteristics and utilisation of Farm Management Information Systems (FMIS) in Germany. *Comput. Electron. Agric., 170*, 105246. https://doi.org/10.1016/j.compag.2020.105246
29. *Naukowcy z SGH opracowali Indeks Cyfryzacji Przedsiębiorstw (ICP).* Retrieved from: https://naukawpolsce.pl/aktualnosci/news%2C102722%2Cnaukowcy-z-sgh-opracowali-indeks-cyfryzacji-przedsiebiorstw-icp.html, 12.12.2025.
30. Navarro-Hellín, H., Martínez-del-Rincon, J., Domingo-Miguel, R., Soto-Valles, F., Torres-Sánchez, R. (2016). A decision support system for managing irrigation in agriculture. *Computers and Electronics in Agriculture, 124*, 121-131. https://doi.org/10.1016/j.compag.2016.04.003
31. Nestel, D., Cohen, Y., Shaked, B., Alchanatis, V., Nemny-Lavy, E., Miranda, M.A., Sciarretta, A., Papadopoulos, N.T., Nestel, D., Cohen, Y., Shaked, B., Alchanatis, V., Nemny-Lavy, E., Miranda, M.A., Sciarretta, A., Papadopoulos, N.T. (2019). An Integrated Decision Support System for Environmentally-Friendly Management of the Ethiopian Fruit Fly in Greenhouse Crops. *Agronomy, 9(8).* https://doi.org/10.3390/agronomy9080459
32. Nikkilä, R., Seilonen, I., Koskinen, K. (2010). Software architecture for farm management information systems in precision agriculture. *Computers and Electronics in Agriculture, Special issue on Information and Communication Technologies in Bio and Earth Sciences, 70(2)*, 328-336. https://doi.org/10.1016/j.compag.2009.08.013
33. Nurlaela, S., Bihrajihant Raya, A., Hariadi, S.S. (2022). Information Technology Utilization Of Young Educated Farmers In Agricultural Entrepreneurship. *Agro Ekonomi, 33(1),* 11. https://doi.org/10.22146/ae.64524
34. Olszańska, A., Szymańska, J. (eds.) (2014). *Agrobiznes 2014: Rozwój agrobiznesu w okresie 10 lat przynależności Polski do Unii Europejskiej*. Wydawnictwo Uniwersytetu Ekonomicznego.
35. *Rolnictwo precyzyjne w Polsce*. Retrieved from: https://www.pfpk.org.pl/wp-content/uploads/2023/11/Rolnictwo-Precyzyjne-w-Polsce-pl.pdf, 25.08.2021.
36. Ronzhin, A., Figurek, A., Surovtsev, V., Dibirova, K. (2025). Digital Transformation and Precision Farming as Catalysts of Rural Development. *Land, 14(7).* https://doi.org/10.3390/land14071464

37. Rooij, S.J.G. de. (2006). Young farmers in Europe: Opting for innovations. *LEISA India, 6(2)*, pp. 24-26. Retrieved from: https://edepot.wur.nl/33737, 5.12.2025.
38. Ropek, D. (2025). Ekonomiczne i społeczne uwarunkowania wdrażania Rolnictwa cyfrowego, precyzyjnego i systemów Wspomagania decyzji w gospodarstwach rolnych. In: *Ekonomia i zarządzanie – wybrane zagadnienia* (pp. 297-315). Homini.
39. Rupnik, R., Kukar, M., Vračar, P., Košir, D., Pevec, D., Bosnić, Z. (2019). AgroDSS: A decision support system for agriculture and farming. *Computers and Electronics in Agriculture, 161*, 260-271. https://doi.org/10.1016/j.compag.2018.04.001
40. Saiz-Rubio, V., Rovira-Más, F., Saiz-Rubio, V., Rovira-Más, F. (2020). From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management. *Agronomy, 10(2).* https://doi.org/10.3390/agronomy10020207
41. Sampurno, R., Seminar, K., Suharnoto, Y. (2014). Weed Control Decision Support System Based on Precision Agriculture Approach. *TELKOMNIKA (Telecommunication Computing Electronics and Control), 12,* 475. https://doi.org/10.12928/TELKOMNIKA.v12i2.1982
42. Santiago, A., Roxas, F. (2015). Reviving Farming Interest in the Philippines Through Agricultural Entrepreneurship Education. *Journal of Agriculture, Food Systems, and Community Development,* 1-13. https://doi.org/10.5304/jafscd.2015.054.016
43. *Software pentru managementul fermei Archives*. Retrieved from: https://nik-ro.com/agricultura-inteligenta/software-pentru-managementul-fermei/, 28.12.20125.
44. Solange, D. (2024). *SolangeD/GENMON [PHP]*. https://github.com/SolangeD/GENMON (Original work published 2016).
45. Thompson, S.C. (1976). Canfarm—A farm management information system. *Agricultural Administration, 3(3),* 181-192. https://doi.org/10.1016/0309-586X(76)90013-3
46. Trendov, N.M., Varas, S., Zeng, M. (2019). *Digital technologies in agriculture and rural areas: Status report.* Food and Agriculture Organization of the United Nations.
47. Tummers, J., Kassahun, A., Tekinerdogan, B. (2019). Obstacles and features of Farm Management Information Systems: A systematic literature review. *Computers and Electronics in Agriculture, 157,* 189-204. https://doi.org/10.1016/j.compag.2018.12.044
48. Tur, C.J., Ciaian, P., Antonioli, F., Fellmann, T., Rocciola, F., Ierardi, I., Crimeni, R., Anastasiou, E. (2025). *The state of digitalisation in EU agriculture.* JRC Publications Repository. https://doi.org/10.2760/4688498
49. Verleye, G., De Marez, L. (2005). Diffusion of innovations: Successful adoption needs more effective soft-DSS driven targeting. *Journal of Targeting, Measurement & Analysis for Marketing, 13(2)*, 140-155. (16002840). https://doi.org/10.1057/palgrave.jt.5740139
50. W br. 5,9 proc. przedsiębiorstw deklarowało wykorzystanie technologii AI. *Nauka w Polsce.* Retrieved from: https://naukawpolsce.pl/aktualnosci/news%2C105878%2Cgus-w-br-59-proc-przedsiebiorstw-deklarowalo-wykorzystanie-technologii-ai, 12.12.2025.
51. Wenkel, K.-O., Berg, M., Mirschel, W., Wieland, R., Nendel, C., Köstner, B. (2013). LandCaRe DSS – An interactive decision support system for climate change impact

assessment and the analysis of potential agricultural land use adaptation strategies. *Journal of Environmental Management, Integrated land-use and regional resource management – A cross-disciplinary dialogue on future perspectives for a sustainable development of regional resources, 127*, S168-S183. https://doi.org/10.1016/j.jenvman.2013.02.051

52. Wrzecińska, M., Czerniawska-Piątkowska, E., Kowalewska, I., Kowalczyk, A., Mylostyvyi, R., Stefaniak, W. (2023). Agriculture in the face of new digitization technologies. *Ukrainian Black Sea Region Agrarian Science, 3(27), Artykuł 27(3).* https://doi.org/10.56407/bs.agrarian/3.2023.09
53. *Zaawansowane Rozwiązania Zarządzania Stadem*. Retrieved from: https://www.afimilk.com/pl/, 23.12.2025.
54. Zhang, F., Zhang, W., Luo, X., Zhang, Z., Lu, Y., Wang, B., Zhang, F., Zhang, W., Luo, X., Zhang, Z., Lu, Y., Wang, B. (2022). Developing an IoT-Enabled Cloud Management Platform for Agricultural Machinery Equipped with Automatic Navigation Systems. *Agriculture, 12(2)*. https://doi.org/10.3390/agriculture12020310

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

RELATIONSHIPS IN THE INNOVATION ECOSYSTEM: THE PERSPECTIVE OF VC FUNDS

Artur RADZIO[1*], Eryk GŁODZIŃSKI[2], Anna Maria LIS[3]

[1] Warsaw University of Technology; artur.radzio.dokt@pw.edu.pl, ORCID: 0000-0002-5956-3276
[2] Warsaw University of Technology; eryk.glodzinski@pw.edu.pl, ORCID: 0000-0001-9327-6046
[3] Gdansk University of Technology; anna.lis@pg.edu.pl, ORCID: 0000-0002-1527-7796
* Correspondence author

Purpose: The paper focuses on the relationships that venture capital (VC) funds develop with other actors in the innovation ecosystem. The main objective of the paper is to identify the nature of these relationships in order to support development of management process.
Design/methodology/approach: Systematic literature review was used to recognize state of the art in the field of the functioning of VC funds within the innovation ecosystem. Web of Science and Scopus were selected to the search procedure. Quantitative and qualitative analysis of the selected publications was conducted.
Findings: Most of the publications deal with the bilateral relationships between VC funds and startups. The broader background of the VC funds relationships with other actors, such as business accelerators, incubators, clusters or bridging institutions, is overlooked. No publications were found that described good practices for managing VC relationships in innovation ecosystems.
Research limitations/implications: Analysis was limited to academic publications that follow the selected search criteria and were published in English. Further studies related to publications in other languages and indexed in another database of peer-reviewed academic literature are required.
Practical implications: There is a strong focus on the VC–startup relationship, but a little attention is paid to how VC funds collaborate with other crucial players in the innovation ecosystem. The nature of VC fund relationships is sensitive and variable. The intensity of the relationship may be reflected in the evolution of investment exits.
Social implications: By strengthening the relationship between VC and innovation ecosystem, the paper supports startup growth, enhances market competition and generates positive social and environmental impacts through more sustainable and innovative products.
Originality/value: The paper contributes to existing knowledge on innovation ecosystems, shedding more light on VC funds. It systematises the existing literature, which can support in identification of cognitive gaps and provide a basis for conducting application-oriented research. The issues described can serve as an inspiration for investment managers, business developers, founders of startups and researchers.
Keywords: Venture Capital, Ecosystem, Relationship, Startup, Systematic Literature Review.
Category of the paper: Research paper.

1. Introduction

Early-stage startups seek to raise capital in order to scale up, develop a profitable business model, establish infrastructure and hire skilled employees (Panda, Dash, 2016). Venture capital (VC) investment funds support startups, as they provide financial resources, but also increase the credibility of the venture subject (Fernández-Alles et al., 2014). Looking at the relationships and synergies of such actors, VC-backed startups are a key driver of innovation, job creation and economic growth (Vedula, Fitza, 2019). Appropriate relationship management enhances the survival and success of ventures by enabling access to critical partner resources (Shafi et al., 2020).

Both startups and the VC funds that support them operate in innovation ecosystems, in which R&D and educational institutions play a key role. In addition, there are many other actors in innovation ecosystems that perform other essential roles (Mikhailov et al., 2021). The innovation ecosystem generally consists of the government, which creates rules and regulations to support entrepreneurship, business angels, the venture capital sector and the financial market, which provides the necessary capital for startups and potential capital exits, and entrepreneurs, who build teams and implement business activities (Khyareh et al., 2019). Considering the broader innovation ecosystem, network connections with business incubators, accelerators, venture capitalists (VCs), business angels, consultants, intermediaries and government administration also take place within it (Brown et al., 2019).

VC creates alternative forms of funding, a new source of capital providers that focus on partnerships, and a process of building long-term relationships based on mutual trust and respect (McCahery, Vermeulen, 2016). Research shows that startups and companies benefit significantly from the right relationships with VC funds (Ragozzino, Blevins, 2021). Occasionally, cooperation involves conflict and can be difficult for each party (Lim, Cu, 2012). On the other hand, venture capital funds must simultaneously manage a number of relationships with investors, portfolio companies, potential acquirers and co-investors who often exert disparate influences on the investment activity and the management of the entity (Sethuram et al., 2021). Publicly-backed VC funds play a more important role in mobilising the regional innovation ecosystem through collaboration (Pierrakis, Saridakis, 2019). The cooperation and strong networking of VC funds puts them in a better position to benefit from their investments (Abell, Nisar, 2007).

While innovation ecosystems have been studied in depth in the literature, a few studies seem to describe these structures through the lens of VC funds and the relationships they establish with other entities. The main aim of this article is to identify the relevance and nature of the relationships that VC funds initiate and develop with other actors in the innovation ecosystem, such as: clusters, business environment institutions, startup accelerators, technology business incubators. In order to achieve such a goal, a systematic literature review was conducted to

systematise the existing literature in this area. The paper focuses on three main research questions:

RQ1: What is the state of the art on the subject of managing relationships between VC funds and other stakeholders in the innovation ecosystem?

RQ2: What are the main topics discussed by the researchers in terms of the functioning of and collaboration with VC funds in the innovation ecosystem?

RQ3: What is the nature of VC funds relationships within the innovation ecosystem?

The paper examines a collection of past research achievements over several decades in the area of managing relationships between venture capital funds and entities that co-create the innovation ecosystem. The conclusions of the review can be the basis for indicating directions for future research in the discussed area, as well as for formulating recommendations for the business sector, including for venture capital investment fund managers.

The article consists of four sections. The first presents a description of the research procedure applied, the second presents the results of the descriptive and thematic analysis. Further parts include a discussion and conclusions with a proposal for theoretical and practical contributions in relation to defining the role of VC funds and the relationship that exists between them and other actors in the innovation ecosystem.

2. Methods

There is a wide variety of procedures for diligently conducting a systematic literature review (SLR). Numerous literature reviews in management science are based on a narrative that often does not include a structured methodology (Briner, Denyer, 2012). Traditional reviews do not explain how the research papers were selected, nor the method of analysis for the formulation of the conclusions (Cronin et al., 2008). The key elements of systematic literature reviews are the orderly conduct of the review and the high level of transparency of the research steps (Jesson et al., 2011). The SLR procedure consists of four phases divided into seven stages (Czakon, 2011): Phase I - definition of the purpose of the study, Phase II - identification of the literature, Phase III - analytical activities, Phase IV - development of the study report. Locke et al. (Locke et al., 2013) distinguished three stages, namely: the issues motivating the problem addressed, the division into sub-themes, and the design of bibliographic references for each sub-theme. Creswell's (2017) recommended way of breaking down the stages comes down to a standardisation of activities starting with the identification of keywords and databases, followed by preliminary and detailed analyses, and ending with a description of the main topics and the impact of the work for the literature. This systematic literature review adopted the procedure, which consists of three core steps (Tranfield et al., 2003). The first is planning, followed by conducting the review, and the final stage - reporting. Considering the specificity

of the study, it was decided not to impose a time limit regarding the publications reviewed, due to the fact that both earlier and later studies could have significant value to the purpose of this article.

2.1. Review planning

According to the selected procedure for conducting a systematic literature review, the first step is planning. A visualisation of the selected systematic literature review process, including the details of each filtering phase, is presented (Figure 1).

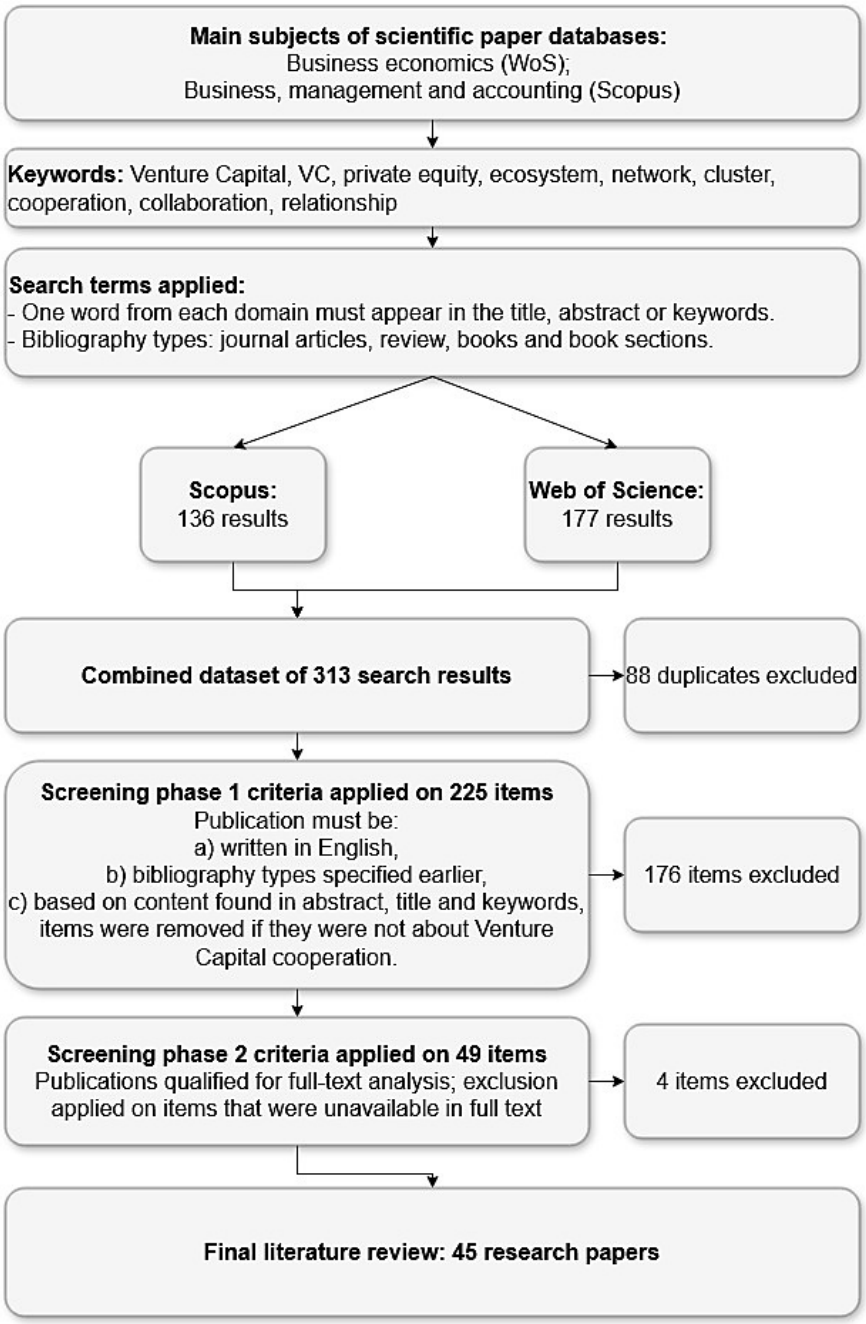


Figure 1. Flow diagram of systematic literature review process.

Source: Own elaboration.

At the beginning, a selection of the databases of research articles and an indication of the thematic areas in which filtering will take place was undertaken. This was guided by the criteria of the prestige and comprehensiveness of the databases (Guerrero-Bote, Moya-Anegón, 2012). Further conditions were applied to the selection in order to obtain the highest quality research sample. This type of action allowed a relatively large number of high-quality publications to be collected for in-depth analysis.

2.2. Conducting the review

The study used two databases of full-text scientific publications - Scopus and Web of Science (WoS). Scopus and Web of Science are widely recognized as the leading multidisciplinary citation databases for bibliometric research because they combine rigorous journal selection, high-quality metadata and reliable citation indexing. Although newer databases such as OpenAlex and Dimensions offer broader coverage, Scopus and Web of Science remain the most frequently used sources for research evaluation and systematic bibliometric analyses (Visser, Van Eck, Waltman, 2021).

It was assumed that the selected document types would be articles, review articles and book chapters, as they describe research that is up to date for the period of publication and are typically scientific. Papers from the areas of Business Economics for the WoS database and Business, Management and Accounting for the Scopus database were considered. The keywords used in the study were divided into three groups, using the logical conjunction ‘and’ between these groups:

1. “Venture Capital”, or “VC”, or “Private Equity”.
2. “Ecosystem”, or “Network”, or “Cluster”.
3. “Cooperation”, or “Collaboration”, or “Relationship”.

This was intended to be as broad as possible and to minimise the risk of publications being wrongly excluded, while keeping the theme of venture capital investment funds collaborating within the innovation ecosystem. The first group of words identified venture capital investment funds. The second group represents the cooperative aspect, i.e. the innovation ecosystem also referred to as a network and cluster for the purpose of the study. The last group of keywords is the link between the first two groups in the form of cooperation, extended to the term relationship. The application of the above filters identified 136 articles in the Scopus database and 177 articles in the WoS database (Figure 1). A total of 88 duplicate articles were identified, which helped to create a single collection of 225 documents. The mentioned results were generated as of February 11th, 2024.

Further research work was divided into two stages. Each was distinguished by criteria that resulted in the elimination of items that did not fulfil them. This was intended to generate a final article collection.

The first stage was based on the fact that the publication had to be in English and comply with the bibliography types specified earlier. The literature review was limited to English-language publications because the authors sought to review studies in their original language, thereby minimizing the risk of interpretation bias. Polish-language or other national-languages publications generally constitute a few of the records available in the databases included in the search. In addition, the content in the abstract, title and keywords had to match the concept of venture capital investment funds collaborating across the innovation ecosystem. This stage resulted in the exclusion of 176 papers, so 49 papers qualified for stage two. Narrowing the search to English emphasises the commonness of the materials and their general accessibility. The compliance with bibliography types specified earlier and the analysis of abstracts allows for the focus to be kept on the management of the relationships of venture capital (VC) investment funds with entities co-creating the innovation ecosystem (e.g.: clusters, business environment institutions, startup accelerators, technology business incubators). The analysis was driven by the fulfilment of criteria, such as: the need to address the topic of relationships and collaboration; alignment with the objectives of the article; and focus on the relationship between VC funds and innovation ecosystem actors.

In the second screening stage, 45 publications were selected for full analysis (4 articles were not fully accessed and were excluded).

2.3. Reporting

By carrying out a two-stage procedure to select the final 45 articles, a detailed descriptive and thematic analysis was initiated. The findings were mainly presented in the form of tables, supplemented by graphs. Tables 1 and 2 contain basic information about each identified article and a summary of the journals in which the papers were published. Moreover, Tables 3 and 4 provide details of the papers, referring to industry context and geographical distribution, as well as the methodology. Table 5 shows a grouping of keywords appearing in the review bibliography. The work carried out was the foundation for creating conclusions and directions for further research.

3. Results

3.1. Descriptive analysis

By analysing the increase in the number of articles on a particular topic, it is possible to understand the dynamics of the development of this area and also identify key trends and research directions. The conducted review revealed that the subject is not often addressed in the literature (Figure 2). Although the trend is increasing, the differences in the number of

publications between years are relatively small, which, combined with the intensive development of VC, indicates the existence of a considerable cognitive gap, and therefore an underestimation of the important role of the VC fund perspective in relationship management, and the need for a synthetic set of guidelines and recommendations for VC managers on the grounds of relationship management.

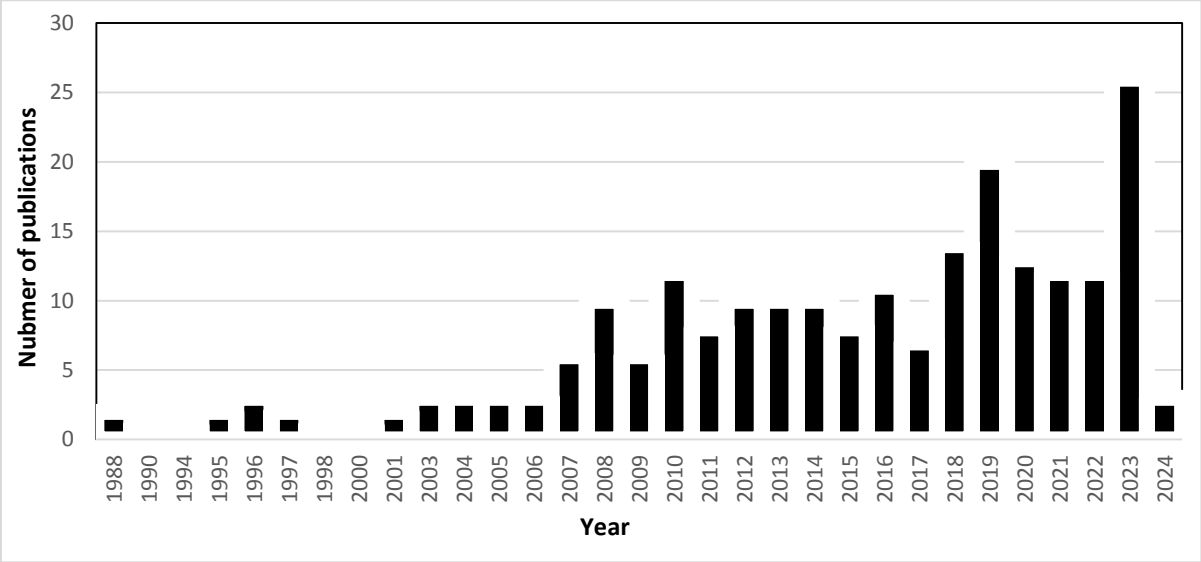


Figure 2. Yearly number of publications.

Source: Own elaboration.

The years with the highest number of publications related to the study topics (6, 8 and 6 articles, respectively) were 2019, 2020 and 2023. Only 4 articles were published in 2022 and just 1 in 2021. The lower research interest may have been due to the Covid-19 pandemic and the associated lower entrepreneurial and economic activity. The 6 papers from 2023 show that, despite the numbers from 2021 and 2022, venture capital investment fund cooperation is still of interest to researchers. It can be assessed that since 2019, research on VC fund collaboration within the innovation ecosystem has become more popular. In the other years, the number of publications did not exceed four per year. The low citation rate of the identified publications is also indicative of the low popularity of the subject (Table 1).

Table 1.
Measurements of publication citations.

	Author	Source of publication	Number of citations as of 11.02.2024
[1]	(Moazzez et al., 2020)	Journal of Science and Technology Policy Management	3
[2]	(Baaziz, 2019)	International Journal of Innovation	5
[3]	(Pierrakis, Saridakis, 2019)	Journal of Technology Transfer	27
[4]	(Wang et al., 2022)	Academy of Management Journal	17
[5]	(Goumagias, 2020)	NA (book chapter)	0
[6]	(Boutillier, 2020)	European Journal of Innovation Management	9
[7]	(Meng et al., 2023)	Journal of Innovation & Knowledge	1

[8]	(Brown et al., 2019)	Industrial Marketing Management	55
[9]	(Vedula, Fitza, 2019)	Strategy Science	34
[10]	(Trunina et al., 2020)	Chinese Management Studies	2
[11]	(Panda et al., 2020)	Industrial Marketing Management	12
[12]	(Müller, Wöhler, 2023)	Venture Capital	1
[13]	(Khyareh et al., 2019)	International Journal of Entrepreneurship	13
[14]	(Padilla-Meléndez et al., 2021)	Knowledge Management Research and Practice	9
[15]	(Shafi et al., 2020)	Academy of Management Journal	21
[16]	(Haider Alvi, Ulrich, 2023)	Journal of Business Research	2
[17]	(Zhang, Guler, 2020)	Administrative Science Quarterly	35
[18]	(Chen et al., 2024)	Technology Analysis and Strategic Management	0
[19]	(Hallen et al., 2020)	Academy of Management Annals	26
[20]	(Banal-Estañol et al., 2023)	Journal of Corporate Finance	0
[21]	(Mikhailov et al., 2021)	Innovation and Management Review	8
[22]	(Rydehell et al., 2019)	Journal of Technology Transfer	21
[23]	(Ragozzino, Blevins, 2021)	Long Range Planning	6
[24]	(Sethuram et al., 2021)	Global Strategy Journal	12
[25]	(Dushnitsky, Lavie, 2010)	Strategic Entrepreneurship Journal	85
[26]	(Tatum, 2007)	Research Technology Management	3
[27]	(Scheela, 2016)	Advances in International Management	3
[28]	(Maula et al., 2009)	Journal of Business Venturing	55
[29]	(Weber, Weber, 2007)	Journal of Engineering and Technology Management	93
[30]	(Weber, Weber, 2011)	Journal of Business Venturing	32
[31]	(Panda, Dash, 2016)	Journal of Small Business and Enterprise Development	30
[32]	(Pahnke et al., 2015)	Academy of Management Journal	131
[33]	(Strömsten, Waluszewski, 2012)	Journal of Business Research	52
[34]	(Lee et al., 2015)	Management Decision	15
[35]	(De Clercq, Dimov, 2008)	Journal of Management Studies	168
[36]	(Khanin et al., 2012)	Journal of International Entrepreneurship	5
[37]	(Fernández-Alles et al., 2014)	Journal of Technology Transfer	49
[38]	(Abell, Nisar, 2007)	Management Decision	32
[39]	(Markman et al., 2008)	Journal of Management Studies	253
[40]	(Lim, Cu, 2012)	Asia Pacific Journal of Management	13
[41]	(Leece et al., 2012)	International Journal of Entrepreneurial Behaviour and Research	9
[42]	(Høvig et al., 2012)	Southern African Journal of Entrepreneurship and Small Business Management	0
[43]	(Basole, Patel, 2018)	Service Science	32
[44]	(McCahery, Vermeulen, 2016)	Annals of Corporate Governance	11
[45]	(Yitshaki, 2008)	International Journal of Conflict Management	31

Source: Own elaboration.

The most cited article among the 45 selected was: "Research and technology commercialization" (Markman et al., 2008), published in 2008, which claims 253 citations (as of 11.02.2024) and 348 citations (as of 16.07.2026). The aforementioned paper focuses on organisational interactions involving universities and companies that result in the commercialisation of research and technology. The second highest citation score belongs to: "Internal Knowledge Development and External Knowledge Access in Venture Capital Investment Performance" (De Clercq, Dimov, 2008) with 168 (as of 11.02.2024) and 192 (as of 16.07.2026). In their article, De Clercq and Dimov examine the performance effects of two knowledge-driven strategies – internal knowledge development and external knowledge

access through inter-firm relationships – in the context of venture capital investing. When looking at Table 1, it can be assessed that older articles generate a higher number of citations. These are mainly those published between 2007 and 2010, 4 of the 5 most cited articles with more than 80 citations come from that period. From the point of view of the current state of knowledge, the issue of venture capital investment fund cooperation within the innovation ecosystem is not popular. Issues regarding the financial and economic domain of venture capital investment funds are much more widespread. In the context of business practice, the VC investment fund industry is in a dynamic phase of development, hence there is potential for managing this type of cooperation. An argument in favour of this state of affairs is the increased research interest in the subject area of venture capital funds.

Another concern of the descriptive analysis was to identify the journals in which the selected papers were published in the systematic literature review. The collection of these journals is highly diverse, and it is difficult to indicate a dominant journal (Table 2). The common denominator is the Business, Management and Accounting category (this was one of the selection criteria in the analysis): 44 of the 45 articles were published in a variety of management and business journals, with the exception of one that is focused on Arts and Humanities. Nevertheless, the mentioned paper focus on how group dynamics influence the growth of inter- organizational collaborations through the addition of new members, that is interesting form the point of understanding the described relationships. The highlighted case indicates that significant research findings are published not only in journals dedicated to business and management.

Table 2.
Citations index of journals

Journal name	No of articles	Journal subject area	H-index in SJR
Academy of Management Annals	1	Business, Management and Accounting	95
Academy of Management Journal	3	Business, Management and Accounting	358
Administrative Science Quarterly	1	Arts and Humanities; Social Sciences	201
Chinese Management Studies	1	Business, Management and Accounting	31
European Journal of Innovation Management	1	Business, Management and Accounting	74
Global Strategy Journal	1	Business, Management and Accounting	40
Industrial Marketing Management	2	Business, Management and Accounting	161
Innovation and Management Review	1	Business, Management and Accounting	11
International Journal of Entrepreneurship	1	Business, Management and Accounting; Economics, Econometrics and Finance	18
International Journal of Innovation	1	Business, Management and Accounting	no data available
Journal of Business Research	2	Business, Management and Accounting	236
Journal of Corporate Finance	1	Business, Management and Accounting; Economics, Econometrics and Finance	120
Journal of Innovation & Knowledge	1	Business, Management and Accounting; Economics, Econometrics and Finance	39
Journal of Science and Technology Policy Management	1	Business, Management and Accounting; Decision Sciences	24

Cont. table 2.

Journal of Technology Transfer	3	Business, Management and Accounting; Engineering	95
Knowledge Management Research and Practice	1	Business, Management and Accounting; Decision Sciences; Social Sciences	45
Long Range Planning	1	Business, Management and Accounting; Economics, Econometrics and Finance; Social Sciences	118
Strategy Science	1	Business, Management and Accounting; Decision Sciences	21
Technology Analysis and Strategic Management	1	Business, Management and Accounting; Decision Sciences	78
Venture Capital	1	Business, Management and Accounting; Economics, Econometrics and Finance	59
Strategic Entrepreneurship Journal	1	Business, Management and Accounting; Economics, Econometrics and Finance	61
Research Technology Management	1	Business, Management and Accounting; Engineering	77
Advances in International Management	1	Business, Management and Accounting	24
Journal of Business Venturing	2	Business, Management and Accounting	211
Journal of Engineering and Technology Management	1	Business, Management and Accounting; Decision Sciences; Engineering	71
Journal of Small Business and Enterprise Development	1	Business, Management and Accounting	80
Management Decision	2	Business, Management and Accounting; Decision Sciences	116
Journal of Management Studies	2	Business, Management and Accounting	206
Journal of International Entrepreneurship	1	Business, Management and Accounting	53
Asia Pacific Journal of Management	1	Business, Management and Accounting; Economics, Econometrics and Finance	89
International Journal of Entrepreneurial Behaviour and Research	1	Business, Management and Accounting	83
Southern African Journal of Entrepreneurship and Small Business Management	1	Business, Management and Accounting; Economics, Econometrics and Finance; Social Sciences	4
Service Science	1	Business, Management and Accounting; Decision Sciences; Mathematics	21
Annals of Corporate Governance	1	Business, Management and Accounting; Economics, Econometrics and Finance; Social Sciences	2
International Journal of Conflict Management	1	Business, Management and Accounting; Social Sciences	61

Source: Own elaboration.

The largest number of publications were in the Academy of Management Journal and the Journal of Technology Transfer (3 publications). 2 articles each were published in: Industrial Marketing Management, the Journal of Business Research, the Journal of Business Venturing, Management Decision and the Journal of Management Studies. The Academy of Management Journal deserves special mention as it has an H-index of 358 and is the definite leader compared to the others. The topics explored in the study are not very popular; however, publications appear in prestigious journals with a large audience. It is worth mentioning journals with a high H-index value such as the previously mentioned Academy of Management Journal (358 points), the Journal of Business Research (236 points), the Journal of Business Venturing (211 points),

the Journal of Management Studies (206 points), the Administrative Science Quarterly (201 points) and Industrial Marketing Management (161 points).

What is more, the articles analysed mostly referred to more than one industry, which is most likely due to the specific nature of venture capital investment funds operating in an ecosystem with other entities, often with different characteristics (Table 3).

Table 3.
Overview of the context, and geographical distribution.

	Context		**Geographical distribution**	
	Mono-industry	**Multi-industry**	**Single-country**	**Multi-country**
[1]	+	-	+	-
[2]	-	+	+	-
[3]	-	+	+	-
[4]	-	+	+	-
[5]	-	+	-	+
[6]	-	+	Non-specified	
[7]	-	+	Non-specified	
[8]	-	+	+	-
[9]	-	+	+	-
[10]	-	+	-	+
[11]	-	+	+	-
[12]	-	+	+	-
[13]	-	+	-	+
[14]	-	+	+	-
[15]	-	+	+	-
[16]	-	+	+	-
[17]	-	+	+	-
[18]	-	+	-	+
[19]	-	+	-	+
[20]	-	+	+	-
[21]	+	-	+	-
[22]	-	+	+	-
[23]	-	+	+	-
[24]	-	+	-	+
[25]	+	-	+	-
[26]	-	+	+	-
[27]	-	+	+	-
[28]	-	+	+	-
[29]	-	+	+	-
[30]	-	+	+	-
[31]	-	+	+	-
[32]	+	-	+	-
[33]	+	-	+	-
[34]	+	-	+	-
[35]	-	+	+	-
[36]	-	+	-	+
[37]	-	+	+	-
[38]	-	+	-	+
[39]	-	+	-	+
[40]	-	+	-	+
[41]	-	+	+	-
[42]	-	+	+	-
[43]	+	-	-	+
[44]	-	+	-	+
[45]	-	+	+	-

Source: Own elaboration.

The context of the selected papers refers to venture capital investment funds, the startups they fund, and innovation ecosystems in a broad sense. Mostly, the articles did not focus on the description of specific industries, hence the content of the publication often did not provide detailed information in this regard. In terms of geographical distribution, the most frequently mentioned countries were the United States (14 times), the United Kingdom (6 times) and Germany (3 times). The other researched countries were: Israel, China, India, Sweden, Iran, South Africa, Algeria, the Philippines, Spain, Canada, Singapore. The research carried out in 9 of the articles was conducted in multiple countries at the same time, which are not specified. This may indicate that the issues studied are global and international in scale. The geographical scope of the research, covering almost all continents, indicates that the subject matter has a global dimension.

In the context of the methodology applied, the most common research design was exploratory design, which applies to more than half of the articles (24) (Table 4).

Table 4.
Overview of the research design, approaches, context, and methods

	Research design	**Research approach**	**Data source**	**Data collection method**	**Data analysis**
[1]	E	Qual.	M	Documents, case study, interviews	Content analysis
[2]	E	Qual.	S	Documents, desk research	Content analysis
[3]	E	Quan.	M	Documents, desk research, questionnaire	Content analysis, regression analysis
[4]	E	Quan.	S	Documents, desk research	Content analysis, regression model, probit model
[5]	E	Qual.	S	Documents, desk research	Content analysis
[6]	D	Qual.	S	Documents, desk research	Content analysis
[7]	E	Qual. + Quan.	S	Documents, desk research	Content analysis, bionics research method
[8]	E	Qual.	M	Documents, interviews	Gioia methodology
[9]	CO	Quan.	S	Documents	Variance decomposition
[10]	E	Quan.	P	Survey	Logistic regression model
[11]	E	Qual.	P	Interviews	Inductive approach
[12]	E	Qual.	M	Interviews, archival data	Inductive approach
[13]	CA	Quan.	S	Documents, desk research	MIMIC model
[14]	E	Qual. + Quan.	M	Documents, interviews	Content analysis
[15]	CA	Quan.	S	Documents	Treatment effect models
[16]	CO	Qual.	S	Documents	Data analysis
[17]	CO	Qual.	M	Documents, interviews	Conditional logit regression
[18]	E	Qual.	M	Interviews, archival data, case study	Data analysis, case study
[19]	D	Qual.	S	Documents, desk research	Literature review
[20]	E	Quan.	S	Documents, desk research	Content analysis
[21]	E and D	Qual.	M	Documents, desk research, interviews	Content analysis
[22]	E	Quan.	P	Documents, questionnaire	Component, correlation and regression analysis
[23]	CA	Quan.	S	Documents, desk research	Statistical analysis
[24]	CA	Quan.	S	Documents, desk research	Negative binomial regressions

[25]	CA	Quan.	S	Documents, desk research	Negative binomial regressions
[26]	D	Qual.	S	Documents, desk research	Content analysis
[27]	E	Qual.	M	Case study	Content analysis
[28]	CA	Quan.	P	Survey	Regression analysis
[29]	CO	Qual. + Quan.	P	Interviews	Content analysis
[30]	E	Qual.	M	Case study	Content analysis
[31]	E	Qual.	M	Case study	Content analysis
[32]	CA	Quan.	M	Interviews	ZIP Poisson regression
[33]	E	Qual.	M	Case study, interviews	Content analysis
[34]	CA	Quan.	S	Documents, desk research	Negative binomial regressions
[35]	CA	Quan.	S	Documents, desk research	Ordered logit model
[36]	CA	Quan.	S	Documents, desk research	Ordinary least squares regression
[37]	CA	Quan.	M	Questionnaires	Binary logistic regression
[38]	E	Quan.	S	Documents, desk research	Content analysis
[39]	D	Qual.	S	Documents, desk research	Review
[40]	CA	Quan.	P	Questionnaires	Ordered logistic regression
[41]	E	Qual.	M	Case study, interviews	Content analysis
[42]	E	Qual.	P	Interviews, case study	Content analysis
[43]	E	Qual.	S	Documents, desk research	Content analysis
[44]	D	Qual.	S	Documents, desk research	Content analysis
[45]	E	Qual. + Quan.	P	Interviews, questionnaire	Content analysis

Note. Author's choice: CA – causal, CO – conceptual, D – descriptive, E – exploratory, N – narrative, Qualitative – Qual., Quantitative – Quan., Primary – P, Secondary – S, Mix – M.

Source: Own elaboration.

In 12 cases, the authors decided on a causal research design due to the verification of the hypotheses and the quantitative approach. Studies designed in a descriptive and conceptual way were less popular. Noting the research approach, the articles were diverse. 22 of them followed the qualitative approach, with 19 focusing on the quantitative approach. 4 studies were carried out using both approaches mentioned. The authors were most willing to use secondary data, which occurred in 22 cases. A mixed form combining primary and secondary data occurred in 15 publications. 8 articles were developed using primary data. Data collection methods also varied. Questionnaires were used to obtain primary data. Occasionally, authors chose to implement the case study method, which is extremely useful in qualitative research. The vast majority of articles were based on secondary data in the form of documents and archival data obtained through desk research. The most prominent method of data analysis was content analysis. Various statistical methods of data analysis were used for quantitative research, including negative binomial regressions, the inductive approach or logistic regression, among others.

3.2. Thematic analysis

This article proposes a thematic analysis focused around areas identified by keywords. The total number of keywords collected from all the selected articles was 211. They were systematised by means of the 4 main key categories and 1 additional (Table 5):

1. Management - the governance necessary for effective collaboration, development and investment delivery.
2. Ecosystem/Network - a set of key actors including VC funds, where collaboration between them takes place and specific relationships are established.

Table 5.
Grouping of keywords appearing in the review bibliography

Keyword groups	Occurrence	Keywords appearing in the review publications
Management	63	Case study, Collaboration challenges, Technological collaboration, Competitiveness, Coopetition, Quintuple Helix, Ambidextrous capabilities, Public policy, Regional development, Policy, Risk, Entrepreneur (2), Knowledge acquisition, Niche evolution, Entrepreneurship (8), Qualitative comparative analysis, Variance decomposition analysis, SME, Logistic model, B2B relationships, Decision making, Economic framework conditions, Entrepreneurial behaviour, Macroeconomic effects of entrepreneurship, Gem model, Knowledge spillover, Surrogate entrepreneurs, Tie discontinuation, Social capital (3), Longitudinal case study, Trends, Information economics, Multiple agency theory, Resource (3), Knowledge, Performance, Social liability, Knowledge transfer (2), Agency theory, Corporate governance, Organizational knowledge transfer, Knowledge diversity, Necessity entrepreneurship, Opportunity entrepreneurship, Value added, Small firm/new venture strategy, Entrepreneurialism, Transformation, Conflict resolution, Conflict.
Ecosystem/ Network	57	Network forming, Engineered collaboration network, Urbanized ecosystem, Entrepreneurial ecosystem (2), Algerian entrepreneurial ecosystem, Ecosystem's Value Chain, Networks (3), Strong and weak ties, Value symbiosis, Innovation ecosystem (2), Social networks (3), Business networks (2), Entrepreneurial networks, Regional entrepreneurial ecosystem, Network ties, Trust (2), Trust formation, Confidence, Entrepreneurial university ecosystems, Inter-organizational relationships, Reputation (2), Signaling theory, Entrepreneurial ecosystems, Incubators, Accelerators, Interorganizational relations, Syndicates, Network faultlines, Intermediaries, International innovation ecosystem, Institutions, Alliance, Network, Collaboration, Complementarities, Relationship risks, Relationship learning benefits, Relational fit, Social network dynamics, Confidence in partner cooperation, Social relations, Knowledge networks, Network density, Actors, Networking, Service ecosystem, Network analysis, Channel relationships.
Venture Capital	45	Venture capital (16), Unicorns, Financing, Banker, Corporate venture capital (5), Equity crowdfunding, VC-backed startup performance, University-focused venture capital firms, Entrepreneurial finance, Innovation finance, Venture capital firms, Founders, Individual investors, External financing, VC, IPO, Investment duration, Patient capital, Gazelles, Private equity, Corporate venture capital triad, Exit strategy, Post investment relationship, Investments, Investors, University funds.
Innovation	23	Intelligent specialization, Mutualized R&D, Innovation (3), Start-ups (3), Silicon Valley, Emerging markets (2), Innovation performance, New technology-based firms, Emerging economies, Commercialization of innovation, Technology-based new firms, Radical innovation, Developing countries, Academic spin-off (2), Spin-off development, Technology transfer, Commercialisation of research.
Other	23	Medical equipment, Useful blocks, Specialized blocks, Europe, Crisis, Agriculture, ICT, Agtech, Localization, Google, Search, Signaling, Foreignness, Institutional distance, Software, Speed, Disagreement and advice, United Kingdom, Biotech, South Africa, FinTech, Visualization, Israel.

Source: Own elaboration.

3. Venture Capital - the main focus of this literature review and the type of capital support offered by funds to startups.
4. Innovation - VC funds invest in and stimulate innovation, research and development.
5. Other - other keywords that could not be assigned to any other group.

The largest number of keywords (63) were assigned to the Management group. Articles mainly focused on entrepreneurship, economics, politics and collaborative management. Some researchers look at the importance of management in the context of startups and early entrepreneurs collaborating with VC funds (Shafi et al., 2020). This brings benefits in terms of the partner's financial resources but is fraught with risks that require efficient management. It can be found an analyse of venture capital (VC) management in innovation processes (Strömsten, Waluszewski, 2012), that shows how the management of venture capital investment funds affects startups and their innovative projects. In contrast, researchers examined the impact of knowledge management by VC funds based on two strategies - internal knowledge development and external access to knowledge through relationships between companies - in the context of venture capital investment (De Clercq, Dimov, 2008). The authors found that investing in industries where the fund has greater knowledge and networks improves investment performance. A startup that has received investment can expect more support from the fund. There is a discussion of the approach to managing cooperation in the ecosystem, which is determined by the source of capital (public or private) (Pierrakis, Saridakis, 2019). With public capital, VC funds show more experience in the way they manage cooperation. On the other hand, VC funds investing only private capital are more parsimonious in dealing with ecosystem partners. There is noted that conflict situations occur during stakeholder collaboration, hence conflict management, including conflicts of interest, is essential (Yitshaki, 2008). The main topic discussed in relation to the management, operation and cooperation of VC funds in the innovation ecosystem was their role as a funder of startups and provider of venture capital (Scheela, 2016). VC funds contribute to technology development within the innovation ecosystem and contribute to the commercialisation of research and the creation of innovations (Markman et al., 2008). The nature of VC fund relationships is sensitive and evolving as they have to pursue their investment goals and cooperate with different stakeholders (multi-stakeholder relationships) (Abell, Nisar, 2007). The intensity of the relationships may be reflected in the formation of the equity exit (Banal-Estañol et al., 2023). Venture capital funds play a key role in providing institutional and financial support to enable a startup to rapidly grow and become competitive (Scheela, 2016). Within this group, the most significant issue was reacted to the word management, which can take the form of relationship management, capital management, knowledge management; however, it all comes down to fulfilling the role of funding innovative ventures run by startups.

The Ecosystem/Network group had a lower keyword value of only 6, i.e. 57. In this group, keywords were related to various types of networks and ecosystems in the business, innovation and entrepreneurial dimension. Within this group the importance of understanding the

relationships between actors within a network or ecosystem, in particular the role of startups and venture capital funds contributing to the development of technology and entrepreneurship is highlighted (Wang et al., 2022). Researchers suggest a model for matching innovative companies with funding that is applicable to entrepreneurial ecosystems (Haider Alvi, Ulrich, 2023). They describe VC funds as a form of increasing funding opportunities for new entrepreneurs, thus stimulating projects, which helps to develop entrepreneurial ecosystems and increase their transnational significance. Researchers present the results of a study based on startups that have received crowdfunding (Brown et al., 2019). Networks and social capital play a key role in crowdfunding and VC investment. This type of funding provides startups with important relational benefits that offer "more than the funding itself". A venture capital fund is part of the innovation ecosystem and is seen as a provider of venture capital. In the ecosystem, it creates relationships with other actors through which it achieves its financial and non-financial goals, such as supporting technological development or the commercialisation of research.

The third largest group was Venture Capital (45), which was concerned with funding, investment funds, investments and capital. Using VC investments as an example, there are considered the interactions between actors in an interorganisational group, specifically focusing on relationships between VC funds (Zhang, Guler, 2020). Khanin et al. (2012) provide knowledge for venture capital funds on how to improve their performance by choosing the right strategy to enter new emerging markets. This is an opportunity for venture capital, but also a major risk due to various uncertainties, including instabilities of a regulatory nature. The following group describes the topics extracted related to relationships between VC funds, which can collaborate and make co-investments to generate more capital to support the startup.

The Innovation group differed significantly in terms of the number of keywords assigned when compared to the three previously mentioned groups. In terms of innovation, investigation of the effect of early relationships on innovation in companies from a competitive perspective is conducted (Pahnke et al., 2015). The authors concluded that indirect relationships with competitors hinder innovation, and that this effect is moderated by several factors related to insider disclosure. Other researchers describe the organisational interdependencies involving universities and companies that result in innovation and the commercialisation of research and new technologies (Markman et al., 2008). Innovation and commercialisation have their barriers at the individual, technological and organisational level, which emphasises their complexity.

The Other group contains thematic words that could not be assigned to one of the four previously identified groups - due to their nature and relevance, e.g. the location of the research or the industry to which the research related. They did not make it possible to isolate the topics discussed in relation to the functioning and cooperation of VC funds in the innovation ecosystem.

The thematic analysis using keywords indicated the importance of the ecosystem, which can provide valuable information regarding the significance and role that the ecosystem plays in the functioning of actors such as VC funds, startups, or scientific and research institutions. Of particular interest is networking, the study of connections and interactions between the different elements of the ecosystem. The creation of an ecosystem and its operation generates many challenges, which are caused by the cooperation of partners with different approaches, goals and capacities (Moazzez et al., 2020). Overcoming these barriers is possible with the trust of VC funds and startups in business organisations, clusters and science parks (the main places where innovations emerge) (Boutillier, 2020). On the other hand, the specific nature of the bond between VC and startup means that their mutual trust is limited and varies according to circumstances (startup performance, VC pressure, etc.) (Panda et al., 2020). Occasionally, this results in conflict, which is inherent in the relationship between VCs and entrepreneurs, as both parties have different concepts of the startup venture (Yitshaki, 2008). It is important to note that the relationship of VC funds within the innovation ecosystem is very sensitive, changeable and dependent on the particular situation and the other parties.

Quintuple Helix relationship-based innovation ecosystems certainly promote innovation and incorporate sustainable economic development (Baaziz, 2019). Educational and research institutions play a key role in developing new knowledge in the ecosystem. In turn, funding is important to enable startups to succeed (Mikhailov et al., 2021). Venture capital funds play a valuable role in providing the institutional and financial support that is lacking in developing economies and ecosystems to enable a startup to rapidly grow and become more competitive (Scheela, 2016). The research shows that groups of actors have their own specific tasks and objectives to fulfil within the network.

The intensity of collaboration depends on certain elements identified by the research. Publicly funded VC funds are more likely to establish relationships with other actors in the innovation ecosystem than those that do not use public funding (Pierrakis, Saridakis, 2019). Collaboration between VC funds affects the form of exit - intensive collaboration increases the chances of exit via acquisition; with less prior experience of collaboration, a funded startup is more likely to exit through an initial public offering (Wang et al., 2022). From the perspective of startups, developing relationships within the ecosystem and reputation can be essential to raising funding from a VC fund (Trunina et al., 2020). A startup with a stronger commitment to stakeholder relations may be more successful in obtaining investment from a VC fund.

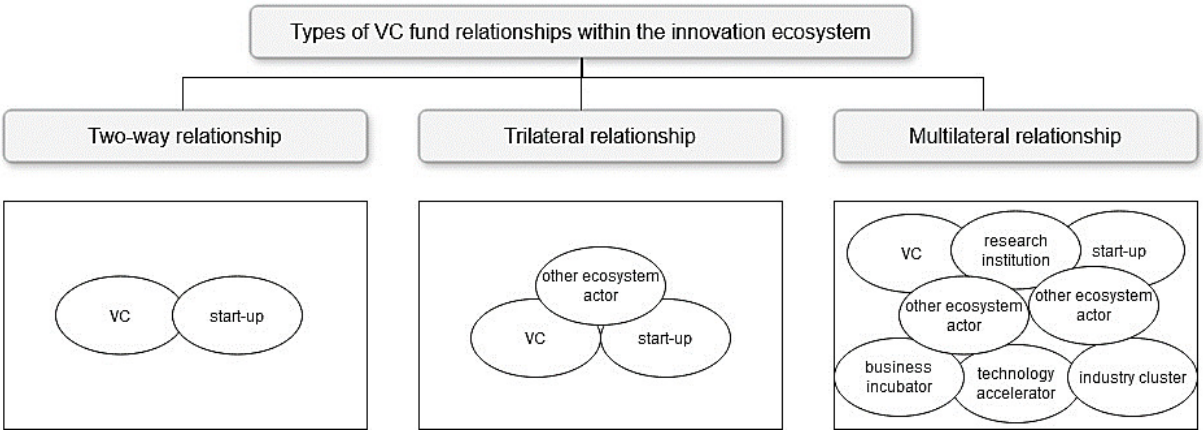


Figure 3. Types of VC fund relationships recognised in selected papers.

Source: Own elaboration.

When describing the innovation ecosystem, the following groups of relationships can be distinguished (Figure 3):

1. venture capital funds and startups (two-way relationship),
2. venture capital funds and startups and an additional actor, which can be, e.g. a university, or a large company (trilateral relationship),
3. an ecosystem in a horizontal sense (multilateral relationship).

The final category is ‘others’, which consists of aspects that could not be allocated to the four groups described above, due to their focus on a different type of cooperation. Some authors focus on corporate venture capital funds in their work (Dushnitsky, Lavie, 2010). Other researchers focus on the relationship between venture capital funds (Zhang, Guler, 2020). Both studies omit the perspective of the complex ecosystem.

The largest group by far is the two-way relationship involving venture capital funds and startups, described in 24 articles. Some authors planned to explore the inherent conflicts that exist between VC investors and startups (Shafi et al., 2020). Furthermore, some researchers propose solutions to prevent conflicts, such as the establishment of conflict management mechanisms and processes. Müller and Wöhler (2023) described the trust of VC funds in the team of originators forming a startup, which has a strong influence on investment decisions. The credibility of the originators is shaped by their working environment, reputation and the way they communicate during meetings. The perception of a person as credible creates trust and increases the willingness to make an investment.

A slightly larger scope is characterised by tripartite interaction, which can consist of a VC-startup fund relationship complemented by an actor in the form of a university (Padilla-Meléndez et al., 2021; Høvig et al., 2023). Twice as frequently (4 times), Numerous time the third party was a large company, due to the specificity of corporate venture capital funds. For instance, it is discussion about CVC's management of large enterprise investments from the startup's point of view (Maula et al., 2009).

The most capacious set is the ecosystem within which multi-stakeholder collaborations of various types take place. In 13 articles, research was conducted on ecosystems in which venture capital investment funds operate. Researchers provide the result of observing California's innovation ecosystem in the context of creating revolutionary innovations in agriculture (Mikhailov et al., 2021). There are examinations of interactions between VC investors and other actors in the innovation ecosystem, such as incubators, universities, research institutes and business support organisations (Pierrakis, Saridakis, 2019).

4. Discussion of the results

As a result of the systematic literature review, it can be concluded that the subject of managing venture capital investment fund collaboration within the innovation ecosystem has been a field of research for years; however, it has been addressed in a very limited thematic scope, mainly in the bilateral VC vs startup relationship. The continuous development of VC in ecosystems, as well as the high dynamics of changes in the relationship between VC and other ecosystem actors, requires further in-depth analysis. Although the analysed literature provides knowledge that is part of the problem of relationships in the innovation ecosystem, it does not exhaust the essence of the issue related to the creation and development of VC relationships within innovation ecosystems (Pierrakis, Saridakis, 2019). The publications analysed omit the perspective of VC funds in terms of their involvement in the innovation ecosystem and in supporting the building of a plan for the development of startups and entrepreneurs (Strömsten, Waluszewski, 2012). This is an important research gap that prevents an in-depth understanding of the issue addressed.

The conducted literature review indicates that further in-depth research is justified in the context of venture capital fund cooperation in the innovation ecosystem (Hallen et al., 2020). Areas worth exploring in the future relate in particular to taking a holistic but also detailed look at the functioning of VC funds in the innovation ecosystem, identifying and describing good practices in the management of venture capital fund relationships within ecosystems and how VCs achieve their goals.

Regarding the first proposed theme, most of the selected papers narrow their spectrum by basing their analyses and conclusions on bilateral VC fund and startup relationships. VC collaboration within the innovation ecosystem takes place in different parts of the world, so it should be deeply analysed and considered from different aspects, including geopolitical, cultural and economic. The selected papers focus on conflicts (Yitshaki, 2008), relationships (Panda et al., 2020), localization (Rydehell et al., 2019) and partnerships (Moazzez et al., 2020), as indicated in the thematic analysis. There are a few articles describing tripartite relationships (Padilla-Meléndez et al., 2021; Høvig et al., 2023) and they often marginalise the role of

VC funds. The papers examining ecosystems seem to be too general, given the collaborative management characteristics of venture capital investment funds. Entities such as business accelerators, incubators, clusters, and business environment institutions are very important from the point of view of investment activity, knowledge sharing and business development (Pierrakis, Saridakis, 2019). The findings confirmed that professionals operating within publicly-backed VC funds are more likely to interact with other players in the innovation ecosystem than professionals from VC investment funds using only private funding. Cooperation with them deserves more attention and detailed study, as they may prove to be one of the fundamental factors in the effectiveness of venture capital funds (Rydehell et al., 2019).

Concerning the second area, this article failed to identify good practices for managing VC relationships in innovation ecosystems. Neither was a synthetic set of guidelines and recommendations identified for VC investment fund managers in the field of relationship management with co-creators of the innovation ecosystem. This indicates the need to develop a relationship management architecture for VC funds, which could enable their effective and efficient cooperation with, among others, clusters, business environment institutions, business accelerators, and incubators (Fernández-Alles et al., 2014). An analysis of the key determinants of effective and efficient cooperation would allow for the identification of directions for the development of new investment funds in terms of building relationships in the innovation ecosystem. It seems that this, in the long term, would result in a higher level of funding for innovation development and support for implementation-oriented research and its commercialization (Markman et al., 2008). In conclusion, VC investment funds provide an important contribution to management and cooperation within ecosystems. This contribution develops innovation, which is an indispensable feature of such ecosystems.

The study also identified a third area worth exploring in more depth, which is how VCs achieve their objectives. Venture capital investment funds collect assets from investors and invest them in the most efficient way. These are the types of entities that are specifically targeted to achieve the expected ROI (Sethuram et al., 2021). In this case, it is an investment in a startup pursuing an innovative venture that will primarily respond to a market need, grow, be scalable and have a high impact. The above factors enable the startup to grow rapidly and thus enable the activation of a business opportunity in the form of a profitable equity exit capital (Scheela, 2016). Intensive collaboration within the innovation ecosystem can become a tool to build and support the objectives (Trunina et al., 2020). Taking into consideration the opportunities, impact and prospects connected with VC funding, this is an extremely up-to-date and promising topic.

5. Conclusions

This article uses the method of a systematic literature review to organise the available scientific knowledge in the area of the functioning of venture capital investment funds within the innovation ecosystem. The study shows that the issue of venture capital investment fund cooperation within the innovation ecosystem is not particularly popular; however, it is increasingly being addressed. The scale and impact of ventures financed and supported by VC funds indicate promising prospects, hence there is potential for managing this type of cooperation and a sense of the need to gather knowledge in this area. The main topics discussed in relation to the functioning and cooperation of VC funds in the innovation ecosystem were their role as funders of startups and providers of venture capital. VC funds contribute to the development of technology within the innovation ecosystem and contribute to the commercialisation of research and the creation of innovations. In addition, the collaboration that happens between VC funds taking the form of co-investments and syndicates is explored. The nature of VC fund relationships is sensitive and variable, as they have to pursue their investment goals related to economic efficiency and cooperate with different stakeholders (multi-stakeholder relationships). The intensity of the relationship may be reflected in the evolution of investment exits. The analysis of the literature indicated that venture capital funds play a key role in providing not only financial support, but should also support partners institutionally to enable the startup to grow rapidly and become more competitive.

The article may also have significant application value. This is because the main contribution of this paper is an in-depth analysis of the available knowledge on the topic of managing venture capital fund relationships with the major actors in the innovation ecosystem. The results of the work and research have important applications for science and business. The issues described can serve as an inspiration for a large group of actors, including investment fund managers, investment managers, business developers employed in entities creating an innovation ecosystem, originators and founders of startups. This study also has some limitations in the interpretation of the results obtained. First of all, only academic publications were taken into account within the framework of the study, thus non-academic sources of information such as: reports from the VC market, documentary studies of companies, economic analyses, etc. were omitted. These types of documents may contain data and information that are relevant to the issue under study. A second key limitation is the need to adhere to the rigour of a systematic literature review, including the search criteria adopted, which may have resulted in the omission of some valuable academic content. Moreover, only English-language publications were included in the analysis.

A valuable element of the article comprises suggestions of directions for future research on developing VC relationships within innovation ecosystems. This article proposes three main areas for research and additional analysis, although they are not exhaustive of all possible issues related to the subject under consideration.

References

1. Abell, P., Nisar, T.M. (2007). Performance effects of venture capital firm networks. *Management Decision, Vol. 45, Iss. 5*, pp. 923-936, doi: 10.1108/00251740710753729
2. Baaziz, A. (2019). Towards new paradigm of „coopetitiveness" in emerging countries: case of the algerian entrepreneurial ecosystems. *International Journal of Innovation*, *Vol. 7, Iss. 1,* pp. 67-86, doi: 10.5585/iji.v7i1.354
3. Banal-Estañol, A., Macho-Stadler, I., Nieto-Postigo, J., Pérez-Castrillo, D. (2023). Early individual stakeholders, first venture capital investment, and exit in the UK startup ecosystem. *Journal of Corporate Finance*, *Vol. 80,* doi: 10.1016/j.jcorpfin.2023.102420
4. Basole, R.C., Patel, S.S. (2018). Transformation through unbundling: Visualizing the global FinTech ecosystem. *Service Science*, *Vol. 10, Iss. 4*, pp. 379-396, doi: 10.1287/serv.2018.0210
5. Boutillier, S. (2020). The economics of the entrepreneur and the banker historical roots and contributions to the management of innovation. *European Journal of Innovation Management*, *Vol. 23, Iss. 2*, pp. 230-250, doi: 10.1108/EJIM-08-2018-0184
6. Briner, R.B., Denyer, D. (2012). Systematic review and evidence synthesis as a practice and scholarship tool. In: Rousseau, D.M. (Ed.), *Handbook of Evidence-Based Management: Companies, Classrooms and Research* (pp. 112-129). Oxford: Oxford University Press, doi:10.1093/oxfordhb/9780199763986.013.0007
7. Brown, R., Mawson, S., Rowe, A. (2019). Start-ups, entrepreneurial networks and equity crowdfunding: A processual perspective. *Industrial Marketing Management*, *Vol. 80*, pp. 115-125, doi: 10.1016/j.indmarman.2018.02.003
8. Chen, X., He, Z., Jiang, T., Xiang, G. (2024). From behind the scenes to the forefront: How do intermediaries lead the construction of international innovation ecosystems? *Technology Analysis and Strategic Management, Vol. 36. Iss. 10,* doi: 10.1080/09537325.2023.2182614
9. Cronin, P., Ryan, F., Coughlan, M. (2008). Undertaking a literature review: a step-by-step approach. *British Journal of Nursing*, *Vol. 17, Iss. 1*, pp. 38-43.
10. De Clercq, D., Dimov, D. (2008). Internal knowledge development and external knowledge access in venture capital investment performance. *Journal of Management Studies*, *Vol. 45, Iss. 3*, pp. 585-612, doi: 10.1111/j.1467-6486.2007.00747.x
11. Dushnitsky, G., Lavie, D. (2010). How alliance formation shapes corporate venture capital investment in the software industry: a resource-based perspective. *Strategic Entrepreneurship Journal*, *Vol. 4, Iss. 1*, pp. 22-48, doi: 10.1002/sej.81
12. Fernández-Alles, M., Camelo-Ordaz, C., Franco-Leal, N. (2014). Key resources and actors for the evolution of academic spin-offs. *Journal of Technology Transfer, Vol. 40, Iss. 6*, pp. 976-1002, doi: 10.1007/s10961-014-9387-2

13. Goumagias, N. (2020). The Internet of Things in Europe: In Search of Unicorns. In: The Internet of Things Entrepreneurial Ecosystems: Challenges and Opportunities. *Springer International Publishing*, pp. 31-55, doi:10.1007/978-3-030-47364-8_3
14. Haider Alvi, F., Ulrich, K. (2023). Innovation finance ecosystems for entrepreneurial firms: A conceptual model and research propositions. *Journal of Business Research*, *Vol. 156*, doi:10.1016/j.jbusres.2022.113450
15. Hallen, B., Davis, J., Murray, A. (2020). Entrepreneurial network evolution: explicating the structural localism and agentic network change distinction. *Academy of Management Annals*, *Vol. 14, Iss. 2*, pp. 1067-1102, doi:10.5465/annals.2018.0063
16. Høvig, Ø.S., Pettersen, I.B., Neethling, A.C., Paschal, B., Taxt, R.E. (2023). The role of investors in developing academic spin offs: The biotech sector in South Africa. *Southern African Journal of Entrepreneurship and Small Business Management*, *Vol. 15, Iss. 1*, doi:10.4102/SAJESBM.V15I1.738
17. Jesson, J., Lacey, F.M., Matheson, L. (2011). *Doing your literature review: Traditional and systematic techniques. Doing your literature review: Traditional and systematic techniques*. SAGE Publications.
18. Khanin, D., Ogilvie, K., Leibsohn, D. (2012). International entrepreneurship, venture capital networks, and reinvestment decisions. *Journal of International Entrepreneurship*, *Vol. 10, Iss. 1*, pp. 1-24, doi:10.1007/s10843-012-0085-6
19. Khyareh, M.M., Khairandish, M., Torabi, H. (2019). Macroeconomic effects of entrepreneurship: Evidences from factor, efficiency and innovation driven countries. *International Journal of Entrepreneurship*, *Vol. 23, Iss. 1*, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85065735527&partnerID=40&md5=00c4a4a846ab8ced6a0b41d1eb780ffd
20. Lee, S., Kim, T., Jang, S. (2015). Inter-organizational knowledge transfer through corporate venture capital investment. *Management Decision*, *Vol. 53, Iss. 7*, pp. 1601-1618, doi:10.1108/MD-12-2014-0668
21. Leece, D., Berry, T., Miao, J., Sweeting, R. (2012). The post-investment relationship between a venture capitalist and its investee companies. *International Journal of Entrepreneurial Behaviour and Research*, *Vol. 18, Iss. 5*, pp. 587-602, doi:10.1108/13552551211253946
22. Lim, K., Cu, B. (2012). The effects of social networks and contractual characteristics on the relationship between venture capitalists and entrepreneurs. *Asia Pacific Journal of Management*, *Vol. 29, Iss. 3*, pp. 573-596, doi:10.1007/s10490-010-9212-x
23. Markman, G.D., Siegel, D.S., Wright, M. (2008). Research and technology commercialization. *Journal of Management Studies*, *Vol. 45, Iss. 8*, pp. 1401-1423, doi:10.1111/j.1467-6486.2008.00803.x

24. Maula, M., Autio, E., Murray, G. (2009). Corporate venture capital and the balance of risks and rewards for portfolio companies. *Journal of Business Venturing*, *Vol. 24, Iss. 3*, pp. 274-286, doi:10.1016/j.jbusvent.2008.10.012
25. McCahery, J., Vermeulen, E. (2016). Venture Capital 2.0: From Venturing to Partnering. *Annals of Corporate Governance*, *Vol. 1, Iss. 2*, doi:10.1561/109.00000007
26. Meng, F., Tian, Y., Han, C., Band, S.S., Arya, V., Alhalabi, M. (2023). Study on Value Symbiosis and Niche Evolution of the Corporate Venture Capital Ecological Community for Innovation and Knowledge. *Journal of Innovation and Knowledge*, *Vol. 8, Iss. 3,* doi:10.1016/j.jik.2023.100363
27. Mikhailov, A., Oliveira, C., Padula, A.D., Reichert, F.M. (2021). Californian innovation ecosystem: Emergence of agtechs and the new wave of agriculture. *Innovation and Management Review*, *Vol. 18, Iss. 3*, pp. 292-307, doi:10.1108/INMR-12-2018-0098
28. Moazzez, H., Torabi Khargh, M., Nilforoushan, H., Sahebkar Khorasani, M. (2020). Challenges and barriers in finding, forming and performing for network creation: A case study of collaboration network in medical equipment. *Journal of Science and Technology Policy Management*, *Vol. 11, Iss. 4*, pp. 357-376, doi:10.1108/JSTPM-04-2019-0043
29. Müller, H., Wöhler, J. (2023). Married at first sight: The process of trust formation throughout the venture capital process during the time of the COVID-19 crisis. *Venture Capital*, *Vol. 25, Iss. 1*, pp. 1-29, doi:10.1080/13691066.2022.2139205
30. Padilla-Meléndez, A., Fuster, E., Lockett, N., del-Aguila-Obra, A.R. (2021). Knowledge spillovers, knowledge filters and entrepreneurial university ecosystems. Emerging role of University-focused venture capital firms. *Knowledge Management Research and Practice*, *Vol. 19, Iss. 1*, pp. 94-105, doi:10.1080/14778238.2020.1740626
31. Pahnke, E., Mcdonald, R., Wang, D., Hallen, B. (2015). Exposed: venture capital, competitor ties, and entrepreneurial innovation. *Academy of Management Journal*, *Vol. 58, Iss. 5*, pp. 1334-1360, doi:10.5465/amj.2012.0777
32. Panda, S., Dash, S. (2016). Exploring the venture capitalist – entrepreneur relationship: Evidence from India. *Journal of Small Business and Enterprise Development*, *Vol. 23, Iss. 1*, pp. 64-89, doi:10.1108/JSBED-05-2013-0071
33. Panda, S., Srivastava, S., Pandey, S.C. (2020). Nature and evolution of trust in business-to-business settings: Insights from VC-entrepreneur relationships. *Industrial Marketing Management*, *Vol. 91*, pp. 246-256, doi:10.1016/j.indmarman.2020.09.011
34. Pierrakis, Y., Saridakis, G. (2019). The role of venture capitalists in the regional innovation ecosystem: A comparison of networking patterns between private and publicly backed venture capital funds. *Journal of Technology Transfer*, *Vol. 44, Iss. 3,* pp. 850-873, doi:10.1007/s10961-017-9622-8
35. Ragozzino, R., Blevins, D. (2021). An investigation of the attention effects of venture capitalist backing on entrepreneurial firms. *Long Range Planning*, *Vol. 54, Iss. 3*, doi:10.1016/j.lrp.2020.101995

36. Rydehell, H., Isaksson, A., Löfsten, H. (2019). Business networks and localization effects for new Swedish technology-based firms' innovation performance. *Journal of Technology Transfer*, *Vol. 44, Iss. 5,* pp. 1547-1576, doi:10.1007/s10961-018-9668-2
37. Scheela, W. (2016). Born-global start-ups in emerging economies. *Advances in International Management*, *Vol. 29*, pp. 147-162, doi:10.1108/S1571-502720160000029010
38. Sethuram, S., Taussig, M., Gaur, A. (2021). A multiple agency view of venture capital investment duration: The roles of institutions, foreignness, and alliances. *Global Strategy Journal*, *Vol. 11, Iss. 4*, pp. 578-619, doi:10.1002/gsj.1402
39. Shafi, K., Mohammadi, A., Johan, S. (2020). Investment ties gone awry. *Academy of Management Journal*, *Vol. 63, Iss. 1,* pp. 295-327, doi:10.5465/amj.2017.0103
40. Strömsten, T., Waluszewski, A. (2012). Governance and resource interaction in networks. The role of venture capital in a biotech start-up. *Journal of Business Research*, *Vol. 65, Iss. 2*, pp. 232-244, doi:10.1016/j.jbusres.2010.11.030
41. Tatum, D. (2007). Innovating the development of innovation. *Research Technology Management*, *Vol. 50, Iss. 3,* pp. 15-18, doi:10.1080/08956308.2007.11657436
42. Tranfield, D., Denyer, D., Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *Vol. 14, Iss. 3*, pp. 207-222, doi:10.1111/1467-8551.00375
43. Trunina, A., Liu, X., Hafeez, M., Chen, J., Sarker, S.A. (2020). Network, reputation, VC-financing: SME in Zhongguancun and Silicon Valley. *Chinese Management Studies*, *Vol. 25, Iss. 3,* pp. 113-134, doi:10.1108/CMS-03-2019-0076
44. Vedula, S., Fitza, M. (2019). Regional recipes: A configurational analysis of the regional entrepreneurial ecosystem for U.S. venture capital-backed startups. *Strategy Science*, *Vol. 4, Iss. 1*, pp. 4-24, doi:10.1287/stsc.2019.0076
45. Visser, M., Van Eck, N.J., Waltman, L. (2021). Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative science studies*, *Vol. 2, Iss 1,* pp. 20-41, doi: 10.1162/qss_a_00112
46. Wang, D., Pahnke, E.C., Mcdonald, R.M. (2022). The past is prologue? Venture-capital syndicates' collaborative experience and start-up exits. *Academy of Management Journal*, *Vol. 65, Iss. 2,* pp. 371-402, doi:10.5465/amj.2019.1312
47. Weber, B., Weber, C. (2007). Corporate venture capital as a means of radical innovation: Relational fit, social capital, and knowledge transfer. *Journal of Engineering And Technology Management*, *Vol. 24, Iss. 1-2*, pp. 11-35, doi:10.1016/j.jengtecman. 2007.01.002
48. Weber, C., Weber, B. (2011). Exploring the antecedents of social liabilities in CVC triads-A dynamic social network perspective. *Journal of Business Venturing*, *Vol. 26, Iss. 2,* pp. 255-272, doi:10.1016/j.jbusvent.2009.07.004

49. Yitshaki, R. (2008). Venture capitalist-entrepreneur conflicts—An exploratory study of determinants and possible resolutions. *International Journal of Conflict Management*, *Vol. 19, Iss. 3*, pp. 262-292, doi:10.1108/10444060810875813
50. Zhang, L., Guler, I. (2020). How to Join the Club: Patterns of Embeddedness and the Addition of New Members to Interorganizational Collaborations. *Administrative Science Quarterly*, *Vol. 65, Iss. 1,* pp. 112-150, doi:10.1177/0001839219834011

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

ETHICAL STANDARDS AND AUDITOR-ENTREPRENEUR BUSINESS RELATIONSHIPS IN A FREE-MARKET CONTEXT

Katarzyna RENIK[1*], Łukasz BIELECKI[2]

[1] Uniwersytet Ekonomiczny w Katowicach; katarzyna.renik@uekat.pl, ORCID 0000-0002-1313-6594
[2] Uniwersytet Ekonomiczny w Katowicach; lukasz.bielecki@uekat.pl, ORCID 0000-0002-0940-0786
* Correspondence author

Purpose: The aim of this article is to identify the dilemmas associated with the auditor–client relationship in the context of the requirements arising from market economy principles and ethical standards.
Design/methodology/approach: The study employed a qualitative approach, including a content analysis of the literature, an analysis of legal regulations, and semi-structured interviews with statutory auditors and business owners (entrepreneurs).
Findings: The results indicate significant discrepancies in perceptions of business relationships. Entrepreneurs emphasize the high value of building business relationships and view them as the foundation of cooperation, whereas statutory auditors are wary of establishing relationships with audited entities, perceiving them as a potential threat to their independence. In professional practice, a problem has been identified whereby auditors operate as market entities expected to build relationships, while simultaneously being subject to regulations that limit their development.
Research limitations/implications: Research was conducted in Poland among a small group of auditors and entrepreneurs. Future investigations require a representative sample of respondents to fulfill the empirical approach and fully address the research gap.
Practical implications: The results suggest a need to clarify the boundaries of permissible conduct in business relations between auditors and clients, and to develop solutions that reconcile ethical requirements with the realities of operating in Poland‘s competitive audit services market.
Originality/value: The article discusses the current challenges auditors face in adapting to and complying with strict ethical and independence requirements while navigating Poland‘s changing economy and growing competition in the audit services market.
Keywords: financial audit, relationship-based sales, business relationships, regulations, incentives.
Category of the paper: Qualitative research.

1. Introduction

Today, there is a serious tension between building business relationships and maintaining the professional independence of a statutory auditor operating as a business entity in the audit services market.

On the one hand, the principles of a free-market economy and relationship marketing concepts highlight the importance of long-term relationships, trust, and cooperation with clients as key factors in a company‘s success. Auditors in Poland often face difficulties reconciling the regulator’s requirements with operating in a competitive audit services market, just like any other business, from an economic perspective, where revenues must exceed costs (Bielecki, 2017).

On the other hand, the regulator, through regulations and guidelines, tightens the framework governing the practice of the statutory auditor profession. Legal regulations, including the Act on Statutory Auditors and Audit Firms (hereinafter UoBR) and the International Code of Ethics for Professional Accountants: Including International Independence Standards (hereinafter Code of Ethics), impose on the statutory auditor the obligation to maintain independence and to limit relationships that could pose ethical threats.

The combination of these two perspectives can create dilemmas not only regarding the provision of various services by a statutory auditor but also in client relationships. In this case, the auditor may fear insufficient engagements to ensure the firm’s survival and growth in the market, while simultaneously failing to maintain independence. As indicated by a systematic review of the literature on the professional ethics of auditors, it is precisely the principle of objectivity (independence) that constitutes the area where the most ethical dilemmas arise (Renik, 2023).

Furthermore, the literature explores the ethical dilemmas arising from the conflict between professional independence and auditors‘ own economic interests. Authors highlight that auditors need to balance ethical requirements and institutional safeguards and strengthen professional awareness of ethical conflicts to reduce threats to independence (Bielecki, Renik, 2026).

On this basis, it can be concluded that a research problem has been identified: auditors operate as market entities expected to build relationships while simultaneously meeting ethical requirements, particularly regarding independence, which may limit their professional development. Furthermore, the issue of business relationships in the operations of audit firms in Poland has not been sufficiently researched and remains a subject of debate among scholars and practitioners, indicating a gap in this area.

The aim of this study is therefore to identify the dilemmas faced by statutory auditors regarding their relationships with audited entities from the perspective of legal regulations and market economy principles.

In this regard, the following research questions were formulated:

RQ1: What principles apply to statutory auditors, and what rules apply to entrepreneurs in a free-market economy?

RQ2: What dilemmas and challenges do statutory auditors currently face in their business relationships with clients?

To provide the answers to the research questions, content analysis of current literature and analysis of auditors' ethical standards have been applied. The first question is covered by the theoretical background based on the previous literature review and standards, the second by the semi-structured interviews with auditors and entrepreneurs.

The paper is structured as follows. The first section introduces. Section 2 presents the study's methodology. In contrast, Section 3 discusses the findings. Section 4 concludes the study, outlines potential future research directions, and presents limitations.

2. Methods

The profession of a statutory auditor is subject to numerous legal regulations; however, beyond a theoretical framework, it requires, above all, a practical approach. The complexity of the dilemmas faced by statutory auditors regarding the business relationships between audit firms and their clients calls for an in-depth examination from a broader perspective. For this reason, this study employed data and research method triangulation (van der Waldt, 2026; Kubinowski, 2010). The research methodology, consisting of content analysis of the current literature, analysis of standards and legal acts, and semi-structured interviews, is presented in Figure 1.

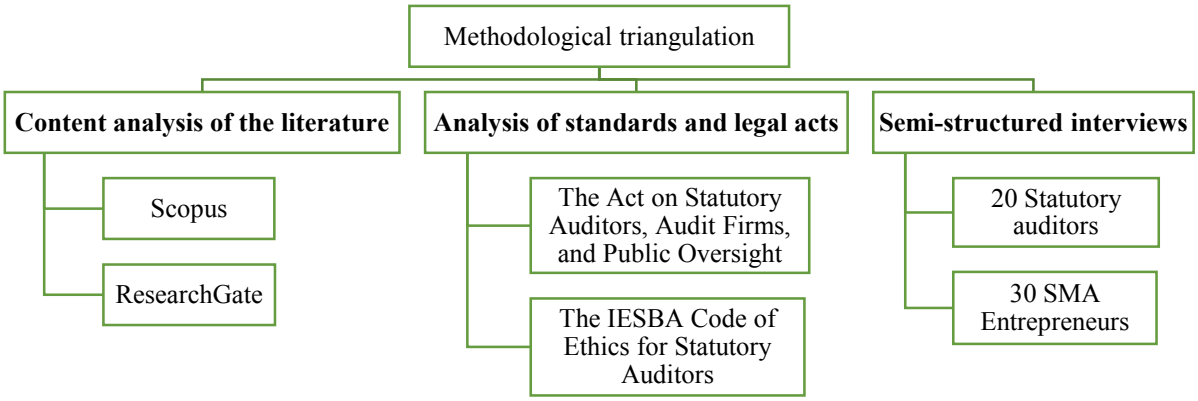


Figure 1. Research methods.

Source: Original work.

Methodological triangulation is based on the integration of multiple methods to provide interpretive depth, validity, and reliability within a single research design (van der Waldt, 2026). The use of the above methods allows for a multidimensional approach to the research problem and a comparison of theoretical legal requirements with the real-world dilemmas of business practice

A scoping review was conducted to analyze the existing body of research and determine the role of auditor independence in building business relationships (Munn et al., 2018). The content analysis was based on Polish- and English-language literature concerning statutory auditors practicing in Poland and business relationships in a free-market economy. The Scopus and ResearchGate databases were used to carry out this stage. Scopus and ResearchGate were selected for their extensive coverage of peer-reviewed publications in accounting and management, providing a comprehensive overview of the latest domestic and international literature. The review allowed us to highlight the identified research gap and present the research problem based on available publications.

An analysis of legal acts was conducted to understand the mandatory restrictions and standards that auditors must comply with. For the analysis of legal acts, the following were taken into account:

- The Act on Statutory Auditors, Audit Firms, and Public Oversight,
- The IESBA Code of Ethics for Statutory Auditors.

The study consists of semi-structured interviews (Quraishi, 2025), conducted with both audit firms (statutory auditors and firm employees) and commercial entities (audited companies) to provide a broader perspective on relationship-building issues.

In the semi-structured interviews, 20 statutory auditors were surveyed: 4 CEOs of audit firms, 3 members of audit firm boards, 1 director at an audit firm, and 12 employees of micro and small Polish audit firms.

Further interviews were conducted with 30 entrepreneurs from small- or medium-sized firms in which the vast majority of the capital was Polish, and there was no separation of roles between the owner and the CEO. The entrepreneurs surveyed operated various types of businesses across different industries, but all were subject to financial statement audits. The interviews were conducted before, after, or during the signing of the contract.

Purposive sampling was used to select respondents for the interviews (Palinkas, 2015; Dudovskiy, 2026). Statutory auditors who run their own firms or are employees of auditing firms with at least 5 years of experience, and senior managers from the SME sector were selected to capture a diverse perspective on the tension at the intersection of ethics and the market.

All interviews were conducted between 2019 and 2024, prior to the audit season and the financial statement audit, i.e., between September and December of each year. Interviews with participants lasted at least 30-40 minutes. Additionally, business owners had to have been audited by a statutory auditor or be considering working with one.

Next, the legal standards applicable to statutory auditors were analyzed, and the interview results were compared with regulations governing the auditor‘s relationship with the client, remuneration, long-term cooperation, and the provision of other services by the statutory auditor to the client.

These research methods will allow for an in-depth analysis of the research problem from the perspective of professional practice. Furthermore, comparing real-world examples from statutory auditors with the literature and legal statutes will highlight potential implications for practice and identify potential research directions for scholars.

3. Results and discussion

3.1. Literature Review

In the current climate, amid the rapid growth of the digital services market, influencers and large corporations investing in brand-building and promoting brand ambassadors, small businesses struggling to find their footing in the market deserve special attention. There is an ongoing search for low-cost, optimal, and effective methods of market development through the acquisition of target customers. One of the most important tasks is identifying and developing potential contacts, as well as providing after-sales service and building relationships.

Currently, a recommendation from someone known to the potential customer is becoming the preferred method for acquiring orders. A genuine and sincere recommendation, compared to ordinary marketing, is (Dutko, 2021, p. 428):

- more effective, because the recommender is not a salesperson but another customer,
- simpler, because collecting recommendations from satisfied customers is easier than building campaigns based on algorithms,
- faster, as the path from online positioning to a “lead” is very long,
- requires time investment solely from the entrepreneur,
- ethical, as it is based on genuine experience,
- non-intrusive—a relationship based on building trust and fulfilling needs, rather than pressuring the customer to buy.

It is worth noting, however, that even the relational nature of entrepreneurs, from a credibility perspective, has its limits. Lewandowska (2020) highlighted this when considering the impact of family relationships on decision-making, concluding that these strong relationships can sometimes distort the logical decision-making process.

International research clearly points to the direction businesses should take to sustain and grow their companies from an economic perspective related to customer ties. The need to understand and adapt to customer needs, achieved through relationship-building, was already highlighted in the last century by Drucker (1974), Levitt (1984), and Kotler (1980).

In Polish literature as well, since the turn of 1989, the need to maintain customer relationships has been emphasized. A company‘s functional relationship is achieved through the constant mutual adjustment between the organization and its environment (Koźmiński, Obłój, 1989). From a Polish perspective, Wadlewski (2024) also highlights the absolute necessity of building relationships, stating that “within the classical approach, the priority was to acquire as many new customers as possible, and all attempts to maintain their loyalty were limited mainly to implementing loyalty reward systems and offering discounts”. Modern marketing concepts, on the other hand, place particular emphasis on building lasting relationships with customers, highlighting the importance of a deep understanding of their needs in order to foster a sense of satisfaction among them”.

Contemporary challenges in the development of new communication channels are shaped by tools such as Facebook, Instagram, TikTok, X (Twitter), LinkedIn, and visual reinforcement via YouTube; however, the essence and focus remain rooted in the need to build relationships (Górka et al., 2024). Some authors even argue that the primary task of corporate sales departments is to build customer relationships (Busławski, Okipna, 2024). Others point out that one of the most common mistakes companies make is dehumanizing processes, including marketing and sales processes, noting that “regardless of whether it is B2B marketing or consumer marketing, nowadays everything should be about P2P (person-to-person) marketing: relationships between people, between human beings (people-to-people), or human-to-human marketing” (Rajamannar, 2024).

It is also worth considering an approach to customer segmentation, as companies may provide services or products to individual customers in such large numbers that building relationships is impossible. However, in such cases, it is advisable to identify and nurture personal connections with key customers, those whose transaction volume is significant to the seller (van Weele, 2018).

Furthermore, relationship building is not merely a one-sided process—that is, the responsibility of the product supplier. Equally important is the perspective focused on fostering long-term relationships with the supplier base, particularly key suppliers. This approach enables entities to adapt to changing competitive conditions (Warner, 2005). The importance of the ability to build trust for effective business management, and the conditions that determine its state, are the subject of empirical research by Latusek-Jurczak (2019), which is based on the assumption that trust is a key resource for business success.

Consequently, the goal from both the supplier ‘s and the customer ‘s perspectives is to foster partnership-based relationships. “This requires mutual commitment and trust, as well as an understanding of the factors influencing the behavior of all parties involved, and the forms of cooperation necessary to achieve success” (Dobiegała-Korona, Herman, 2006).

3.2. Analysis of Legal Standards

The primary legal act governing statutory auditors is Ustawa z dnia 11 maja 2017 r. o biegłych rewidentach, firmach audytorskich oraz nadzorze publicznym [the Act of May 11, 2017, on Statutory Auditors, Audit Firms, and Public Oversight], hereinafter referred to as the “UoBR”. When performing assurance engagements, i.e., audits of financial statements, statutory auditor practice their profession on behalf of an audit firm (Article 3.3, UoBR) “as:

- a natural person conducting business activity in their own name and on their own account […],
- a partner in an audit firm […],
- a natural person in an employment relationship with an audit firm […],
- a natural person, including a person conducting business activity […], who has entered into a civil law contract with an audit firm” (Article 3.2 UoBR).

Consequently, a statutory auditor is closely associated with the audit firm in which he or she is an employee, owner, or partner. Regardless of the type of activity they choose, regulators have established standards and regulations requiring statutory auditors to adhere to ethical principles to safeguard against fraud, manipulation, or conflicts of interest that could lead to a loss of credibility for the statutory auditor’s institution. Pursuant to Article 69 (UoBR), a statutory auditor:

- “maintains integrity, objectivity, professional skepticism, and due diligence,
- possesses appropriate professional competence,
- maintains professional secrecy”.

In addition, statutory auditors are bound by the IESBA Code of Ethics (International Code of Ethics for Professional Accountants, 2022), specifically Sections 4A and 4B.

This Code specifically identifies relationships that preclude an auditor from engaging with a client, as such relationships could compromise the auditor‘s independence. These conditions primarily concern economic and financial ties, family ties, partnerships, and other close relationships of the auditor or a member of the audit team, as well as issues related to fees for services and client incentives.

Section 520 states that “a close business relationship with the audit client or its management may create a threat of self-interest or intimidation” (par. 520.2 Code of Ethics). Therefore, the following must be excluded:

- any business relationship with the firm, a firm within the network, a member of the audit team, or their immediate family,
- holding joint ownership interests in an entity with a concentrated ownership structure,
- purchases of products or services from the audited entity that, by their nature and volume, create a threat of self-interest.

Family and personal relationships may also threaten independence through self-interest, undue familiarity, or intimidation (par. 521.2 Code of Ethics). If family or personal relationships could influence the audit results, the auditor or any member of the audit team with contact with immediate family, close family, or other close relationships must be excluded from the audit engagement. This exclusion also applies when the firm‘s partners or employees are aware of such relationships. Factors relevant in this case when assessing the level of threat of self-interest, familiarity, or intimidation arising from such a relationship “include:

- the nature of the relationship between such a person and a member of the engagement team,
- the position held by the person within the client‘s organization,
- the role of the engagement team member (521.7 A1 Code of Ethics).

To avoid the risk of excessive familiarity, the member of the engagement team should be removed, and if this directly concerns the auditor, the auditor must decide not to conduct the audit of the entity in question.

An analysis of the subsequent paragraphs leads to the conclusion that a different relationship exists. What entrepreneurs aim for in their activities, namely, building the closest possible relationships with other entrepreneurs, is interpreted as a threat and as an action not recommended. When assessing the level of threats to objectivity in paragraph 325.7 A1, the auditor should take into account, among other things:

- “the individual‘s role and seniority within the organization,
- the nature of the individual‘s relationship with others involved in the engagement,
- the length of time the individual was previously involved in the engagement and the role they performed,
- when the individual was last involved in the engagement prior to being appointed as the engagement quality control reviewer, and any subsequent significant changes in the circumstances of the engagement,
- the nature and complexity of the issues that required the individual to make significant subjective judgments during their prior involvement in the engagement”.

Accordingly, a network firm or a member of the engagement team may not have a close business relationship with the audit client or its management, unless the financial interest is immaterial and the business relationship is insignificant to the client or its management and, respectively, to the firm, the network firm, or the member of the engagement team (par. 520.4 Code of Ethics).

Another risk is the duration of the service relationship between the audit firm and the company whose financial statements are being audited. According to market principles, the longer the relationship between business partners, the better. In the case of a statutory auditor, the need for rotation due to the possibility of excessive familiarity is indicated, among other things, by Article 134 (UoBR) and par. 540.2 (Code of Ethics).

A statutory auditor must therefore meet a number of stringent requirements, both domestic and international, regarding the practice of a profession of public trust, while simultaneously conducting the commercial activities of a firm whose revenue is derived from fees paid by the audited entity for conducting audits and attesting to sustainability reporting, which are received by the audit firm, the statutory auditor, and subcontractors.

Pursuant to Article 80 UoBR, remuneration "shall not be:

- contingent upon any conditions, including the outcome of the audit or attestation of sustainability reporting,
- determined or contingent upon the provision of additional services, other than the audit or attestation of the sustainability report, to the entity subject to the audit or attestation of the sustainability report or to its related entities by the audit firm or any entity related to the audit firm or belonging to the network".

This is another example of a regulation intended to minimize bias and promote the integrity and independence of the auditor. However, even in the general provisions regarding fees, the Code of Ethics states that "fees for professional services are usually negotiated with and paid by the audit client, which may create threats to independence" (par. 410.3 A1 Code of Ethics). Furthermore, "when fees are negotiated with and paid by the audit client, this creates a self-interest threat and may create an independence threat arising from intimidation" (par. 410.4 A1 Code of Ethics).

However, it states that the agreed-upon fee "is a business decision made by the firm, taking into account the facts and circumstances of the engagement, including the requirements of technical and professional standards (410.5 A1 Code of Ethics)". Additionally, the Act on Statutory auditors states that the remuneration agreed upon in the contract should reflect the labor intensity, the degree of complexity of the work, and the required qualifications (Article 80 UoBR).

Another issue worth addressing regarding the auditor's independence is the auditor holding various positions and performing other activities for the client. In addition to assurance services, a statutory auditor may perform many other non-assurance services, such as accounting, administrative, legal, tax, support, recruitment, IT, finance, or internal audit services (par. 600 Code of Ethics).

However, there are numerous prohibitions and exclusions under which a statutory auditor may not enter into a business relationship with a client, e.g., when providing advice and issuing recommendations (par. 600.11 A1) or assuming management responsibilities while performing an internal audit service (par. 605) may create a self-review threat. Similarly, it is prohibited

for a partner or employee of the firm to serve as a member of the board of directors or senior management at the client‘s entity for an assurance engagement when such a role creates threats of self-review and self-interest (par. 523.2, par. 523.3, par. 923.2, and par. 923.3 Code of Ethics).

Therefore, it is important for a firm, or a firm within a network that provides multiple non-attestation services to an audit client, to consider whether, in addition to the threats posed by each service individually, the cumulative effect of these services creates or exacerbates threats to independence (par. R600.12).

3.3. Semi-structured interviews

Examining a statutory auditor’s business relationships from the perspectives of both the audit firm and the business owner, in the context of the code of ethics and the principles of a free-market economy, can pose dilemmas for statutory auditors when establishing such relationships. Accordingly, the opinions gathered during interviews with both groups of respondents, statutory auditors and entrepreneurs, were analyzed and then compiled in the summary Table 1.

Table 1.
An Analysis of Dilemmas in Business Relationships from the Perspective of an Audit Firm and a Commercial Firm

Subject of the analysis	Audit firm‘s perspective	Commercial firm‘s perspective
The relationship between the client and the team member conducting the audit	The more distant the relationship with the client, the higher the level of risk for those providing the service. This often leads to the decision not to accept the job.	A commercial company‘s perspective. The closer the relationship, the higher the level of cooperation and the greater the chances of successfully completing projects. This usually results in signing a contract with the client.
The position held by a member of the audit team at the client‘s company	The lower the position of the person with whom representatives of the audit firm have a relationship, the greater the security for those providing the service.	The higher the position, the greater the opportunity to develop the partnership and the faster the decision-making process for executing the engagement.
Remuneration previously received or currently being received from entities affiliated with the client	The fewer such dependencies there are, the lower the risk and the greater the security for those providing the service.	The more connections you have, the higher the likelihood of establishing, maintaining, and developing a relationship with a client.
The ability of an audit firm or its affiliates to provide additional services to a client	This poses a significant risk to the ability to conduct an independent audit of the financial statements. A highly undesirable outcome.	This is definitely desirable for both parties, as it leads to broader partnership-based cooperation in which both companies or corporate groups strive for mutual growth.

Source: Original work based on semi-structured interviews and the IESBA International Code of Ethics (2022).

The table above presents examples of threats to an auditor’s independence related to the issues discussed in the section on the analysis of legal standards. These threats are contrasted with opportunities for commercial firms.

A review of the literature and interviews with entrepreneurs (commercial firms) clearly indicate that collaborations built on relationships and trust lead to growth and are desirable. At the same time, audit firms burdened by restrictive regulations rooted in mistrust and suspicion are a rarity in the market.

For cooperation between entrepreneurs to occur, it requires the recognition of short-term or long-term benefits, which often arise during negotiations as so-called "incentives", which the code of ethics "considers to improperly influence a person 's behavior if it causes that person to act unethically". Such undue influence may be directed both at the recipient and at another person who has a relationship with the recipient" (par. 340.9 Code of Ethics).

Having relationships within the immediate or close family circle in itself creates potential threats to compliance with fundamental principles. When analyzing potential inducements, the closeness of the relationship between the audited entity and the audit firm must be taken into account—the closer the relationship, the greater the threat, according to the code, because it increases the risk of influencing the auditor's professional judgment (para. 340.13 A1).

An important element in assessing threats to auditors is the nature or closeness of the relationship between the auditor and the client (para. 250.13). The provisions clearly indicate that the more distant the relationship, the better the service's performance from the perspective of the code of ethics.

Observations of practicing auditors lead to the conclusion that this professional group avoids any business relationships due to the existing threat to independence arising directly from legal standards, while simultaneously requiring clients to cooperate closely before, during, or after signing an assurance engagement letter and during the audit of financial statements. Interviews conducted with the CEOs of the audited companies and the statutory auditor led to the clear conclusion that the current situation is highly problematic for both parties.

The Code of Ethics for Statutory Auditors by IESBA, while warning against threats that may affect the proper performance of services due to doubts regarding the applicability of fundamental ethical principles, indicates that one of the fundamental solutions is to withdraw from or terminate business relationships with those submitting the proposal (Par. 250.10 A2 Code of Ethics).

Furthermore, Article 69.5 (UoBR) stipulates that "The audit firm and the key auditor shall take the necessary steps to ensure that, in conducting the audit, their independence is not affected by any actual or potential conflict of interest, business relationships, or any other direct or indirect relationships between the audited entity and the audit firm, members of the audit team, members of the network to which the audit firm belongs, the management of the audit firm, or persons related to them by a control relationship", which effectively precludes situations where the auditor or the audit firm has close ties with the client or establishes business (economic) relationships with the client.

Consequently, the surveyed auditors, being aware of the above statutory provisions, avoid any situations that could be viewed as a threat to the application of fundamental ethical principles. They are wary of establishing relationships and making business arrangements, avoid excessive contact with clients that suggests a higher level of familiarity, accept even the least valuable gifts that could be considered an "incentive", and avoid any extended conversations or meetings with representatives of the audited company that could be perceived as violating ethical principles.

On the other hand, managers of audited companies want to build business relationships with various stakeholder groups to develop the company at different levels and across various industries. However, in the financial audit sector, they point to a lack of opportunity for contact and understanding with statutory auditors, who demand extensive explanations and demonstrate a lack of understanding of the business entity.

This causes significant frustration among respondents, both from the perspective of statutory auditors, who forgo the opportunity to provide services to entities they are familiar with to avoid allegations of violating the code of ethics, and from that of business owners, who feel monitored and stressed by the highly formal nature of the collaboration with an unfamiliar statutory auditor. When statutory auditors audit entities they are unfamiliar with and have no business relationship with, the quality and quantity of information obtained may, by definition, not be of the highest standard.

Accordingly, all the examples of dilemmas identified in the interviews regarding proposals for cooperation resulted in the auditor refusing to work with the client, thereby limiting the number of engagements and the firm's growth.

From the perspective of the literature on building business relationships, this poses a dilemma for audit firms and a challenge for statutory auditors: how to balance their actions to run an audit firm ethically while simultaneously building a brand that is reliable, credible, and reputable in the business market.

4. Summary

On the one hand, the IESBA Code of Ethics for Professional Accountants sets out restrictions that statutory auditors must comply with to maintain the independence of financial statement audits. These regulations are restrictive from a business perspective, which may lead to the rejection of proposed engagements and limit audit firms' and statutory auditors' ability to establish business relationships. The analysis showed that restrictive interpretations of the Code of Ethics lead auditors to avoid business relationships, which, paradoxically, may limit their access to key information and reduce audit quality. Interviews conducted with statutory auditor confirm that this statement aligns with their actual professional practice.

On the other hand, a review of the literature and interviews with business owners in the micro, small, and medium-sized enterprise sectors confirm the necessity of building business relationships. These relationships are viewed as a source of long-term growth and success for commercial enterprises.

This article emphasizes that regulations governing the auditing profession, in a certain sense, hinder business operations by treating audit firms as necessary entities that should not focus on conducting business, building relationships, or generating profit.

Given the changes occurring in the free-market economy, where business activity is focused on company growth through the building of business relationships, there is a need to find a compromise for audit firms representing statutory auditors as public trust figures who simultaneously operate in an economic market governed by rules different from those applicable to auditors.

Consequently, in order to reduce the dilemmas faced by statutory auditors, there is a significant need to clarify the boundaries of acceptable business relationships between statutory auditors and clients in light of current market conditions, as well as to adapt practical solutions that allow for simultaneous compliance with ethical requirements and the operation of audit firms in a competitive market for audit services.

This study contributes new insights by identifying the “auditor’s paradox” in which the pursuit of full ethical independence can lead to the dehumanization of business relationships and the creation of an information gap. The findings of this study can assist regulatory authorities (PANA, PIBR) in clarifying guidelines on permissible business relationships, thereby increasing the profession's attractiveness without compromising its ethics.

According to the study's qualitative approach, the main limitation is the relatively small sample size, which means the results are exploratory and cannot be fully generalized to the entire population of certified public accountants in Poland.

This indicates a major future research direction, namely extending the research into a quantitative study that employs questionnaires and statistical methods. It is also worth examining the roles of the Polish Audit Oversight Agency (PANA) and the PIBR in shaping the attitudes of certified public accountants (based on non-source materials). It would be worth examining whether it is a specific fear of the regulator, rather than the provisions of the Code of Ethics themselves, that causes excessive avoidance of business relationships and the resulting dehumanization of cooperation. Future research could also examine the impact of digitalization on auditing and how technologies are changing the way trust and relationships are built in the virtual world.

References

1. Busławski, A., Okipna, I. (Eds.). (2024). *Innowacyjne zarządzanie. Studium przypadków* [*Innovative management: Case studies*]. Difin.
2. Bielecki, Ł. (2017). Niepokojący kierunek zmian legislacyjnych w zakresie rachunkowości, sprawozdawczości i rewizji finansowej w Polsce [A disturbing direction of legislative changes in accounting, reporting, and financial auditing in Poland]. *Przedsiębiorczość i Zarządzanie* [*Entrepreneurship and Management*], *18*, pp. 141-152.
3. Bielecki, Ł.J., Renik, K.A. (2026). Self-interest as an ethical dilemma for Polish statutory auditors operating as private entrepreneurs. *Scientific Papers of Silesian University of Technology. Organization and Management Series, 243*, 63-76. https://doi.org/10.29119/1641-3466.2026.243.4
4. Dobiegała-Korona, B., Herman, A. (Eds.) (2006). *Współczesne źródła wartości przedsiębiorstwa* [*Contemporary sources of enterprise value*]. Difin.
5. Drucker, P.F. (1974). *Management: Tasks, responsibilities, practices*. Harper & Row.
6. Dudovskiy, J. "Purposive Sampling". Research Methodology. research-methodology.net/sampling-in-primary-data-collection/purposive-sampling/, 07.08.2026.
7. Dutko, M. (Ed.) (2021). *Biblia e-biznesu 3.0* [*E-business bible 3.0*]. Onepress/Helion.
8. Górka, M., Janas, A., Bugajła, K. (2024). Media społecznościowe w komunikacji marketingowej przedsiębiorstwa [Social media in corporate marketing communication]. In: M. Górka (Ed.), *Współczesne wyzwania marketingu – wybrane zagadnienia* [*Contemporary challenges of marketing: Selected issues*] (pp. 9-23). Instytut Naukowo-Wydawniczy „Spatium".
9. International Ethics Standards Board for Accountants (2022). *2022 handbook of the International Code of Ethics for Professional Accountants: Including International Independence Standards*. International Federation of Accountants.
10. Kotler, P. (1980). *Marketing management: Analysis, planning, and control*. Prentice Hall.
11. Kotarbiński, J. (2021). Nowe rynki e-biznesu [New e-business markets]. In: M. Dutko (Ed.), *Biblia e-biznesu 3.0* [*E-business bible 3.0*] (pp. 32-36). Onepress/Helion.
12. Kozarkiewicz, A., Swałdek, T. (2021). Dojrzałość projektowa młodych organizacji w sektorze IT [Project maturity of young organizations in the IT sector]. In: E. Ziemba, A. Karmańska (Eds.), *Transformacja cyfrowa organizacji i społeczeństw* [*Digital transformation of organizations and societies*] (pp. 44-61). Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach.
13. Koźmiński, A.K., Obłój, K. (1989). *Zarys teorii równowagi organizacyjnej* [*An outline of the theory of organizational equilibrium*]. Państwowe Wydawnictwo Ekonomiczne.

14. Kubinowski, D. (2010). *Jakościowe badania pedagogiczne: Filozofia, metodyka, ewaluacja* [*Qualitative pedagogical research: Philosophy, methodology, evaluation*]. Wydawnictwo Uniwersytetu Marii Curie-Skłodowskiej.
15. Latusek-Jurczak, D. (2019). *Zaufanie w zarządzaniu organizacjami* [*Trust in the management of organizations*]. PWN.
16. Levitt, T. (1983). *The marketing imagination*. Free Press.
17. Lewandowska, A. (2020). *Strategiczna logika firm rodzinnych: Model BELIEFS* [*The strategic logic of family firms: The BELIEFS model*]. PWN.
18. Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A., Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18*, Article 143. https://doi.org/10.1186/s12874-018-0611-x
19. Quraishi, M.K., Jahan, N., Habib, M.M., Shafeen, Y.H., Badhon, E.A. (2025). Impact of digitalization on accounting and auditing in a developing country context. *Open Journal of Social Sciences, 13*(2), pp. 360-381. https://doi.org/10.4236/jss.2025.132022
20. Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N., Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and policy in mental health, 42(5),* 533-544. https://doi.org/10.1007/s10488-013-0528-y
21. Rajamannar, R. (2024). *Quantum marketing: Mastering the new marketing mindset for tomorrow's consumers*. Znak Litera Nova.
22. Renik, K. (2023). Dylematy etyczne biegłych rewidentów – systematyczny przegląd literatury [Auditor's ethical dilemmas: A systematic literature review]. *Studia i Analizy Instytutu Finansów, 1*, pp. 113-134. https://doi.org/10.60749/vj8a-vj79
23. Ustawa z dnia 11 maja 2017 r. o biegłych rewidentach, firmach audytorskich oraz nadzorze publicznym [Act of 11 May 2017 on statutory auditors, audit firms, and public oversight], Dz.U. 2017 poz. 1089, as amended.
24. Van der Waldt, G. (2026). Methodological triangulation in social science inquiry: Advancing research in public administration and management. *Administratio Publica, 34*(1), pp. 1-19. https://doi.org/10.61967/adminpub.2026.34.1.1
25. van Weele, A.J. (2018). *Purchasing and supply chain management* (7th ed.). Cengage Learning.
26. Wadlewski, A.A. (2025). *Multi-level marketing: Determinanty sukcesu biznesowego [Multi-level marketing: Determinants of business success*]. Wydawnictwo Uniwersytetu Łódzkiego. https://doi.org/10.18778/8331-613-0
27. Warner, M., Witzel, M. (2005). *Zarządzanie organizacją wirtualną* [*Managing the virtual organization*]. Oficyna Ekonomiczna.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

INTERCONNECTIONS BETWEEN STRATEGY AND STRATEGIC THINKING – LITERATURE REVIEW

Jacek RYBICKI[1*], Emilia DOBROWOLSKA[2]

[1] University of Gdansk; jacek.rybicki@ug.edu.pl, ORCID: 0000-0002-6365-1543
[2] University of Gdansk; Emilia.dobrowolska@ug.edu.pl@ug.edu.pl, ORCID: 0000-0003-0792-7274
* Correspondence author

Purpose: The authors assume that the strategy is the result of strategic thinking process. Both terms "strategy" and "strategic thinking" in strategic management literature are ambiguous and lack of consolidation. From this perspective the aim of the article is to present a comprehensive model that combines strategy and strategic thinking elements.
Design/methodology/approach: The theoretical research was conducted following Systematic Literature Review (SLR) guidelines with the elements of Bibliometric Analysis. The authors reviewed Web of Science Core Collection database to find out how strategy and strategic thinking concepts can be decomposed to elements and how they are interlinked within strategic management literature.
Findings: SLR enabled the authors to identify components of strategy, namely: mission statement, market domain, competitive advantage, functional programmes, core logic, resource domain, business model and strategic objectives and components of strategic thinking, namely: strategic intent, market risk, competitors actions, strategy implementation, approaches to strategy formulation, investment in resources, value proposition and strategic decisions. This allowed the authors to propose a theoretical model illustrating the interconnections between strategy and strategic thinking elements.
Research limitations/implications: The proposed model has theoretical implications and contributes to the development of strategic management literature. The authors proposal requires further verification in empirical study. The dependency analysis needs to be set in a business context.
Originality/value: The article attempts to diminish the ambiguity within strategy and strategic thinking concepts in strategic management literature and proposes a holistic approach to understanding these concepts through strategic perspective and strategist perspective.
Keywords: strategy, strategic thinking , strategic perspective, strategist perspective.
Category of the paper: Literature Review.

1. Introduction

In the ontological field, there are many different approaches to defining strategy and strategic thinking. In the epistemological field, this issue boils down to the scope of application of existing or emerging methods aimed at defining the concept of strategy and measuring the level of strategic thinking in various types of organizations (Meyer, 2007). These include: Strategy Profiler, Strategy Preference Indicator (Reece, 2008), Strategic Thinking Questionnaire (Pisapia et al., 2011), and the Questionnaire on Strategic Thinking and Action Style (Bajcar, 2012), which allows for the measurement of indicators of strategic thinking. The article contributes by providing a theoretical framework for understanding the evolution of strategy concept alongside strategic thinking as core attributes of strategic management studies.

The aim of this article is to present a comprehensive approach to the strategy and strategic thinking concepts. The article focuses on analyzing the dominant theoretical approaches to defining strategy and strategic thinking. Systematic Literature Review enabled the authors to identify key elements constituting both concepts, allowing to present their interconnections. As a result, an integrated model of strategy and strategic thinking was proposed. It presents the interrelationships between these two terms, emphasizes the need to reduce the ambiguity in strategic management theory, and outlines their significance for the development of contemporary strategic management theory and practice.

2. The methodology

The authors of the article decided to combine Systematic Literature Review with the elements of Bibliometric Analysis that is known as Bibliometric – Systematic Literature Review (Marzi et al., 2025) The theoretical research is devoted to understanding the essence of the strategic management field, in particular relations between two perspectives – strategy and strategic thinking.

Systematic Literature Review (SLR) or Structured Literature Review in management science is the matter of concern how to encourage a focus on continuous improvement of research work (Rojon, Okupe, McDowall, 2021). High-quality systematic review papers play an important role in a discipline's progress and advancing knowledge (Paul, Menzies, 2023). A. Kuckertz and J. Block (2021) consider SLR to be a variant of literature reviews, primarily aiming at increasing the transparency of the literature selection process underlying the review. Doing so helps to minimize subjectivity concerning which studies are included in the review and reducing what could be called the sampling error of unsystematic literature reviews. D. Denyer and D. Tranfield, (2009, p. 671) indicate that SLR articulates a replicable approach

for collecting, analyzing and synthesizing literature with clear audit trails about what is and what is not known regarding a research question or set of questions. P.C. Sauer and S. Seuring (2023) present classification of SLR guidelines, that consider the following steps: (1) Defining the research question; (2) Determining the required characteristics of primary studies; (3) Retrieving a sample of potentially relevant literature; (4) Selecting the pertinent literature; (5) Synthesizing the literature; (6) Reporting the results.

Following P.C. Sauer and S. Seuring (2023) classification of SLR guidelines, the authors carried it out in relation to both concepts, i.e. strategy and strategic thinking.

The research questions (RQ) (step 1) were formulated as follows:

RQ 1: What is the essence of "strategy" and how it evolves in management studies?

RQ2: What is the essence of "strategic thinking" and how it evolves in management studies?

RQ3: How "strategy" and "strategic thinking" as essential concepts of strategic management correspond to each other and what are their understanding in literature?

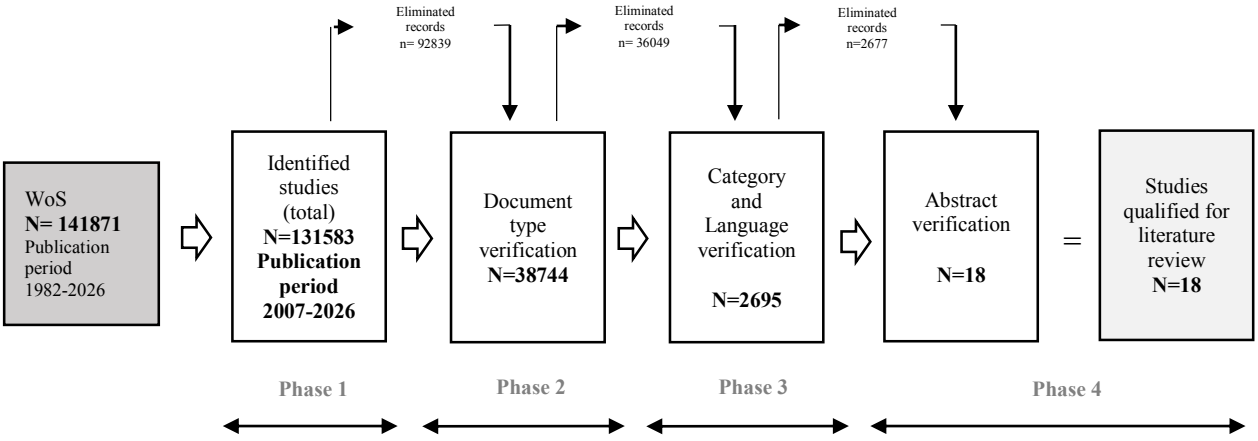
This is the first step of SLR and next steps regarding strategy and strategic thinking concepts will be presented in the following chapters.

The authors of the article decided to limit their research only to the Web of Science Core Collection database, omitting other databases because of the large number of publications on strategy and strategic thinking concepts. The additional restrictions the authors adopted include: open access publications and focus only on articles that refer to the "Business" and "Management" categories, which was motivated by the aim of capturing the essence of strategy and strategic thinking concepts in management sciences.

3. Proposed concept of strategy

Scholars highlight that strategy is not only the central concept of the field of strategic management, but also it is a concept that suffers from the semantic problem in question. (Ronda-Pupo, Guerras-Martin, 2012, pp. 162-163). Strategy is not something static, finished, which renders the concept complex and difficult to grasp. In this sense understanding the essence of the strategic management field requires historical perspective on its central concept: strategy (Ronda-Pupo, Guerras-Martin, 2012, pp. 162-163). As F.D. Poazi (2026) notices no one has been able to agree on a single definition of strategy. Many researchers have tried to define it by identifying its key features, but no one has had much success. One of the reasons is that various people have different approaches to strategy, which can cause misunderstandings. Similarly claim G.A. Ronda-Pupo and L.Á. Guerras-Martin (2012), pointing that the reason of great diversity in the definitions of strategy is the result of both the different terms used and the central ideas of what each author considers the essence of the concept to be.

The Web of Science Core Collection is the database used in search for relevant publications. This allowed moving to step 2 - defining the required characteristics of primary studies. The study of strategy as a term associated with management began to materialize during the 1950s (Ronda-Pupo, Guerras-Martin, 2012). Within the period 1950-2026 in Web of Science Core Collection database 892 501 open access publication were identified. Due to the large numbers of publications the temporal scope of the study covers the years 2007-2026, which outlines the changes in the essence of strategy concept. The four-phase process of identifying the works qualifying for SLR is shown in Figure 1.



Note:
1. Query: "strategy" OR "strategy definition" OR "strategy concept".
2. Knowledge base search criteria: WoS: authors keywords.
3. Document type: Article. Only documents such as open access articles were included in the study.
4. Publication period: 2007-2026.

Figure 1. The stages of identifying publications from the scope of strategy in Web of Science Core Collection database.

Source: Authors' elaboration based on Web of Science Core Collection. Access: 17.04.2026.

As shown in Figure 1, based on the search query formulated, specified category verification, language verification, and abstract verification, only 18 identified documents out of the 2695 potentially relevant documents (step 3) were qualified for the literature review. The selection process (step 4) was conducted as follows. Only open access articles and articles from database category "Business" were qualified to further SLR. Papers written in languages other than English were eliminated from further consideration.

On the basis of 2695 identified papers the elements of Bibliometric analysis with the help of VOSviewer, namely keyword co-occurrence was conducted. The study incorporated co-occurrence mapping analyses. Co-occurrence mapping delved into keyword correlations. A minimum requirement of seven instances for each phrase was set to enable the complete counting technique in keyword analysis. Out of the 7938 keywords, 256 met this criterion. Frequently appearing phrases encompassed "strategy" "innovation", "business strategy" "sustainability", "competitive strategy" with occurrence frequencies of 545, 123, 147, 96 and 87, respectively. Figure 2 depicts word co-occurrence as a network diagram. The 7938 keywords divided into ten color-coded clusters.

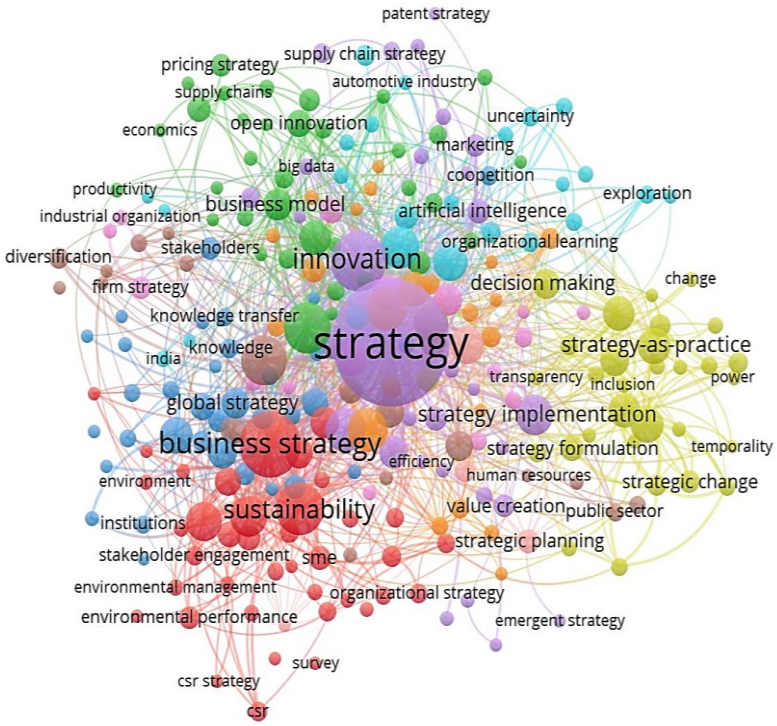


Figure 2. Keyword Co-Occurrence Network Visualization for strategy concept.

Source: own elaboration on the basis of VOSviewer, access: 20.04.2026.

"Business strategy", "organizational strategy", "sustainability" and "sustainable development" dominate in Cluster 1 (Red). The researches i.e. in this cluster consider the choice of the firm's strategy (proactive/innovative vs analyzer/following) as the road to more sustainable firm, that depends on the alternative employment models (Lopez-Cabrales, DeNisi, 2021).

Cluster 2 (Dark green) discusses the trends in "business models", "competitive strategy" and "open innovation". The researches i.e. in this cluster states that the innovation strategies of organizations should become a dynamic structure due to the unsteady conditions of the market and competitive environment and the shortening of product life cycles (Çubukcu, Özözer, Bingüler, 2024) The conducted studies also seek to ascertain whether there is any measurable relationship between a strategy and a business model (Štefan, Branislav, 2016) and present how to implement open innovation strategy in response to major economic shocks (Trantopoulos, Woerter, von Krogh, 2024).

Cluster 3 (Bark Blue) covers such keywords as i.e. "global strategy", "cooperation", "coopetition", "nonmarket strategy". The articles within this cluster examine i.e. the global strategies of corporations that are analyzed using the "governance triangle" that examines governance through coordination (the role of the state), governance through competition (the market), and governance through argumentation (civil society) (Buckley, 2022).

Cluster 4 (Yellow) explores i.e. "strategy as practice", "behavioral strategy", "open strategy", "strategic change". Research within this cluster present i.e. a methodology for tracking all six manifestations of strategy (intended, realized, deliberate, emergent, unrealized,

and ephemeral strategy), highlighting the interdependent relations among them (Mirabeau, Maguire, Hardy, 2018).

"Strategy execution", "strategy implementation", "project strategy", "patent strategy", "marketing strategy", "management strategy" and "artificial intelligence" dominate in Cluster 5 (Purple). In example the research within this cluster deals with the question how does one strategize when the technologies core to organizational action is constantly changing (Faraj, Leonardi, 2022). Moreover, the research consider new trends within AI strategy formulation (Hofmann et al., 2026).

Cluster 6 (Light Blue) explores i.e. "entrepreneurial strategy", "resilience", "strategy formation", "entrepreneurship", "technology strategy", "supply chain strategy". One of the papers within this cluster deals with the question: if the potential for a technology is given by the fundamental character of a given technological trajectory, then why does entrepreneurial strategy matter? (Gans et al., 2021).

Cluster 7 (Orange) presents the following keywords i.e.: "business model innovation", "innovation strategy", "radical innovation", "manufacturing strategy". Within this cluster one of the paper presents business model innovation as a powerful strategic tool, able to offer competitive advantage, create markets and reshape industries (Mateu, March-Chorda, 2016).

Cluster 8 (Brown) covers such keywords as i.e. "corporate strategy", "development strategy", "digital transformation strategy", "collaboration", "absorptive capacity". The researches i.e. in this cluster consider how companies can align logistics environmental sustainability with corporate strategies (Prataviera et al., 2025).

"Human resource strategy", "firm strategy", "change management", "dynamic capabilities dominate" in Cluster 9 (Pink). Within this cluster one of the paper analyzes human resource management (HRM) strategy as an essential tool for transforming business strategy into results (Gonzalez-Benito, Suárez-González, González-Sánchez, 2022).

Cluster 10 (Light Orange) discusses the trends in "strategic planning", "strategic management" and "organizational change". The researches i.e. in this cluster analyzes how strategic planning and management control tools interact and evolve in a large public sector organization (Sundström, Svärdsten, 2026).

The abstract evaluation stage within SLR allowed to identify articles that concentrate on the essence of strategy concept. Moving to the step that concerns synthetizing the results of systematic literature review (5), the authors distinguished different approaches in strategy formulation process. The proposed concept for a strategy comprises of eight elements. They may be characterized as followed:

1. The mission statement: It is the starting point for strategy design. Mission is perceived as an effective strategic tool (Berisha Qehaja, Kutllovci, 2020; Breznik, Law, 2019) that can help on the one hand implement strategic change, and on the other hand that can be experienced as a disruption in people's sense of "who we are" as an organization (Sasaki et al., 2020). The effectiveness of the mission can be measured by variable indicators: the extent to which the member of organizations are moving in clear direction; how inspiring it is, and generating the passion and commitment in the performance of the company (Zsigmond, Machová, Zsigmondová, 2021).
2. The market domain: This is the second core element of strategy concept that has been identified within retrieved literature sample. The market domain can be thought of as the marketplace where providers compete for customers (Geissinger et al., 2021).
3. Strategic objectives: They should be formulated in terms of success metric. Strategic management is a series of permanent phases that aims to realize the long-term objectives formulated internally by the company. While the strategy is estimated as the mechanism to obtain the objectives, and with it, its execution is to make everything carried out through the standards designed for the purposes (Yepes-Jiménez et al., 2023). The researches not only focus on different examples of strategic objectives like profit margins, enterprise value (Haiyan, Ahmed, Nanere, 2021), financial performance (Villarreal Archiva, Pardo Pérez, 2020), but also emphasize how the use of technology in practice in Industry 4.0. era enable companies to achieve strategic objectives (de Medeiros, Lavarda, Erdmann, 2020).
4. Competitive advantage: A classic topic of debate in academic circles, that is the key to a company's success. The business strategy represents a long-term plan to achieve a competitive advantage by affecting the company's financial behavior (Wang et al., 2021). Strategists seek a competitive advantage by balancing legitimacy and novelty. Each of the approach has distinct risks and trade-offs (Imbrogno et al., 2025).
5. Operational action plans (or functional programmes): They are linked to the implementation of strategy, and are also seen as one of the elements of strategy concept. In the implementation of strategy, they consist of actions aimed at achieving operational objectives, which are the lowest-level objectives but are essential for the achievement of tactical and strategic objectives. In other words, functional programs are perceived as tools to help carry out strategy at the operational level (Corbett-Etchevers, Parmentier-Cajaiba, 2022).
6. Core logic: Strategic objectives and functional action plans must be primarily aligned with the company's mission and core logic. A strategy is characterized by a certain probability of market success, where the measure of success itself stems from business logic (Pereira, Vence, 2012) and, in essence, from the aspirations of the strategy's architects**.**

7. Strategic resources: They are crucial element of strategy concept. Especially when strategy implementation is considered, because it requires internal alignment among several key areas. In this matter, the resources and capabilities using the internal value chain analysis need to be examined to see if each element supports the strategy (Rowe, Nevmerzhytskyi, 2025). Moreover, interaction of innovation strategy and strategic resources may influence the size of companies' debt (capital structure) (Faria et al., 2024).
8. Business model: A business strategy describes and explains how, where and for what purpose and goal a business model will be used (Štefan, Branislav, 2016). On this basis business model is also perceived as an element of strategy concept. A firm's degree of business model development - the extent to which strategic choices are crystallized - moderates the impact of a scientific approach to decision-making on performance (Novelli, Spina, 2024). Moreover, researchers state that business model research should integrate three research streams: complexity theory, demand side theories of strategy and supply side theories of strategy (Lanzolla, Markides, 2021).

Five basic elements of strategy concept: mission, market domain, functional action plans, competitive advantage, strategic objectives (Obłój, 2007) were complemented with three new elements: the resource domain, core logic and business model (Rybicki, 2012).

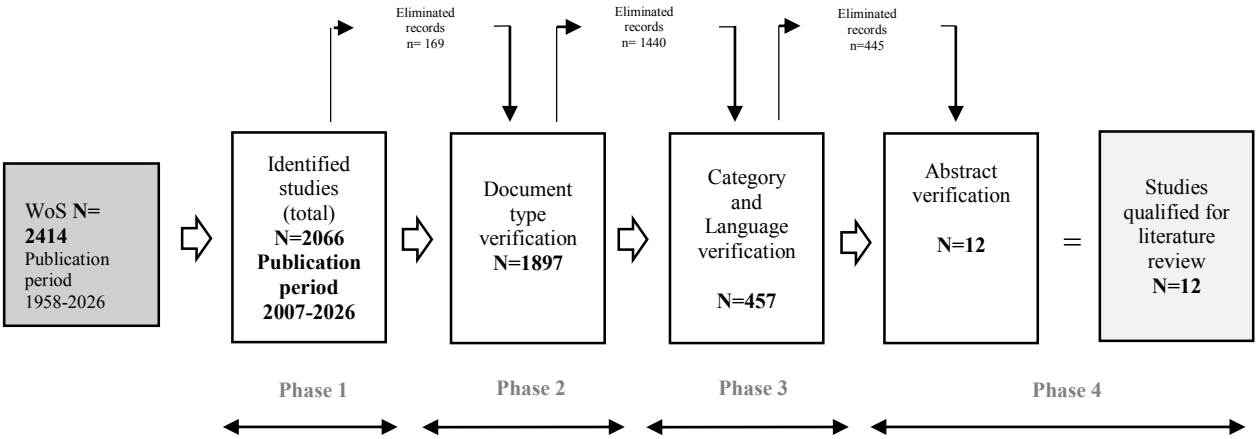
4. Proposed concept of strategic thinking

Strategic thinking is increasingly viewed as a dynamic process that continuously influences the mission, strategy and outcomes of activities aimed at meeting customer needs in a highly competitive environment (Moon, 2013). Strategic thinking can be seen as a catalyst of innovative performance (Obeidat, 2025), competence (Aukenov, Žukovskis, Lipovka, 2025; Nuntamanop, Kauranen, Igel, 2013) or factor that influences competitive advantage (Dixit et al., 2021).

Although a growing body of studies on strategic thinking has explored this phenomenon (e.g. Allio, 2025; Ledi et al., 2024; Srivastava, D'Souza, 2020; Moon, 2013), only few have addressed its definition and components (Geier, 2024; Rybicki, 2023). The definition and core dimensions of strategic thinking are unclear in the literature (Geier, 2024). These circumstances was an incentive to conduct SLR within strategic thinking concept.

Step 2 of SLR - defining the required characteristics of primary studies was followed by search for papers that concern "strategic thinking" in the Web of Science Core Collection database. The early publications that discussed "strategic thinking" process dates back to 1958. Within the period 1958-2026 in Web of Science Core Collection database 2414 publications were identified. The temporal scope of study covers the years 2007-2026. Similarly, to the

search of: "strategy" or "strategy definition" or "strategy concept", the four-phase process of identifying the publications qualified for SLR is shown in Figure 3.



Note:
1. Query: "strategic thinking".
2. Knowledge base search criteria: WoS: Topic (title, abstract, keyword plus, and author keywords).
3. Document type: Only documents such as articles, proceeding papers, book chapters and books were included in the study.
4. Publication period: 2007-2026.

Figure 3. The stages of publication identification from the scope of strategic thinking in Web of Science Core Collection database.

Source: Authors' elaboration based on Web of Science Core Collection. Access: 19.04.2026.

As shown in Figure 3, based on the search query formulated, specified category verification, language verification, and abstract verification, only 12 publications out of the 457 identified potentially relevant documents (step 3) were qualified for the literature review. The selection process (step 4) was conducted as follows. Only articles, proceeding papers, book chapters and books from database categories "Business" and "Management" were qualified to further SLR. Only publications written in English were taken into further consideration.

On the basis of 457 identified papers, the elements of Bibliometric analysis, with the help of VOSviewer, keyword co-occurrence was conducted. The study incorporated co-occurrence mapping analyses. Co-occurrence mapping delved into keyword correlations. A minimum requirement of seven instances for each phrase was set to enable the complete counting technique in keyword analysis. Out of the 1990 keywords, 65 met this criterion. Frequently appearing phrases encompassed "strategic thinking", "performance", "innovation" "management", "model", "strategy", "strategic management" with occurrence frequencies of 98, 54, 45, 50, 35 and 44, respectively. Figure 4 depicts word co-occurrences as a network diagram. The 1990 keywords divided into six color-coded clusters.

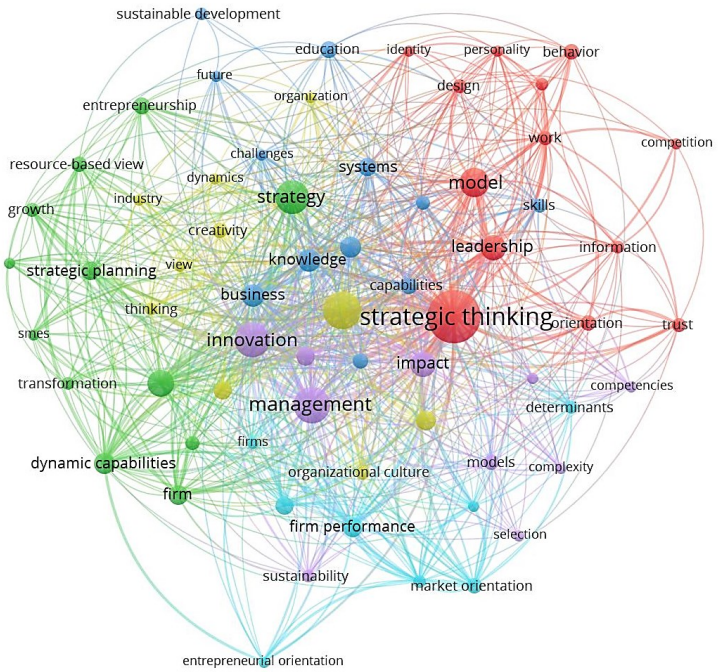


Figure 4. Keyword Co-Occurrence Network Visualization for strategic thinking concept.
Source: own elaboration on the basis of VOSviewer, access: 30.04.2026.

Cluster 1 (Red) discusses the trends in "strategic thinking", "leadership development, model", "information", "competition". Publications within this cluster consider, i.e. the importance of strategic planning and even more the importance of strategic thinking in volatile, unstable, complex, ambiguous (VUCA) times (Allio, 2025). One of the studies outlines that leadership and strategic thinking are becoming an inseparable whole. To be able to read the change in the environment, to be able to see organizational variables as a whole, and to be able to express a visionary perspective are the obligations to think strategically. Leaders with strategic thinking have distinctive features such as long-term thinking, predicting retrospectively, constructing an organizational system, and reinforcing creativity level (Zorlu, 2018).

"Strategy", "strategic planning", "strategic management", "resource-based view" dominate in Cluster 2 (Green). The researches in this cluster i.e. states that the strategic thinking process is emergent, complex, interconnected, informal and is embedded within pivotal places alongside governance, strategic planning and other key processes (Karami, Gorzynski, 2022), and indicates, on the basis of RBV, the understanding how the nature of strategic thinking has influenced the research in the field of multinational enterprises strategy (Dabic, González-Loureiro, Furrer, 2014).

Cluster 3 (Blue) covers such keywords as i.e. "knowledge management", "sustainable development", "capabilities". Within this cluster research aims to recognize areas in which knowledge management theory and practice need to be rethought and subsequently develop a new kind of strategic thinking (Laihonen, Huhtamäki, 2023).

Cluster 4 (Yellow) explores i.e. “performance”, “decision making”, “competitive advantage”. Researches within this cluster examine i.e. relationship between strategic thinking and marketing performance (Moon, 2013) or analyze the mediating effect of strategic thinking between its antecedents and competitive advantage (Dixit et al., 2021).

“Management”, “innovation”, “impact”, “sustainability”, “complexity” are keywords that dominate in Cluster 5 (Purple). One of the studies indicates that leaders' rationality is bounded and their strategic thinking is a mix of rationality and insight. Therefore, strategic thinking research should investigate both the rationality and intuition that can support business innovation (Calabrese, Costa, 2015).

Cluster 6 (Light Blue) discusses the trends in “entrepreneurial orientation”, “market orientation”, “product development”. The articles within this cluster examine i.e. the role of entrepreneurial strategic thinking as an antecedent of entrepreneurial orientation and its influence on product performance. It further investigates how a dynamic environment shapes these relationships (Srivastava, Atinc, Taneja, 2026).

The abstract evaluation stage allowed to identify articles that concentrate on the essence of strategic thinking concept. Moving to the step that concerns synthetizing the results of systematic literature review (5), the authors distinguished different elements of strategic thinking concept, namely:

1. The strategic intent: The strategi intent is a short, succinct, and inspiring statement of what the organization intends to become and to achieve at some point in the future, often stated in competitive terms. It is an obsession of winning at all levels of the organization and that is sustained for a long period of time (Odita, Bello, 2015). In the creation of strategic intent, the sharing of an obsession, strategy intent is a rhetorical tool for achieving coherence between multiple intents (Mantere, Sillince, 2007). One of the identified research within SLR states that China and India adopt very different 'strategic intent' in developing their auto industries. The strategies underpinning the success have been built more upon the strategic thinking in soft areas of supply chain relationships (Chatterjee, 2009).
2. Market risk: This category requires the answer to the question: what is the risk of failure in the market? The results of one of the empirical analysis provide evidence that the attitude of firms' management toward risk taking, among other factors: the CEO's emphasis on strategic thinking, interdepartmental teams in the organization, and marketing competency foster strategic thinking at the organizational level (Moon 2013). The other example of study in the food sector in Italy emphasizes crucial question: in the long run, which products will be demanded by the market and which ones risk to become obsolete? The research states that the common economic forecasting techniques might be ineffective to answer this question, rather long-term strategic thinking may be supportive (Ginanneschi, 2021).

3. Competition: Competitor assessment is a part of strategic analysis and planning. The ability to sense and accurately predict competitors' future moves, in other words competitive prediction capability, can form a basis for sustainable competitive advantage (Lim, 2013). Strategic thinking and the entrepreneurial activities in an ecosystem influence one another in a cycle that perpetuates and even sparks innovation (Zahra, Nambisan, 2012).
4. Strategy implementation: For instance, in Portuguese SMEs Balanced Score Card was a crucial instrument in initiating a process of strategic thinking (Cardim et al., 2018).
5. Strategy formulation approaches: One of the study concentrates on identification of strategic thinkers' types and their potential impact on the process of strategy formulation in an enterprise. There are specific features distinguishing strategic thinkers from other leaders: a strategic long-term orientation, a reflective thinking style, the acceptance of uncertainty and changes, influencing future, processing information and decision making, collectivity as well as frequency and intensity of the strategic thinking disposition. These are the basis for development of strategic thinkers' typology (Lichtarski et al., 2025).
6. Investment in resources: Companies must decide which resources to develop, which to maintain, and which are unnecessary and which should be eliminated. According to studies only few companies devote enough resources to strategic thinking, which results in strategic insanity (i.e., firms repeatedly applying the same strategies with the expectation of different outcomes) (Benito-Ostolaza, Sanchis-Llopis, 2014).
7. Value proposition: Managers should determine what the expected value proposition for the customer is. It’s worth noting that managerial cognition grapples with the role of holistic mental models and strategic thinking for designing effective configurations of business model attributes, that brings value to the customers (Snihur, Eisenhardt, 2022).
8. Strategic decisions: Researchers emphasize that business must start adopting strategic thinking practices in their decision-making process to create a competitive advantage (Dixit et al., 2021).

The proposed concept of strategic thinking emerge from strategy concept. It has cognitive value and is presented from strategists perspective.

5. Strategy and strategic thinking concepts interdependence – results of Systematic Literature Review

Detailed conclusions can be made based on literature review (Step 6 – Reporting the results). The steps taken so far in the SLR procedure, which have been carried out in relation to the concept of strategy and strategic thinking, allow for the juxtaposition of the strategic

perspective with the strategist's perspective that derives from strategic thinking concept and the demonstration of their interdependencies. Both perspectives comprise as a comprehensive model and are set out in table 1.

Table 1.
Comprehensive model that combines strategy and strategic thinking elements within strategic and strategist perspectives

Strategy conceptualization	Strategic perspective	Strategic thinking conceptualization	Strategist perspective
	Mission statement		Strategic intent
	Market domain		Calculation of market risk
	Competitive advantage		Competitors actions control
	Functional programmes		Strategy implementation
	Core logic		Approaches to strategy formulation
	Resource domain		Investment in resources
	Business model		Value proposition
	Strategic objectives		Strategic decisions

Source: own elaboration based on SLR.

Interdependencies in both perspectives requires deeper consideration:

1. Mission statement versus strategic intent: Strategists, the mission transforms into a strategic intent, which may also be included in the mission.
2. Market domain versus calculation of market risk: Strategists must identify the market risk associated with failing to maintain a competitive advantage in selected market segments.
3. Competitive advantage versus competitive actions: Competitive advantage is a relative concept and must be defined in relation to the competition. In strategic thinking, one must anticipate the market actions of direct and indirect competitors; therefore, the strategist should monitor the activities of rival firms.
4. Functional programmes versus strategy implementation: Strategists are considering how to put strategies into practice in the business reality.
5. Core logic versus approaches to strategy formulation: the core logic of doing business in a given sector or market dictates how strategies are formulated.
6. Resources domain versus investment in the resources domain: Strategists consider which resources are absolutely essential to achieve strategic objectives. They consider the development of appropriate strategic resources through targeted investment.
7. Business model versus value proposition for customer: The business model should be analysed by strategists who make decisions regarding the value proposition for the customer.
8. Strategic objectives versus strategic decisions: Strategists consider how strategic decisions can lead the company to success and minimise the probability of failure.

The strategic perspective enables a strategy to be developed in accordance with its proposed components. While the strategist's perspective – explains what needs to be considered during the strategy development process.

6. Discussion

The authors of the article proposed a strategy concept that comprises of eight elements namely: mission, market domain, functional action plans, competitive advantage, strategic objectives, resource domain, core logic and business model. Different elements of the strategy concept can be identified in others researches. F.W.D. Poazi (2026) emphasizes the role of strategic objectives. The author claims that the formulation of strategy must intrinsically connect to the notion of compliance. A strategy can facilitate a business's progress and act as a roadmap for attaining the ultimate objectives. A similar position is held by N.T.H. Phuong (2024) who states that the identification of fundamental long-term goals pertains to the process of developing coherent and achievable strategic objectives. These objectives serve as the foundation for strategy formulation, as without clearly defined goals, progress becomes unattainable. I. Alegre, J. Berbegal-Mirabent, A. Guerrero and M. Mas-Machuca (2018) stress the importance of mission statement. The authors discern mission statement as a strategic tool that emphasizes an organization’s uniqueness and identity. Strategic resources perceived by the authors of the article as the element of strategy concept elements are also mentioned in A.S. Khalifa (2020) research, where strategy is presented as an entity’s evolving theory of winning high-stake challenges through power creating use of resources and opportunities in uncertain environments. During SLR there were also identified new trends that consider strategy concept but were not included in the model presented in the paper. These are AI systems that becomes a part of decision making process. In strategic decision making, what matters is not only whether AI is used but which AI system is deployed and how it scaffolds and helps human reasoning in the development of a strategy (Camuffo et al., 2026). As F.A. Csaszar, G. Lee, P. Zemsky and T. Zenger (2026) state AI systems begin to participate directly in decision making, understanding how they reshape these interaction patterns becomes essential.

The proposed in the article strategic thinking concept also comprises of eight elements namely: the strategic intent, market risk, competition, strategy implementation, approaches to strategy formulation, investment in resources, value proposition and strategic decisions. Many of the elements of the proposed strategic thinking concept were discussed in management studies. E.F. Goldman (2012) emphasizes the importance of decision making in strategic thinking and states that strategic thinking is a process that aims at improving organizational functioning through smart decision-making process. Strategic thinking demands creativity, foresight and insight. Foresight means shadowing the future; that is, foreseeing its shape before it materializes. Insight revolves around uncovering ways that give birth and meaning to the future (Zahra, Nambisan, 2012). Strategic thinking involves a set of recursive activities (scanning, questioning, conceptualizing, and testing) to identify (planned) organizational strategy and/or make sense of patterns that infer (emergent) organizational strategy (Goldman

et al., 2015). The authors of the article did not take into account in proposed strategic thinking concept aspects that consider developing strategic thinking competencies, that is widely discussed in strategic management literature (Al Maaitah et al., 2026; Bani-Hani, 2021; Norzailan, Yusof, Othman, 2016).

7. Summary

The aim of the article was to propose a theoretical model illustrating the interconnections between strategy and strategic thinking elements. The aim was achieved within two steps. Firstly, SLR enabled the decomposition of the elements of strategy concept and strategic thinking concept. Secondly, the interdependencies between the elements of these concepts was presented by the authors (table 1).

The SLR allowed to aswer RQ1 and RQ2 showing the essence of "strategy" and "strategic thinking concepts" and the evolution of studies conducted in these fields through the last twenty years. While the set of components of strategic and strategist perspectives and their interdependecies allowed to aswer RQ3 showing how these crucial strategic management concepts are interrelated.

The model presented in the article is purely theoretical in nature. It demonstrates the interdependence between strategy and strategic thinking concepts. The decomposition of these concepts present eight elements in each of the concept. The model has been adopted on the basis of SLR so it requires empirical verification. Moreover, the SLR is restricted to only one database, namely Web of Science Core Collection and the analysis is limited to the review of papers published within 2007-2026.

The future research should concentrate on the identification of key issues within keyword co-occurrence analysis conducted in the article. They strictly correspond to strategy concept. The crucial issues that requires future development concentrate on strategic tools like AI tools that enable strategy formulation (Hofmann et al., 2026), the choice of the firm's strategy to protect firm's sustainability (Lopez-Cabrales, DeNisi, 2021), open innovation strategy implementation (Trantopoulos, Woerter, von Krogh, 2024), relations between strategy an technology (Faraj, Leonardi, 2022), interactions between strategic planning and management control tools (Sundström, Svärdsten, 2026). Future research should also correspond to strategic thinking keyword co-occurrence analysis. The key aspects that should be developed, according to the authors of the article, consider reinforcing leadership strategic thinking competencies (Zorlu, 2018), the role of entrepreneurial strategic thinking as an antecedent of entrepreneurial orientation and its influence on product performance (Srivastava, Atinc, Taneja, 2026) and development of new kind of strategic thinking on the basis of knowledge management theory (Laihonen, Huhtamäki, 2023).

References

1. Al Maaitah, H., Ensour, W., Darwish, Z., Suleiman, M. (2026). Benchmarking women's leadership programs in Jordan: aligning national practices with international competency frameworks. *Journal of Business and Socio-economic Development*, pp. 1-21, doi: 10.1108/JBSED-05-2025-0163
2. Alegre, I., Berbegal-Mirabent, J., Guerrero, A., Mas-Machuca, M. (2018). The real mission of the mission statement: A systematic review of the literature. *Journal of Management & Organization*, *Vol. 24, Iss. 4*, pp. 456-473, doi: 10.1017/jmo.2017.82
3. Allio, M.K. (2025). Strategic Thinking: Practicing and Promoting Strategic Thinking and Doing in Family Enterprises. *The Journal of Entrepreneurship*, *Vol. 34, Iss. 4*, pp. 716-740, doi: 10.1177/09713557251400572
4. Aukenov, A., Žukovskis, J., Lipovka, A. (2025). Strategic Planning and Strategic Thinking Competencies of Kazakhstan's Managers in the Agricultural Sector. *Management Theory and Studies for Rural Business and Infrastructure Development*, *Vol. 47, Iss. 3*, pp. 352-360, doi: 10.15544/mts.2025.28
5. Bajcar, B. (2012). Kwestionariusz styl myślenia i działania strategicznego - nowe narzędzie do pomiaru wskaźników myślenia strategicznego. *Studia Psychologiczne (Psychological Studies)*, *T. 50, Z. 2*, pp. 5-24, doi: 0.2478/v10167-010-0043-7
6. Bani-Hani, J. (2021). The moderating influence of managers strategic thinking on the effect of talent management on organization core competency. *Management Science Letters*, *Vol. 11, Iss. 1*, pp. 213-222, doi: 10.5267/j.msl.2020.8.013
7. Benito-Ostolaza, J.M., Sanchis-Llopis, J.A. (2014). Training Strategic Thinking: Experimental Evidence. *Journal of Business Research*, *Vol. 67, Iss. 5*, pp. 785-789, doi: 10.1016/j.jbusres.2013.11.045
8. Berisha Qehaja, A., Kutllovci, E. (2020). Strategy tools in use: New empirical insights from the strategy-as-practice perspective. *Management: Journal of Contemporary Management Issues*, *Vol. 25, No. 1*, pp. 145-169, doi: 10.30924/mjcmi.25.1.9
9. Breznik, K., Law, K.M. (2019). What do mission statements reveal about the values of top universities in the world? *International Journal of Organizational Analysis*, *Vol. 27, Iss. 5*, pp. 1362-1375, doi: 10.1108/IJOA-08-2018-1522
10. Buckley, P.J. (2022). Navigating three vectors of power: Global strategy in a world of intense competition, aggressive nation states, and antagonistic civil society. *Global Strategy Journal*, *Vol. 12, Iss. 3*, pp. 543-554, doi: 10.1002/gsj.1444
11. Calabrese, A., Costa, R. (2015). Strategic thinking and business innovation: Abduction as cognitive element of leaders' strategizing. *Journal of Engineering and Technology Management*, *Vol. 38*, pp. 24-36, doi: 10.1016/j.jengtecman.2015.06.001

12. Camuffo, A., Gambardella, A., Kazemi, S., Pandey, A. (2026). Beyond black boxes: Designing and testing agentic AI systems for strategy. *Strategy Science*, *Vol. 11, Iss. 1*, pp. 137-156, doi: 10.1287/stsc.2025.0432
13. Cardim, S., Nunes, A., Fernandes, P.O., Branco, F. (2018). Implementation of Balanced ScoreCard: Simplify Strategic Thinking Development in Portuguese SMEs. *European Conference on Innovation and Entrepreneurship*. Portugal: Academic Conferences International Limited.
14. Chatterjee, S.R. (2009). Trust and learning as moderators in achieving global supply-chain competitiveness: Evidence from the Chinese and Indian auto-component sectors. *Global Business Review*, *Vol. 10, Iss. 1*, pp. 87-102, doi: 10.1177/097215090801000
15. Corbett-Etchevers, I., Parmentier-Cajaiba, A. (2022). Making strategy out of everyday tools: A collective bricolage perspective. *M@n@gement*, *Vol. 25, Iss. 3*, pp. 39-56, doi: 10.37725/mgmt.v25.4560
16. Csaszar, F.A., Lee, G., Zemsky, P., Zenger, T. (2026). Can AI Do Strategy? *Strategy Science*, *Vol. 11, Iss. 1*, pp. 1-15, doi: 10.1287/stsc.2026.intro.v11.n1
17. Çubukcu, A., Özözer, Y.Ö., Bingüler, A.H.E. (2024). Innovation Strategies and the Business Perspective: A Synthesis of Existing Research and a Composed and Comprehensive Framework. *Journal of Organisational Studies & Innovation*, *Vol. 11, No. 1*, pp. 24-41, doi: 10.51659/josi.23.192
18. Dabic, M., González-Loureiro, M., Furrer, O. (2014). Research on the strategy of multinational enterprises: key approaches and new avenues. *BRQ Business Research Quarterly*, *Vol. 17, Iss. 2*, pp. 129-148, doi: 10.1016/j.brq.2013.09.001
19. de Medeiros, A.P., Lavarda, R.A.B., Erdmann, R.H. (2020). Strategy materiality and technology implementation practices in "Industry 4.0" context. *Revista Gestão & Tecnologia*, *Vol. 20, No.* 2, pp. 279-301, doi: 10.20397/2177-6652/2020.v20i2.1856
20. Denyer, D., Tranfield, D. 2009. Producing a Systematic Review. *The Sage Handbook of Organizational Research Methods*. Los Angeles: SAGE, pp. 671-689.
21. Dixit, S., Singh, S., Dhir, S., Dhir, S. (2021). Antecedents of strategic thinking and its impact on competitive advantage. *Journal of Indian Business Research*, *Vol. 13, Iss. 4*, pp. 437-458, doi: 10.1108/JIBR-08-2020-0262
22. Faraj, S., Leonardi, P.M. (2022). Strategic organization in the digital age: Rethinking the concept of technology. *Strategic Organization*, *Vol. 20, Iss. 4*, pp. 771-785, doi: 410.1177/14761270221130253
23. Faria, A.M.D., Kayo, E.K., Meireles, B.L., Borini, F.M., Oliveira, M.D.M. (2024). The effect of innovation and strategic resources on capital structure. *Revista de Administração de Empresas*, *Vol. 64, Iss. 6*, doi: 10.1590/S0034-759020240608
24. Gans, J.S., Kearney, M., Scott, E.L., Stern, S. (2021). Choosing technology: An entrepreneurial strategy approach. *Strategy Science*, *Vol. 6, No. 1*, pp. 39-53, doi: 10.1287/stsc.2020.0115

25. Geier, M.T. (2024). Strategic thinking: theoretical development and assessment. *Journal of strategy and management*, *Vol. 17, Iss. 1*, pp. 1-21, doi: 10.1108/JSMA-10-2021-0212
26. Geissinger, A., Laurell, C., Öberg, C., Sandström, C., Sick, N., Suseno, Y. (2021). Social media analytics for knowledge acquisition of market and non-market perceptions in the sharing economy. *Journal of Knowledge Management*, *Vol. 25, Iss. 2*, pp. 500-512, doi: 10.1108/JKM-01-2020-0038
27. Ginanneschi, M. (2021). Long-term strategic thinking, the Themis method and the future of food. *Technological Forecasting and Social Change*, *Vol. 165*, doi: 10.1016/j.techfore.2020.120468
28. Goldman, E.F. (2012). Leadership practices that encourage strategic thinking. *Journal of Strategy and Management*, *Vol. 5, Iss. 1*, pp. 25-40, doi: 10.1108/17554251211200437
29. Goldman, E.F., Scott, A.R., Follman, J.M. (2015). Organizational practices to develop strategic thinking, *Journal of Strategy and Management, Vol. 8 No. 2*, pp. 155-175, doi: 10.1108/JSMA-01-2015-0003
30. Gonzalez-Benito, J., Suárez-González, I., González-Sánchez, D. (2022). Human resources strategy as a catalyst for the success of the competitive strategy: an analysis based on alignment. *Personnel Review*, *Vol. 51, Iss. 4*, pp. 1336-1361, doi: 10.1108/PR-04-2020-0254
31. Haiyan, D., Ahmed, K., Nanere, M. (2021). Life cycle, competitive strategy, continuous innovation and firm performance. *International Journal of Innovation Management*, *Vol. 25, No. 01*, doi: 10.1142/S1363919621500043
32. Hofmann, P., Meierhöfer, S., Müller, L., Oberländer, A.M., Protschky, D. (2026). Conceptualizing the Design Space of Artificial Intelligence Strategy: A Taxonomy and Corresponding Clusters. *Business & Information Systems Engineering*, *Vol. 68, No. 2*, pp. 401-430, doi: 10.1007/s12599-025-00941-7
33. Imbrogno, J.P., Parnell, J.A., Staggs, T.B., Scott, J.T. (2025). The cost of conformity: How deviating from norms increases performance potential. *Journal of Management & Organization*, *Vol. 32, Iss. 3*, pp. 853-868, doi: 10.1017/jmo.2025.10038
34. Karami, A., Gorzynski, R.A. (2022). Connection to nature and sustainability in small- and medium- sized environmental organizations: A dynamic strategic thinking approach. *Business Strategy and the Environment*, *Vol. 31, Iss. 1*, pp. 371-389, doi: 10.1002/bse.2898
35. Khalifa, A.S. (2020). Strategy: restoring the lost meaning. *Journal of Strategy and Management*, *Vol. 13, Iss. 1*, pp. 128-143, doi: 10.1108/JSMA-09-2019-0158
36. Kuckertz, A., Block, J. (2021). Reviewing systematic literature reviews: ten key questions and criteria for reviewers. *Management Review Quarterly*, *Vol. 71, Iss. 3*, pp. 519-524, doi: 10.1007/s11301-021-00228-7
37. Laihonen, H., Huhtamäki, J. (2023). Organisational hybridity and fluidity: deriving new strategies for dynamic knowledge management. *Knowledge Management Research & Practice*, *Vol. 21, Iss. 2*, pp. 216-228, doi: 10.1080/14778238.2020.1794993

38. Lanzolla, G., Markides, C. (2021). A business model view of strategy. *Journal of Management Studies*, *Vol. 58, Iss. 2*, pp. 540-553, doi: 10.1111/joms.12580
39. Ledi, K.K., Dumeda, R.B., Bandoma, S., Ameza-Xemalordzo, E. (2024). Strategic thinking and innovation as panaceas for hotel performance in turbulent business environments. *Cogent Business & Management*, *Vol. 11, Iss. 1*, doi: 10.1080/23311975.2024.2328330
40. Lichtarski J. M., Piorkowska K., Witek-Crabb A., Wrona S. (2025). Strategic thinking and strategic thinkers: Research in progress on the typology identification. In: S. Soliman Khalid (Eds.), *Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage*. Proceedings of the 34th international business information management association conference (IBIMA) (pp. 10185-10191). International Business Information Management Association.
41. Lim, L.K. (2013). Mapping competitive prediction capability: Construct conceptualization and performance payoffs. *Journal of Business Research*, *Vol. 66, Iss. 9*, pp. 1576-1586, doi: 10.1016/j.jbusres.2012.09.021
42. Lopez-Cabrales, A., DeNisi, A. (2021). The road to more sustainable firms in the face of a pandemic: Changes needed in employment relationships. *BRQ Business Research Quarterly*, *Vol. 24, Iss. 3*, pp. 241-248, doi: 10.1177/23409444211017913
43. Mantere, S., Sillince, J.A. (2007). Strategic intent as a rhetorical device. *Scandinavian Journal of Management*, *Vol. 23, Iss. 4*, pp. 406-423, doi: 10.1016/j.scaman.2007.03.002
44. Marzi, G., Balzano, M., Caputo, A., Pellegrini, M.M. (2025). Guidelines for bibliometric-systematic literature reviews: 10 steps to combine analysis, synthesis and theory development. *International Journal of Management Reviews*, *Vol. 27, Iss. 1*, pp. 81-103, doi: 10.1111/ijmr.12381
45. Mateu, J. M., March-Chorda, I. (2016). Is experience a useful resource for business model innovation? *Technology Analysis & Strategic Management*, *Vol. 28, Iss. 10*, pp. 1195-1209, doi: 10.1080/09537325.2016.1182630
46. Meyer, R. (2007), *Mapping the Mind of the Strategist. A Quantitative Methodology for Measuring the Strategic Beliefs of Executives*, Rotterdam: Erasmus Research Institute of Management (ERIM), pp. 43-58.
47. Mirabeau, L., Maguire, S., Hardy, C. (2018). Bridging practice and process research to study transient manifestations of strategy. *Strategic Management Journal*, *Vol. 39, Iss. 3*, pp. 582-605, doi: 10.1002/smj.2732
48. Moon, B.J. (2013). Antecedents and outcomes of strategic thinking. *Journal of business research*, *Vol. 66, Iss. 10*, pp. 1698-1708, doi: 10.1016/j.jbusres.2012.11.006
49. Norzailan, Z., Yusof, S.M., Othman, R. (2016). Developing strategic leadership competencies. *Journal of Advanced Management Science Vol, 4, No. 1*, pp. 66-71, doi: 10.12720/joams.4.1.66-71

50. Novelli, E., Spina, C. (2024). Making business model decisions like scientists: Strategic commitment, uncertainty, and economic performance. *Strategic Management Journal*, *Vol. 45, Iss. 13*, pp. 2642-2695, doi: 10.1002/smj.3636
51. Nuntamanop, P., Kauranen, I., Igel, B. (2013). A new model of strategic thinking competency. *Journal of Strategy and Management*, *Vol. 6, Iss. 3*, pp. 242-264, doi: 10.1108/JSMA-10-2012-0052
52. Obeidat, A.M. (2025). Enhancing innovative performance through strategic thinking: The moderating effect of the high-performance work practices. *Human Systems Management*, doi: 10.1177/01672533251390729
53. Obłój, K. (2007). *Strategia organizacji.* Warszawa: PWE, pp. 327-332.
54. Odita, A.O., Bello, A. (2015). Strategic intent and organizational performance a study of banks in Asaba, Delta state Nigeria. *Information and Knowledge Management, Vol. 5, No. 4*, pp. 60-71.
55. Paul, J., Menzies, J. (2023). Developing classic systematic literature reviews to advance knowledge: Dos and don'ts. *European Management Journal*, *Vol. 41, Iss. 6*, pp. 815-820, doi: 10.1016/j.emj.2023.11.006
56. Pereira, Á., Vence, X. (2012). Key business factors for eco-innovation: an overview of recent firm-level empirical studies. *Cuadernos de gestión*, *Vol. 12*, pp. 73-103, doi: 10.5295/cdg.110308ap
57. Phuong, N.T.H. (2024). Business strategy concept: a systematical review. *Journal of Knowledge Learning and Science Technology*, *Vol. 3, Iss. 2*, pp. 128-142, doi: 10.60087/jklst.vol3.n2.p148
58. Pisapia J., Morris J.D., Cavanaugh G., Ellington L. (2011), *The Strategic Thinking Questionnaire: Validation and Confirmation of Construct.* The 31st SMS Annual International Conference, Miami, Florida.
59. Poazi, F.D.W. (2026). Understanding the Concept of Business Strategy: A Systematical Review. *American Journal of Entrepreneurship, Economics and Management, Vol. 12, No. 1,* pp. 119-125.
60. Prataviera, L.B., Creazza, A., Perotti, S., Rodrigues, V.S. (2025). How to align logistics environmental sustainability with corporate strategy? An Italian perspective. *International journal of logistics research and applications*, *Vol. 28, Iss. 9*, pp. 931-953, doi: 10.1080/13675567.2023.2230916
61. Reece S. (2008), Strategic thinking – Leaders vary in their approach to strategy. *Executive Excellence*, *Vol. 25, No. 19*, pp. 122-154.
62. Rojon, C., Okupe, A., McDowall, A. (2021). Utilization and development of systematic reviews in management research: what do we know and where do we go from here? *International Journal of Management Reviews*, *Vol. 23, Iss. 2*, pp. 191-223, doi: 10.1111/ijmr.12245

63. Ronda-Pupo, G.A., Guerras-Martin, L.Á. (2012). Dynamics of the evolution of the strategy concept 1962-2008: a co-word analysis. *Strategic Management Journal*, *Vol. 33, Iss.* 2, pp. 162-188, doi: 10.1002/smj.948
64. Rowe, W.G., Nevmerzhytskyi, S. (2025). Demonstrating the importance of the strategy implementation process to an entire organization. *Organizational Dynamics*, *Vol. 54, Iss. 4*, doi: 10.1016/j.orgdyn.2025.101153
65. Rybicki, J. (2012). Holistyczny model strategii przedsiębiorstwa. *Organizacja i Kierowanie*, *No. 1A(149),* pp. 87-96.
66. Rybicki, J. (2023). Inteligencja strategiczna w procesie myślenia i działania strategicznego–rozważania terminologiczno-systematyzujące. *Journal of Modern Science*, *Vol. 52, No. 3*, pp. 152-171, doi: 10.13166/jms/173461
67. Sasaki, I., Kotlar, J., Ravasi, D., Vaara, E. (2020). Dealing with revered past: Historical identity statements and strategic change in Japanese family firms. *Strategic Management Journal*, *Vol. 41, Iss. 3*, pp. 590-623, doi: 10.1002/smj.3065
68. Sauer, P.C., Seuring, S. (2023). How to conduct systematic literature reviews in management research: a guide in 6 steps and 14 decisions. *Review of Managerial Science*, *Vol. 17*, pp. 1899-1933, doi: 10.1007/s11846-023-00668-3
69. Snihur, Y., Eisenhardt, K.M. (2022). Looking forward, looking back: Strategic organization and the business model concept. *Strategic Organization*, *Vol. 20, Iss. 4*, pp. 757-770, doi: 10.1177/14761270221122442
70. Srivastava, S., Atinc, G., Taneja, S. (2026). Strategic Thinking and Entrepreneurial Orientation: The Relationship and Role in Product Performance. *The Journal of Entrepreneurship*, *Vol. 35, Iss. 1*, pp. 70-105, doi: 10.1177/09713557261420849
71. Srivastava, S., D'Souza, D. (2020). An empirical examination of the relationship between managerial strategic thinking and absorptive capacity of the organization. *Journal of Strategy and Management*, *Vol. 13, Iss. 1*, pp. 51-71, doi: 10.1108/JSMA-05-2019-0077
72. Štefan, S., Branislav, Z. (2016). Relationship between business strategy and business model studied in a sample of service companies. *Journal of Competitiveness*, *Vol. 8, Iss. 4*, pp. 72-84, doi: 10.7441/joc.2016.04.05
73. Sundström, A., Svärdsten, F. (2026). Modes of strategic control: shifting dynamics between planning and control tools in strategy implementation. *Public Management Review*, *Vol. 28, Iss. 4*, pp. 1062-1086, doi: 10.1080/14719037.2025.2492299
74. Trantopoulos, K., Woerter, M., von Krogh, G. (2024). Open innovation during the 2008 financial crisis. *Industry and Innovation*, *Vol. 31, Iss. 2*, pp. 159-182, doi: 10.1080/13662716.2023.2228724
75. Villarreal Archiva, S.M., Pardo Pérez, K.S. (2020). The effects of business strategies on the financial performance of the rubber and plastic industries. *Cuadernos de Administración (Universidad del Valle)*, *Vol. 36, Iss. 67*, pp. 109-125, doi: 10.25100/cdea.v36i67.8724

76. Wang, C., Brabenec, T., Gao, P., Tang, Z. (2021). The business strategy, competitive advantage and financial strategy: A perspective from corporate maturity mismatched investment. *Journal of Competitiveness*, *Vol. 13, Iss. 1*, pp. 164-181, doi: 10.7441/joc.2021.01.10
77. Yepes-Jiménez, I., Valle-Robles, J., Ramírez, J., Roa-Barros, J. (2023). Analysis of the implementation of management strategies in the agribusiness sector in Colombia. *Polish Journal of Management Studies*, *Vol. 28, No. 2*, pp. 441-456, doi: 10.17512/pjms.2023.28.2.25
78. Zahra, S. A., Nambisan, S. (2012). Entrepreneurship and strategic thinking in business ecosystems. *Business horizons*, *Vol. 55, Iss. 3*, pp. 219-229, doi: 10.1016/j.bushor.2011.12.004
79. Zorlu, K. (2018). Strategic thinking and dimensions of effective leadership. In: H. Dincer, Ü. Hacioglu, S. Yüksel (Eds.), *Strategic Design and Innovative Thinking in Business Operations: The Role of Business Culture and Risk Management* (pp. 173-188). Cham: Springer International Publishing.
80. Zsigmond, T., Machová, R., Zsigmondová, A. (2021). Strategic management from the perspective of SMEs operating in service sector. *Quality Innovation Prosperity*, *Vol. 25, Iss. 2*, pp. 37-53, doi: 10.12776/qip.v25i2.1549

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

CROWDSHIPPING IN LAST-MILE LOGISTICS: WILLINGNESS TO PERFORM DELIVERIES DURING DAILY TRIPS

Anna RYCHLIK[1], Roman DOMAŃSKI[2*]

[1] Faculty of Engineering Management, Poznan University of Technology; anna.rychlik@student.put.poznan.pl
[2] Faculty of Engineering Management, Poznan University of Technology; roman.domanski@put.poznan.pl, ORCID: 0000-0001-5861-4978
* Correspondence author

Purpose: Assessing the willingness of Poznań agglomeration residents to provide last-mile delivery services within a crowdshipping model during their daily commutes, thereby addressing the growing demand for sustainable urban logistics solutions.
Design/methodology/approach: The research objectives are achieved through a survey conducted on a statistically representative sample of 167 individuals within the Poznań agglomeration, examining the perspectives of potential crowdshipping service providers on the introduction of this delivery model.
Findings: The crowdshipping model demonstrates the greatest potential for small parcels located directly along the commuting routes of potential couriers, provided that attractive remuneration is guaranteed. Furthermore, the results highlight a necessity to find solutions to identified operational risks and barriers.
Research limitations/implications: The primary limitation of this study is its geographic focus on a single Polish agglomeration (Poznań) and a sample size of 167 respondents. Future research could expand both the geographic and demographic scope.
Practical implications: For entities seeking to implement this solution, the findings imply that platform operators must design robust, competitive remuneration, while actively mitigating perceived user risks to ensure operational viability.
Social implications: This research supports sustainable urban development and the deployment of the sharing economy by utilizing spare transport capacity, which can contribute to reducing urban traffic congestion and the carbon footprint of last-mile deliveries.
Originality/value: This paper addresses a significant gap in the literature, as empirical research on crowdshipping within the Polish context remains scarce. It delivers the first empirical assessment of supply-side willingness in the Poznań agglomeration. It offers essential benchmarks for logistics managers, platform developers, and urban policymakers.
Keywords: crowdshipping, crowd logistics, urban logistics, last-mile delivery, questionnaire survey.
Category of the paper: Research paper.

1. Introduction

Last mile is a crucial part of the supply chain. Customer satisfaction depends largely on it. At the same time, the last mile generates a significant part of delivery costs. In recent years, last mile deliveries are becoming more popular due to the constantly growing e-commerce market. The number of deliveries is rising. The customer expectations in terms of speed and flexibility of deliveries are increasing as well. Logistics companies are facing huge challenges regarding fulfilling customers requirement while simultaneously complying with environmental standards and reducing emissions. Conventional delivery models are proving to be insufficient.

Contemporary dilemmas in distribution logistics are not limited to the difficulty of meeting customer requirements and adhering to environmental regulations, but they also include numerous concerns associated with urban logistics. Traffic congestion, limited unloading space and noise are some further encountered obstacles. The literature features a number of innovative solutions designed to address contemporary challenges in the last-mile delivery market. Examples include autonomous and unmanned models, urban micro-hubs and cargo bikes. These represent only a fraction of the proposed solutions. Whilst autonomous vehicles and drones require enormous capital outlays and logistics infrastructure investments, there is untapped potential in solution such as crowdshipping. This model does not require substantial financial investment, as it relies on already existing resources.

Crowdshipping is grounded in the principles of sharing economy and is a part of crowd logistics. By definition, crowdshipping can offer a number of benefits. The model is premised on leveraging underutilized resources, such as empty space within a vehicle, and delivering parcels without generating new routes. Crowdshipping aligns with the principles of sustainable development, as it includes its three main elements- environmental, economic and social. However, crowdshipping is still used to a very limited extent. In Poland it is not widely adopted, although start-ups offering crowdshipping services are beginning to emerge (Strulak-Wójcikiewicz, Wagner, 2021).

The decision to explore this research area was driven by crowdshipping's strong alignment with current trends in urban mobility. In the opinion of the authors of this article, it has the potential to resolve many of the previously mentioned urban logistics issues. Crowdshipping is a relatively new concept – by far, few articles have been written on the subject. Furthermore, an even narrower research gap has been identified, as only a limited number of studies investigate crowdshipping in Poland. From a cognitive perspective, it is worthwhile to investigate whether there would be interest in the concept of crowdsourced deliveries. The authors undertake the topic of crowdshipping form the perspective of potential service providers.

This article aims to assess the readiness and willingness of residents of the agglomeration of Poznań to render delivery services using the crowdshipping model, carried out as part of their daily journeys. A complementary objective of this study is to identify the key factors (motivators and barriers) shaping the willingness to work of potential service providers. The findings presented in this article are intended to answer three research questions:

RQ1: Would the residents of the agglomeration of Poznań be willing to work as 'crowdshippers'?

RQ2: What operational conditions would need to be fulfilled for crowdshipping to have implementation potential from the perspective of potential service providers?

RQ3: What are the main barriers to implementing a crowdshipping model?

The article consists of the following sections: a review of the literature on crowdshipping, a description of the materials and methods used, a presentation of the results of original research findings, a summary with conclusions and an outline of future research directions.

2. Literature review

The literature review was conducted in December 2025 and January 2026 using the Scopus database, which enables users to search for publications from peer-reviewed sources. A total of 173 publications related to the term 'crowdshipping' were identified, of which only 6 concerned Poland. There were no articles found concerning the agglomeration of Poznań or the city of Poznań in the context of crowdshipping. In recent years, there has been a noticeable increase in the number of articles related to crowdshipping, which is examined from various perspectives (Mohri et al., 2023).

Crowdshipping falls under the umbrella of crowd logistics, defined as "the outsourcing of logistics services to a mass of (not necessarily business) actors, whereby the coordination is supported by a technical platform, which is hosted and managed by a crowd logistics provider" (Frehe, Mehmann, Teuteberg, 2017).

There are many definitions of crowdshipping proposed in the literature. Authors define crowdshipping as:

- "an app-based platform that connects an individual wanting to ship a packet with an individual willing to carry the shipment in the first or last mile logistics of urban areas; a key distinction of the courier (i.e. CS driver-partner) as discussed in this research is that this is not necessarily an additional trip but a trip that leverages the typical travel patterns of the courier; the selected courier may be the closest to the delivery route, offer the cheapest delivery fee, or have the best reputation in the system" (Le, Ukkusuri, 2019);

- "crowdshipping is a goods delivery service that is outsourced to occasional carriers drawn from the public of private travelers and is coordinated by a technical platform to achieve benefits for the involved stakeholders" (Punel, Stathopoulos, 2017).

In the context of the issues discussed in this article, the authors consider the following definition to be the most applicable: "crowdshipping is an information connectivity enabled marketplace concept that matches supply and demand for any kind of transportation of goods with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis, and is compensated accordingly" (Buldeo Rai et al., 2017).

Existing research on crowdshipping focuses both the perspective of potential service providers – the supply side – and that of service users – the demand side. The topic is also analysed in the context of sustainable development (Mohri et al., 2023), which is one of the key challenges for modern urban logistics. The subject has also been examined from the perspective of the socio-demographic characteristics of potential 'crowdshippers' (Bajec et al., 2025).

Survey questionnaire has been used as a research tool in numerous publications (Punel, Ermagun, Stathopoulos, 2018; Le, Ukkusuri, 2019; Bajec, Pivtorak, Svadlenka, 2025; Bajec, Podovšovnik, 2025; Zhou, Rasouli, Wong, 2025). The authors investigated: key factors influencing the willingness to work of potential 'crowdshippers' (Bajec, Podovšovnik, 2025), individuals' willingness to deliver parcels within specific delivery scenarios (Le, Ukkusuri, 2019; Bajec, Pivtorak, Svadlenka, 2025), barriers affecting the willingness to work as a 'crowdshipper' (Bajec, Pivtorak, Svadlenka, 2025) and determinants of crowdshipping usage based on differences between users and non-users of crowdshipping (Punel, Ermagun, Stathopoulos, 2018).

Authors examining crowdshipping in the Polish context have investigated the potential for integrating electric vehicles and crowdshipping systems into urban logistics (Deja et al., 2024), the integration of automated intelligent parcel locker systems, distribution networks, crowdshipping, last-mile deliveries and supply chain management (Sawik, 2024), the potential of sharing economy in the context of goods delivery within Polish cities, crowd logistics and its impact on sustainable urban logistics in the context of legal framework (Kulińska E., Kulińska K., 2019), and a new delivery model integrating a professional delivery fleet with crowdshipping, which is expected to contribute to reducing the total cost of delivery (Gdowska, Viana, Pedroso, 2018). Studies addressing crowdshipping in Poland have employed a variety of research methods such as: case studies, simulation, surveys and stochastic modelling.

In order to assess the potential of crowdshipping, the authors of this article, in line with other scholars, employ a survey-based research method. Understanding the perspective of potential service providers is extremely valuable in this context. The topic of individuals' willingness to work as 'crowdshippers' has already been addressed in previous studies, but none of the studies have focused on the agglomeration of Poznań or the city of Poznań.

3. Methods

For the purpose of evaluating the potential for implementing crowdshipping for parcel deliveries in the city, the standpoint of potential service providers was examined. A questionnaire was developed using Google Forms. An online survey form was designed, divided into five distinct sections: Introduction to the study, socio-demographic profile, driver profile and route characteristics, willingness to participate in crowdshipping (opportunities) and barriers to crowdshipping implementation (threats). The survey aimed to examine the readiness of individuals in the agglomeration of Poznań to perform parcel deliveries as a part of crowdshipping, along with the key enablers and barriers to the functioning of this model. It included single-choice and multiple-choice questions. A five-point Likert scale was used. The questions were mainly closed-ended, with a few allowing respondents to select the 'other' option and provide their own answer. This was intended to facilitate obtaining unambiguous responses that were easy to analyse further. The total number of questions was 25.

The research subjects were adult residents of the agglomeration of Poznań who regularly travel around Poznań or commute to Poznań as part of their daily routine. This specific group was selected as potential service providers. For the purposes of this article, the geographical scope of the Poznań agglomeration was adopted, corresponding to the territory of the Poznań Metropolis Association. This area encompasses the city of Poznań, the municipalities of Poznań County, as well as Oborniki, Skoki, Szamotuły, and Śrem. Based on data from the Central Statistical Office, the size of the study population was determined to be 896 163 individuals (Local Data Bank, 2026). Due to the absence of more recent data, population statistics for the year 2024 were adopted. Assuming a significance level of 5%, which ensures 95% certainty that the results obtained from the sample will be consistent with reality, and an allowable estimation error of 8%, the sample size is 151, which indicates the minimum number of surveys that needed to be conducted. An allowable estimation error of 8% was adopted, as this is the closest error value for which the sample is statistically valid. A total of 167 correctly completed surveys were collected, indicating that the survey was statistically representative.

The survey questionnaire was distributed through social media (Facebook). It was conducted throughout January and February 2026. It was anonymous. The results of the survey will be presented in the next section of the article.

4. Results and discussion

The aim of the survey was to gain insight into the attitudes of the Poznań agglomeration residents concerning the possibility of taking on the role of a 'crowdshipper'. The survey provided information on the preferences and concerns of individuals regarding crowdshipping. This article presents an analysis of the responses to selected questions from the online survey. A total of 167 completed questionnaires were obtained.

In terms of gender distribution, the sample comprised 55.1% female and 43.1% male respondents, with the remaining 1.8% of respondents selecting the option "other/prefer not to say". The largest age group among respondents was those aged 18-24 (43,1%). The second largest group consisted of those aged 25-34 (25,7%). Regarding employment status, employed individuals accounted for 57,5% of the respondents, followed by students at 38,3%, while the remaining 4,2% were unemployed or retired. Over half of those taking part in the survey live in the city of Poznań. The most frequently indicated trip purpose was commuting to work. Individuals travelling by car accounted for 52,7% of the respondents, while 41,3% reported using public transport. Only a small proportion of respondents (6,0%) indicated travelling by bicycle, scooter, or on foot.

At the beginning of the survey, respondents were asked about their familiarity with the concept of crowdshipping (Figure 1). As many as 74,3% of respondents encountered the concept for the first time. Only 13,8% were familiar with it. Given that crowdshipping is a relatively new concept and the crowdsourced delivery model itself is not yet widely adopted in Poland, the observed distribution of responses appears to be reasonable. The findings regarding familiarity with the concept of crowdshipping are similar to those obtained by researchers studying crowdshipping in other European countries. The authors found that around 60–70% of residents in Slovenia, the Czech Republic and Ukraine are unfamiliar with this delivery method or do not have sufficient knowledge of it (Bajec et al., 2025). Awareness of the concept was also surveyed amongst students in Rome – the majority of whom had not encountered the term before (Mohri et al., 2023).

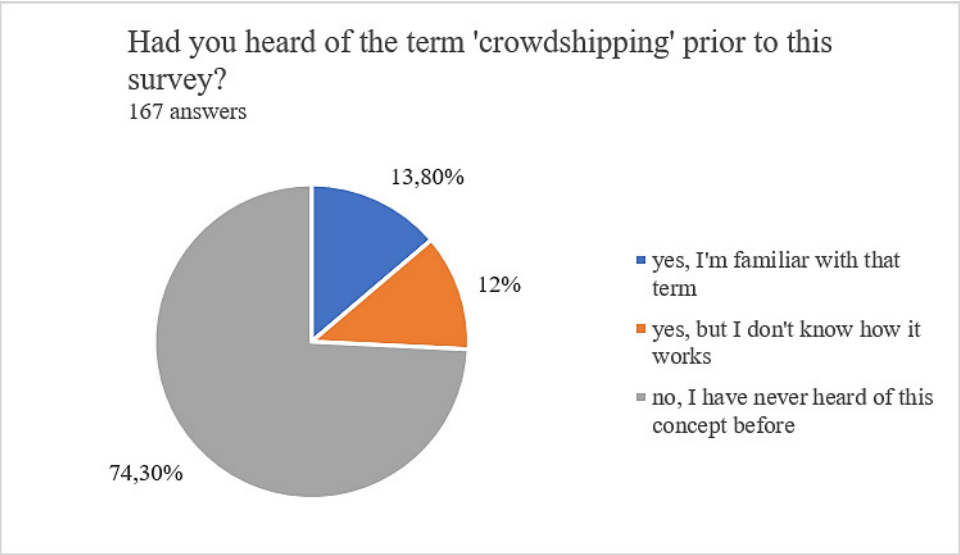


Figure 1. Familiarity with the term ‘crowdshipping’.

Source: compiled by the authors based on original survey data.

A fundamental question, crucial in the context of the conducted study, concerns respondent’s willingness to collect a small parcel and deliver it to its destination for a small fee, provided that the delivery point is located along their commuting route. This survey question addressed the first research question (RQ1). 62,9% of respondents expressed a willingness to perform such a delivery (Figure 2). Assuming that those who were undecided (16.2%) did not identify themselves as outright opponents of the solution, three-quarters of respondents are potentially willing to engage in crowdshipping, which is a very optimistic result. Men expressed a greater willingness compared to women, though the difference between genders was small. Among age groups, the youngest respondents (18–24 years) showed the greatest willingness. Those in the oldest age group (65+) were the least willing to undertake deliveries. The authors investigated people’s willingness to engage in crowdshipping in other European countries – the results were very similar to those obtained in Poznań. The majority of respondents in the Czech Republic, Slovenia and Ukraine said they were willing to deliver parcels with varying degrees of regularity: 77,0% of Czechs, 77,0% of Slovenians and 86,0% of Ukrainians (Bajec et al., 2025). As many as 87,0% of students in Rome would also be willing to work as ‘crowdshippers’ (Mohri et al., 2023). The authors also investigated the willingness of people living outside Europe to engage in crowdshipping. These results were also similar to those obtained in Poznań – as many as 78,0% of respondents in the US were willing to work as ‘crowdshippers’ (Le, Ukkusuri, 2019).

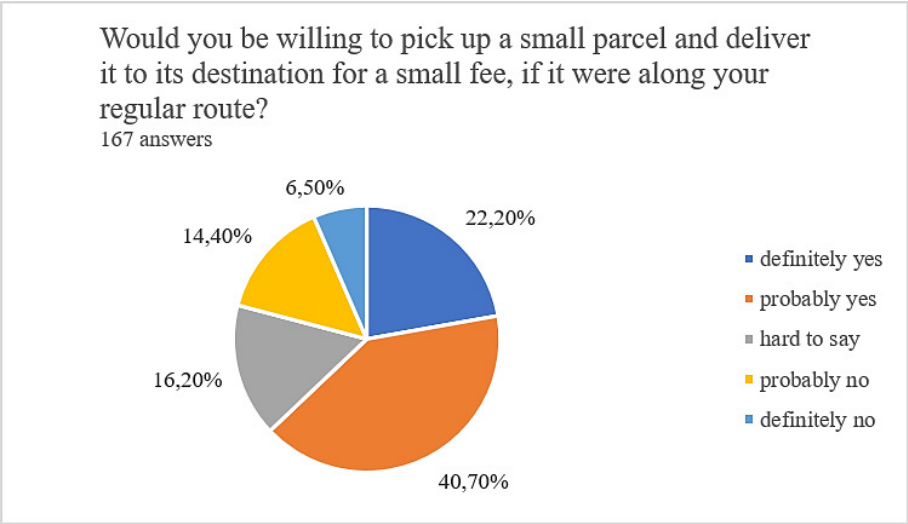


Figure 2. Willingness to participate in crowdshipping.

Source: compiled by the authors based on original survey data.

In order to assess the feasibility of implementing the delivery model in question, it is important to identify the conditions under which this service has the greatest operational potential. The next three survey questions relate to the second research question (RQ2). In the survey, respondents were asked about the specific conditions for carrying out crowdshipping if they were to undertake such a service. The largest proportion of respondents (44,9%) indicated a maximum allowable detour time of up to 5 minutes for the purpose of parcel pickup or delivery. The second most frequently selected option (29,9%) was a time range of up to 10 minutes. Respondents prefer the parcel to be on their route (16,8%), or are willing to make only a short detour to collect it (Figure 3). By way of comparison, students in Rome indicated that the maximum accepted deviation from their route is around 3 km (Mohri et al., 2023), whilst Americans indicated that an acceptable additional delivery time would be around 23 minutes (Le, Ukkusuri, 2019).

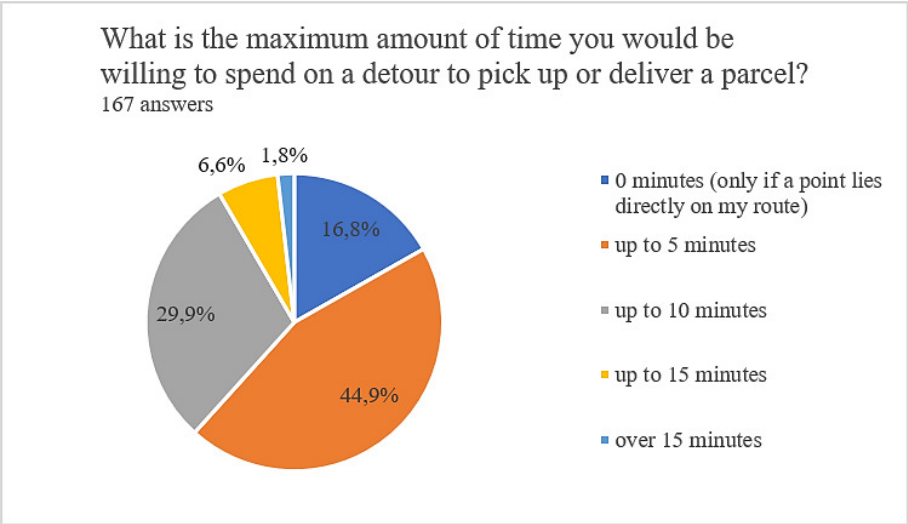


Figure 3. Maximum acceptable detour time in crowdshipping.

Source: compiled by the authors based on original survey data.

Crucial to the operational viability of delivery operations was also the question regarding the types (sizes) of parcels that respondents would be willing to carry. A significant correlation was observed between parcel size and people's willingness to carry them: the smaller the parcel, the greater the proportion of people who would agree to carry it. For example, as many as 86,2% of respondents would agree to transport envelopes weighing up to 3 kilograms, whereas only 1,8% would agree to transport oversized items (Figure 4).

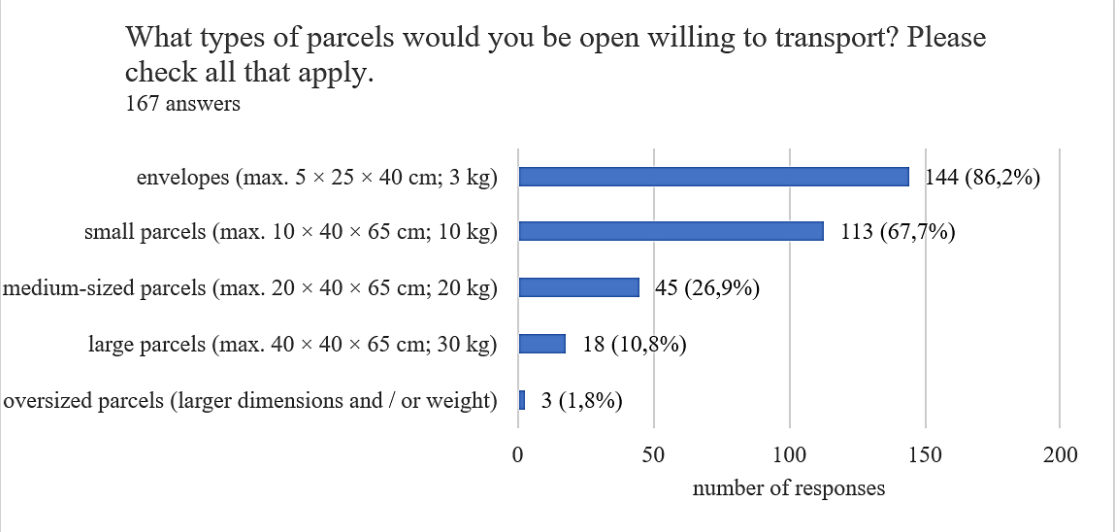


Figure 4. Preferences regarding the size and weight of parcels in crowdshipping.
Source: compiled by the authors based on original survey data.

Possible reasons for this distribution of responses include the issue of available resources – whether a potential delivery person has the space to load the parcel or is physically able to transport it – and the ease of delivery: a small, light parcel is much easier to transport than a large, heavy one. The vast majority of respondents stated that they travel by car or public transport. A larger parcel would probably fit in a car. However, public transport (without additional charges) limits the ability to carry parcels to smaller sizes only. Researchers studying crowdshipping in Europe point out that the large size of a parcel has a negative impact on individuals' willingness to undertake deliveries (Mohri et al., 2023). Most Americans, on the other hand, are willing to deliver any parcel provided they got paid (Le, Ukkusuri, 2019).

Respondents were then asked about their main motivation for undertaking crowdshipping deliveries. Extra income was the most frequently chosen option – as many as 71,3% of respondents selected it. Helping others was chosen by 16,8% of individuals, whilst a positive impact on the environment was selected by 9,6% of respondents (Figure 5). The financial aspect is frequently featured in other authors' studies as well – financial gain is a key factor in motivating people to work as 'crowdshippers' (Gdowska, Viana, Pedroso, 2018; Le, Ukkusuri, 2019; Mohri et al., 2023; Bajec, Pivtorak, Svadlenka, 2025; Bajec, Podovšovnik, 2025).

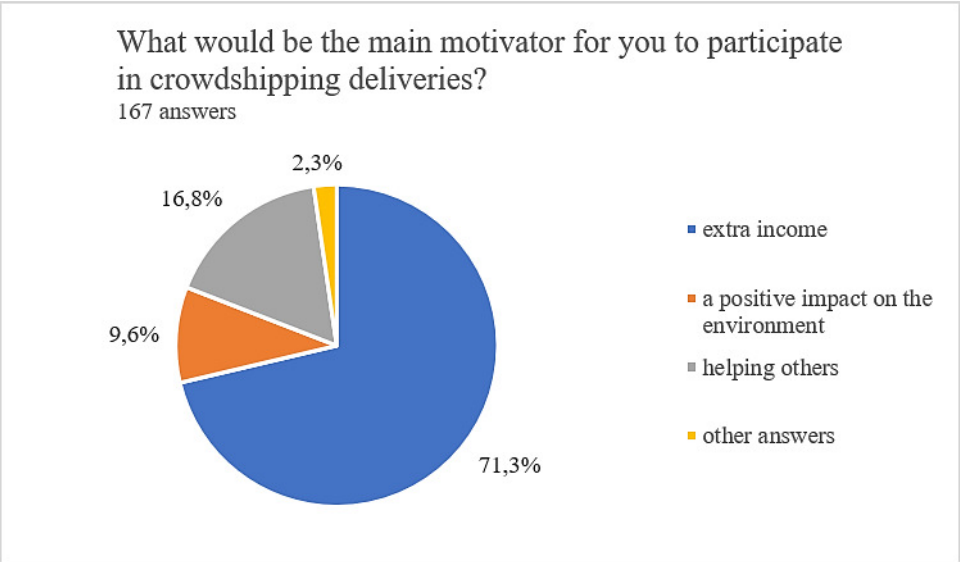


Figure 5. Motivators for undertaking crowdshipping deliveries.

Source: compiled by the authors based on original survey data.

Based on the questions in the 'opportunities' category, it can be concluded that the crowdshipping model has the greatest potential for small parcels located along the commuting routes of potential 'crowdshippers', provided that an appropriate (attractive) remuneration is offered for deliveries.

Six of the survey questions addressed the concerns that might be associated with performing a crowdshipping service. These survey questions corresponded to the third research question (RQ3). In order to identify potential barriers to crowdshipping service implementation, respondents were asked to rate the extent to which these concerns might apply to them – on a scale of 1 to 5, where 1 indicates little significance and 5 indicates great significance. The concerns respondents were asked about were: concerns about illegal contents of the parcel, concerns about contact with a stranger, concerns about parking facilities at collection/delivery points, concerns about the lack of appropriate legal framework, concerns regarding the further use of personal data, concerns regarding financial liability for parcel damage or loss, and concerns about remuneration being too low. According to the respondents' assessment, concerns regarding illicit package contents hold the greatest significance the most significant concerns relate to the illegal contents of parcels (Figure 6), financial liability for the parcel (Figure 7) and the further use of personal data (Figure 8) – only these will be discussed in the article.

The illicit content of parcels constitutes a substantial challenge – 61% of respondents report this issue. The chart shows that this concern is a major factor – ratings of 5 and 4 predominate (the right-hand side of the chart in Figure 6). Concerns about the illegal contents of parcels are also highlighted in studies by other authors. The fear of unknowingly delivering illegal or dangerous items has been identified as a major barrier amongst staff and students in Ukraine and the Czech Republic (Bajec, Pivtorak, Svadlenka, 2025). Research in the United States also reveals widespread concern about the contents of parcels (Le, Ukkusuri, 2019).

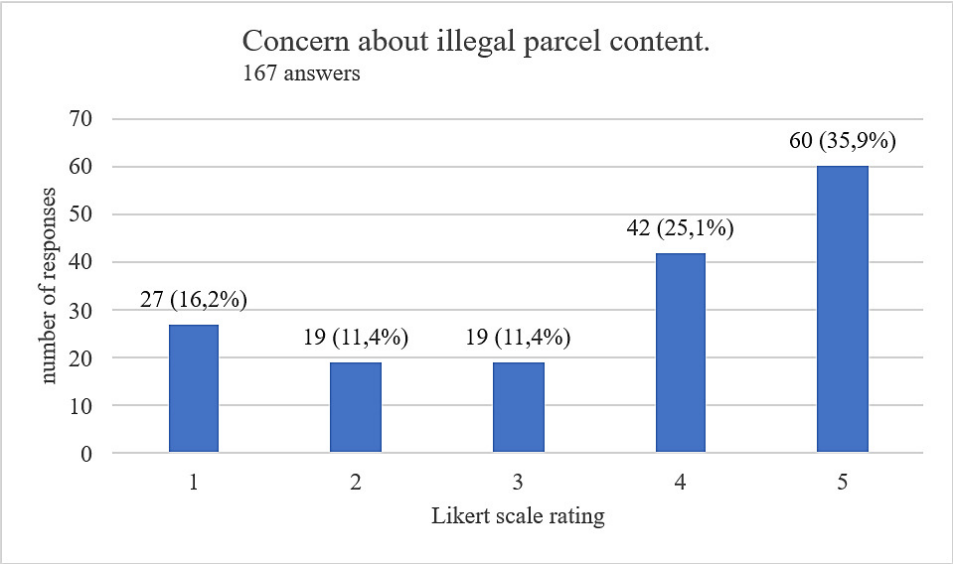


Figure 6. Concerns about illegal parcel contents in crowdshipping.

Source: compiled by the authors based on original survey data.

Financial liability for the transported parcel is also a major concern for respondents – 77,8% of those surveyed cited this as a concern. As in the previous chart, ratings of 5 and 4 predominate. In studies by other authors, financial risk and additional costs were also identified as barriers to undertaking crowdshipping deliveries (Bajec, Pivtorak, Svadlenka, 2025; Bajec, Podovšovnik, 2025).

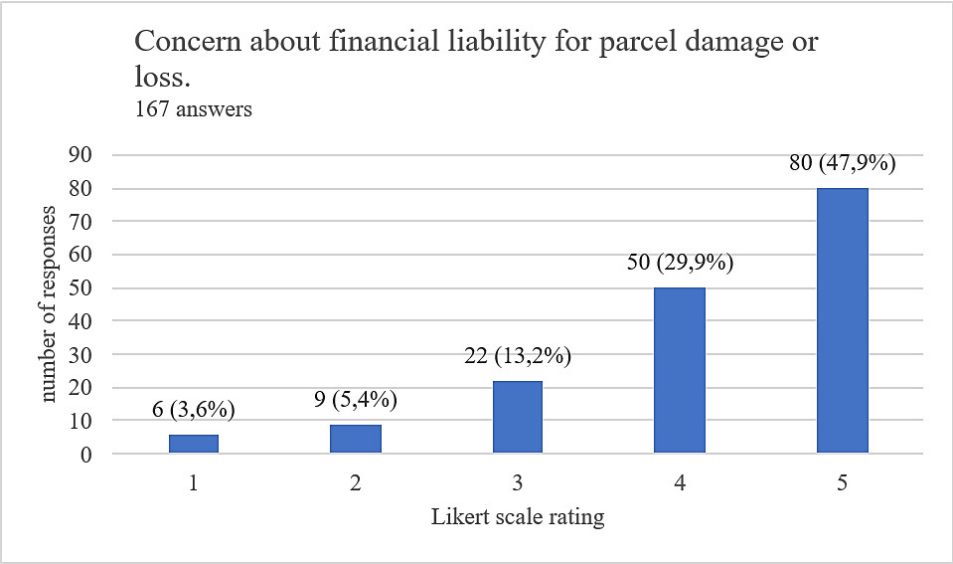


Figure 7. Concerns about financial liability for parcels in crowdshipping.

Source: compiled by the authors based on original survey data.

Respondents are also concerned about the unauthorised use of personal data – 53,9% are aware of this risk. A rating of 4 was the most commonly selected option, although ratings of 3 and 5 were also a frequent choice. It is noteworthy that financial liability for parcels represents another major concern. This concern has also been highlighted in studies by other authors (Mohri et al., 2023; Bajec, Pivtorak, Svadlenka, 2025; Bajec, Podovšovnik, 2025).

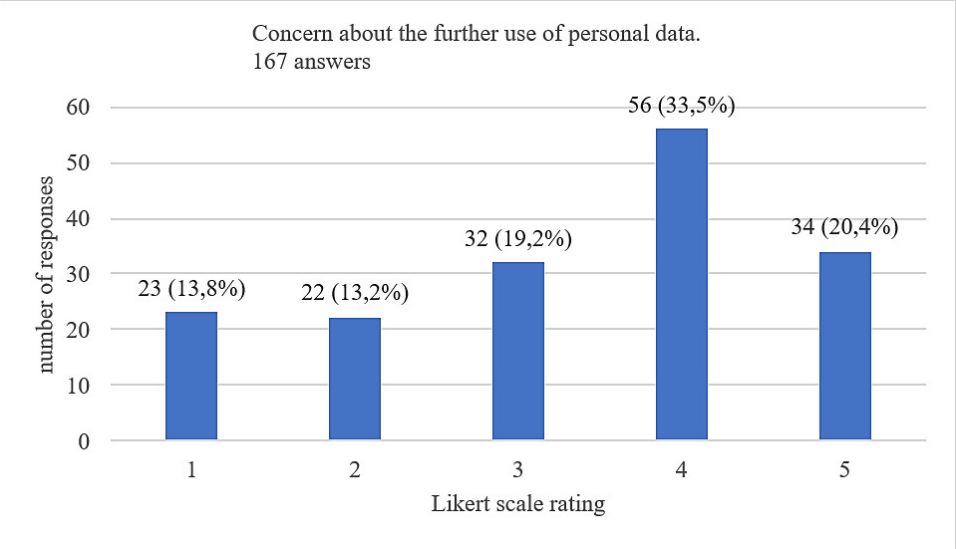


Figure 8. Concerns about the unauthorised use of personal data in crowdshipping.

Source: compiled by the authors based on original survey data.

Questions relating to risks highlight three significant barriers to this delivery model. There is a lack of trust. Respondents are concerned about the risk of illegal parcel contents. In the crowdshipping model, parcels are not checked by a sorting centre or any other entity. The delivery person never knows for certain what is inside the parcel. Furthermore, the concern regarding financial liability also emerges as critical. In the traditional delivery model, parcels are typically covered by insurance – similarly, the crowdsourced delivery model should also include parcel insurance. The survey results also indicate that data security is an important issue for respondents. Individuals fear that their personal data may be misused.

Both women and men cite the same three main concerns: financial liability, illegal parcel content and data misuse. However, women rate each of these concerns higher on a five-point scale.

5. Summary

The aim of this article was to assess the potential for implementing a crowdshipping service in the Poznań agglomeration. Based on the responses obtained from the survey, it is possible to identify the factors that influence the willingness to work of potential 'crowdshippers'. The study also identified the concerns of potential service providers, highlighting areas requiring particular attention during the implementation and development of this delivery model. The results obtained largely correspond with the findings of other researchers.

The survey responses reveal a lack of familiarity with the concept of crowdshipping. This last-mile delivery model has the potential to be implemented successfully, but it is essential to promote this model and raise awareness among potential users regarding the potential

benefits of its implementation. Despite low familiarity with the term, over 55% of respondents indicated a willingness to perform deliveries (RQ1).

The crowdshipping model has the greatest potential for small parcels located along the commuting routes of potential 'crowdshippers', provided that an appropriate (attractive) payment is offered for deliveries (RQ2). It is precisely this additional payment that is the main motivator cited by respondents. However, the survey results highlight the need to find solutions to the identified risks. The findings clearly indicate that the main barrier hindering the development of crowdshipping in the Poznań agglomeration is not a lack of physical readiness to deliver parcels, but a high perception of risk. A problem typical of the sharing economy – a lack of trust – arises. In addition, potential service providers fear the consequences of a parcel being lost or damaged. In an era of growing awareness of cybersecurity, potential suppliers are also concerned about data privacy – the fear of losing their anonymity (RQ3).

Unlocking the real potential for crowdshipping's market integration and operation requires addressing the identified risks. Entities seeking to implement a crowdshipping platform in the future must be aware of the potential service providers' concerns. In order to attract service providers, it will be essential to find solutions to the identified operational barriers. Specifically, the implementation of automated insurance policies and robust user verification protocols could significantly alleviate these anxieties. What is more, establishing a transparent legal framework is critical to fostering trust and ensuring long-term participant retention.

The study focused on the Poznań agglomeration, but the findings of this article are also applicable to other agglomerations and cities in Poland. Moreover, the research sample could be wider, which would result in greater certainty of the results (limitations). A comparative survey could also be conducted in other agglomerations to assess the potential for implementing crowdshipping.

This paper addresses a significant gap in the literature, as empirical research on crowdshipping within the Polish context remains scarce. It delivers the first empirical assessment of supply-side willingness in the Poznań agglomeration (new knowledge).

The research results are important for both platform developers seeking to implement crowdshipping solution (practical implications) and urban policymakers support sustainable urban development and the deployment of the sharing economy (social implications). This article thus responds to the growing demand for sustainable logistics solutions in cities. The research results have broad implications, so the information obtained should be used further.

Acknowledgements

This research was funded by the by the Polish Ministry of Science and Higher Education – project No. 0812/SBAD/4237.

References

1. Bajec, P., Pivtorak, H., Svadlenka, L. (2025). Research on Last-Mile Crowdshipping: Identification of Barriers Impacting Willingness-To-Work as a Crowdshipper Across Diverse Groups and Countries. *Transportation Research Procedia*, *90*, pp. 472-479, DOI: 10.1016/j.trpro.2025.06.118
2. Bajec, P., Pivtorak, H., Švadlenka, L., Vrba, R. (2025). Analyzing the characteristics of potential last-mile crowdshippers: insights from survey data in Slovenia, Ukraine, and the Czech Republic. *Transportation Research Procedia*, *83*, pp. 1-10, DOI: 10.1016/j.trpro.2025.02.003
3. Bajec, P., Podovšovnik, E. (2025). Evaluating Barriers and Enablers of Willingness-To-Work as a Crowdshipper – A Comparison of Business-To-Business and Business-To-Customer Models from a Slovenian Perspective, *Promet - Traffic&Transportation*, *37(2),* pp. 248-269, DOI: 10.7307/ptt.v37i2.916
4. *Bank Danych Lokalnych (Local Data Bank)* (2026). Retrieved from: https://bdl.stat.gov.pl/bdl/start, 15.02.2026.
5. Buldeo Rai, H., Verlinde, S., Merckx, J., Macharis, C. (2017). Crowd logistics: an opportunity for more sustainable urban freight transport? *European Transport Research Review*, *9(39),* pp. 1-13, DOI: 10.1007/s12544-017-0256-6
6. Deja, A., Ślączka, W., Kaup, M., Szołtysek, J., Dzhuguryan, L., Dzhuguryan, T. (2024). Supply Chain Management in Smart City Manufacturing Clusters: An Alternative Approach to Urban Freight Mobility with Electric Vehicles. *Energies*, *17(21),* 5284, pp. 1-27, DOI: 10.3390/en17215284
7. Frehe, V., Mehmann, J., Teuteberg, F. (2017). Understanding and assessing crowd logistics business models–using everyday people for last mile delivery. *Journal of Business and Industrial Marketing*, *32(1),* pp. 75-97, DOI: 10.1108/JBIM-10-2015-0182
8. Gdowska, K., Viana, A., Pedroso, J.P. (2018). Stochastic last-mile delivery with crowdshipping. *Transportation Research Procedia*, *30*, pp. 90-100, DOI: 10.1016/j.trpro.2018.09.011

9. Kulińska, E., Kulińska, K. (2019). Development of ride-sourcing services and sustainable city logistics, *Transportation Research Procedia*, *39*, pp. 252-259, DOI: 10.1016/j.trpro.2019.06.027
10. Le, T.V., Ukkusuri, S.V. (2019). Crowd-shipping services for last mile delivery: Analysis from American survey data. *Transportation Research Interdisciplinary Perspectives*, *1*, 100008, pp. 1-12, DOI: 10.1016/j.trip.2019.100008
11. Mohri, S.S., Ghaderi, H., Nassir, N., Thompson, R.G. (2023). Crowdshipping for sustainable urban logistics: A systematic review of the literature. *Transportation Research Part E: Logistics and Transportation Review*, *178*, 103289, pp. 1-22, DOI: 10.1016/j.tre.2023.103289
12. Punel, A., Ermagun, A., Stathopoulos, A. (2018). Studying determinants of crowd-shipping use, *Travel Behaviour and Society*, *12*, pp. 30-40, DOI: 10.1016/j.tbs.2018.03.005
13. Punel, A., Stathopoulos, A. (2017). Modeling the acceptability of crowdsourced goods deliveries: Role of context and experience effects. *Transportation Research Part E: Logistics and Transportation Review*, *105*, pp. 18-38, DOI: 10.1016/j.tre.2017.06.007
14. Sawik, B. (2024). Optimizing Last-Mile Delivery: A Multi-Criteria Approach with Automated Smart Lockers, Capillary Distribution and Crowdshipping, *Logistics*, *8(52),* pp. 1-29, DOI: 10.3390/logistics8020052
15. Strulak-Wójcikiewicz, R., Wagner, N. (2021). Exploring opportunities of using the sharing economy in sustainable urban freight transport. *Sustinable Cities and Society*, *68*, 102778, pp. 1-11, DOI: 10.1016/j.scs.2021.102778
16. Zhou, D., Rasouli, S., Wong, M. (2025), Understanding Travelers' Willingness to Participate in Crowd-sourced Parcel Delivery Based on a Stated Adaptation Choice Experiment. *9th International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS)*, pp. 1-6, DOI: 10.1109/MT-ITS68460.2025.11223522

SILESIAN UNIVERSITY OF TECHNOLOGYPUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIESNO. 253

INTEGRATED MANAGEMENT SYSTEM AND ITS RELATIONSHIP WITH THE IMPLEMENTATION OF THE MEDICAL FACILITY STRATEGY – CONCEPTUAL MODEL

Krzysztof SKOWRON

Silesian University of Technology, Faculty of Organization and Management; krzysztof.skowron@polsl.pl, ORCID: 0000-0001-5458-6738

Purpose: This article is another in a series of publications whose primary goal is to introduce the use of integrated management systems in healthcare facilities and their connection to strategy. Due to the broad scope of the topic, the primary research issue addressed in this study is to discuss how management system integration can impact the strategy of healthcare organizations. The primary goal, in turn, is to discuss the possibilities of integrating management systems and their potential impact on the implementation of the adopted strategy. Due to the nature of the article, the thesis is that management system integration serves as a strategy implementation mechanism in healthcare organizations.
Design/methodology/approach: The article is based on theoretical analysis and literature review.
Findings: The article describes the theoretical assumptions regarding integrated management systems, their premises and possibilities of application in medical facilities, defining the directions of further research.
Research limitations/implications: The presented content constitutes an outline of further research area.
Practical implications: The presented considerations and references to theories constitute the basis for further research, which will enable the identification of a possible impact on improving the management and quality of health services provided in medical facilities.
Social implications: Undertaking research based on the theoretical assumptions described should improve the management of medical facilities and more rational use of resources in order to improve the access to services and their quality and safety.
Originality/value: The article is addressed primarily to health care managers, as well as economists and public administration employees dealing with the issues of management in health care and public health.
Keywords: Healthcare system, Integrated Management Systems, quality, public management, strategic planning, strategic management, health strategies.
Category of the paper: General review.

1. Introduction

The concept of an "integrated management system" (IMS) – as is commonly known – does not have a single, universally accepted definition. However, an analysis of the literature allows for clear directions for its interpretation. Generally speaking, an IMS refers to the integration of various management areas within a single, coherent organizational system, encompassing objectives, processes, resources, and mechanisms for supervision and improvement.

The earliest and most classic definitions originate from the literature on the integration of quality and environmental systems. Karapetrovic and Willborn argued that integration involves combining separate management systems into a single, cooperative whole, while Karapetrovic's later work emphasized the importance of linking both standards and their corresponding organizational systems (Karapetrovic, Willborn, 1998; Karapetrovic, 2002). In this approach, an IMS primarily signifies the structural and functional interconnection of management subsystems.

The next stage in the development of the concept was brought about by the work of Wilkinson and Dale, who emphasized that integration should not be reduced to the formal combination of system documentation. These authors pointed out that the essence of an IMS is the creation of a coherent management concept encompassing organizational goals, processes, and practices (Wilkinson, Dale, 1999). This approach was further developed by Jørgensen, Remmen, and Mellado, who distinguished three levels of integration: system compatibility, process coordination, and integration based on organizational culture and learning (Jørgensen et al., 2006). Thus, integration was linked to organizational maturity, not just the formal level.

A significant expansion of the IMS definition was introduced by the work of Asif et al., who proposed a process-based and meta-management approach. In their view, an integrated management system should be designed around key organizational processes and stakeholder requirements, rather than around individual norms or standards (Asif et al., 2009, 2010). Integration therefore means jointly managing processes, resources, and governance mechanisms, leading to the creation of an overarching management architecture.

In the monographic literature, the IMS concept is developed towards a systems and strategic approach. Bugdol and Jedynak point out that an integrated management system can take various forms: from partial integration to full system integration, and its essence is the holistic management of an organization through shared goals, processes, and resources (Bugdol, Jedynak, 2015). A similar approach is presented by Nunhes, Bernardo, and Oliveira, who identify a set of guiding principles for IMS that enable the unification of research and practical approaches (Nunhes et al., 2019). Chountalas and Lagodimos, in turn, point out that contemporary IMS research is shifting from the issue of norm integration towards an analysis of the organizational value and strategic significance of integration (Chountalas, Lagodimos, 2024).

A resource-process approach has also emerged in recent literature. Ispas, Mironeasa, and Silvestri define IMS as a set of interconnected processes utilizing a common pool of human, informational, and material resources to achieve multiple goals for various stakeholders (Ispas et al., 2023). This approach emphasizes the importance of resource sharing and functional integration as key elements of the system. In Polish literature, however, definitions of integrated management systems are more unambiguous and normative. Grzesiak and Grzesiak define IMS as a single, coherent, and documented system enabling the simultaneous management of multiple aspects of an organization's operations through unified policies and goals (Grzesiak, Grzesiak, 2010). Łunarski, in turn, views integrated management systems as a tool supporting organizational management through the integration of standard systems (Łunarski, 2011). These approaches are complemented by the work of Łukasiński, who embeds IMS within the concept of pro-quality organizational development and maturity (Łukasiński, 2012, 2016).

Based on the literature review, four main definitional approaches to integrated management systems can be distinguished: normative, process, systemic-strategic, and cohesion (characteristic of the Polish literature). The normative approach focuses on the integration of standard requirements, the process approach on common management processes and mechanisms, the systems approach on the overall organizational architecture, and the cohesion approach emphasizes the uniformity of an organization's policies and goals. Consequently, it should be concluded that the contemporary understanding of integrated management systems goes beyond the simple integration of standards and documentation. IMS is currently viewed as an integrated management architecture encompassing processes, resources, goals, and stakeholders, enabling an organization to function effectively in a complex and multidimensional environment.

The concept of "strategy", in turn, is a key concept in management and quality sciences. However, as with integrated management systems, it lacks a single, universally accepted definition. In the literature, strategy is conceptualized as a plan of action, a pattern of behavior, a set of decisions, or a method for achieving competitive advantage. The diversity of these approaches stems from the evolution of strategic management theory and the changing organizational environment. One of the most classic definitions was formulated by Chandler, who defines strategy as the setting of long-term organizational goals and the adoption of courses of action and the allocation of resources necessary to achieve them (Chandler, 1962). In this approach, strategy is planning and structural in nature, and its essence lies in the rational alignment of organizational goals and resources.

A different approach was proposed by Porter, who defines strategy as a method of competing and building competitive advantage (Porter, 1980, 1985). In his view, the key factors are the organization's position in the environment and the ability to achieve above-average results through the appropriate selection of strategic actions. Strategy is closely linked to the analysis of the environment and sector.

A significant expansion of the concept of strategy was introduced by Mintzberg, who questioned its exclusively planning nature and proposed the concept of the so-called "5Ps of strategy". According to this approach, strategy can be understood as a plan, a pattern of action, a position, a perspective, and a maneuver (Mintzberg, 1987, 1994). The distinction between intended and emerging strategy is particularly important, which emphasizes the dynamic and adaptive nature of strategic management.

Contemporary literature expands on these approaches, emphasizing the importance of strategy as a tool for coping with environmental uncertainty and complexity. Grant points out that strategy encompasses not only the definition of goals and directions of action but also the organization's ability to adapt and utilize resources in changing conditions (Grant, 2022). Similarly, Johnson, Scholes, and Whittington conceptualize strategy as a long-term direction for an organization's development, taking into account the configuration of resources and stakeholder expectations (Johnson et al., 2020).

A process approach also appears in the literature, according to which strategy is not merely a document but a continuous process encompassing planning, implementation, and control of activities. This approach is developed, among others, by Ansoff, who views strategy as a set of decision-making rules defining an organization's relationships with its environment (Ansoff, 1965). Similarly, Kvint defines strategy as a system of actions aimed at achieving long-term goals in conditions of volatility and resource constraints (Kvint, 2009).

In Polish literature, definitions of strategy are consistent with international scholarship, but more often emphasize its practical and decision-making nature. Obłój defines strategy as a set of key choices regarding the organization's course of action and methods for building competitive advantage (Obłój, 2007). Krupski, on the other hand, views strategy as a process of managing the development of an organization, encompassing both planning and implementing activities in a changing environment (Krupski, 2008). In both approaches, strategy is a tool for shaping the organization's future through conscious choices.

Based on the literature review, four main definitional approaches to strategy can be distinguished. First, the planning approach, focusing on goals and resource allocation. Second, the competitive approach, emphasizing building market advantage. Third, the behavioral and emergent approach, emphasizing the dynamic nature of strategy. Fourth, the process and systems approach, conceptualizing strategy as a continuous process of managing an organization in relation to its environment. Consequently, it must be concluded that the contemporary understanding of strategy goes beyond its classical conception as an action plan. Strategy is now viewed as an integrated concept of organizational management, encompassing goals, resources, processes, and relationships with the environment, as well as a tool for adapting to conditions of uncertainty and complexity.

2. Contemporary research on integrated healthcare management

In the contemporary literature, strategic management in healthcare is evolving towards a systems-based, long-term, and adaptive approach. Healthcare organizations operate in conditions of high uncertainty and complexity, which requires a shift from short-term planning to a strategy based on systems thinking and the ability to continuously adapt (Huebner, 2022). Available research confirms that strategic planning remains significantly linked to organizational performance, but this relationship is indirect and depends on the implementation capabilities and resources of the organization. At the same time, it is indicated that the quality of management practices has a direct impact on the quality of healthcare (Ward et al., 2025). In Polish literature, this issue is analyzed primarily in the context of public sector reforms and the "New Public Management" concept, indicating that implementing public management tools leads to increased efficiency, but its effectiveness is strongly determined by the institutional and regulatory context (Klich, 2014; Frączkiewicz-Wronka Austen, 2011).

One of the key developments in the literature is the concept generally referred to as "integrated healthcare" (or "coordinated medicine"), which addresses the fragmentation of healthcare systems. This integration encompasses multiple levels, from the clinical to the systemic level, and aims to improve continuity of care and the patient experience (Hafiz et al., 2024; Barr, 2024). At the same time, available research indicates that the effects of integration are varied and depend on the systemic context and the adopted implementation models. It is worth noting that this concept is closely linked to the "value-based healthcare" (VBHC) approach, which focuses on maximizing health value through the integration of clinical outcomes and costs (De Mattia et al., 2024). However, implementing VBHC requires organizational transformation, including data integration, changes in financing models, and the development of performance measurement systems. Polish literature, on the other hand, emphasizes that implementing this concept encounters significant institutional and organizational barriers (Czerw, Pajewska, Partyka, 2023).

Another important area of research is integrated management systems, which encompass the integration of various organizational functions, such as quality, safety, process efficiency, and environmental aspects. Available research indicates that integrating quality and environmental management systems can lead to improved operational efficiency and the quality of patient care (Simion Luduşanu et al., 2025). Simultaneously, concepts of integrated safety management are being developed, which connect various levels of the healthcare system and emphasize the need for a holistic approach to patient safety (Vella Bonanno et al., 2025). The effectiveness of quality interventions depends on their integration with management practices and organizational culture (Hajiyeva, Jarl, Saha, 2025). It is worth emphasizing that in the Polish literature, these issues are mainly analyzed in a fragmented manner, which indicates the need to build comprehensive models integrating various management areas.

Performance measurement tools and organizational maturity models are essential elements of contemporary management systems. It has been pointed out that such a popular tool as the Balanced Scorecard has evolved into a tool supporting strategy implementation, not merely monitoring performance (Prenestini Lega, Masella, 2024). At the same time, the importance of maturity models is growing, allowing for the assessment of an organization's level of development across various dimensions, including management, processes, and technology (Aiwerioghene, Lewis, Rea, 2024).

In the literature on the subject, process management and the "Lean Healthcare" concept are gaining increasing importance. Available research indicates that its implementation leads to improved operational efficiency, quality of care, and cost reductions, but its effectiveness in this regard depends largely on the organization's ability to manage change (Talero-Sarmiento et al., 2024). Polish literature, however, emphasizes that this concept should be treated as a comprehensive management philosophy, not just a set of optimization tools (Rydlewska-Liszkowska, 2015).

The growing importance of information technology and knowledge management is also worth noting. Integration of IT systems influences workflow, care coordination, and the quality of decision-making (Cachata et al., 2024). Polish literature indicates that information systems constitute the foundation of knowledge management and support decision-making processes in healthcare organizations (Korczak, 2018).

Analysis of the available literature and research conducted to date indicates that contemporary healthcare management is integrated and multidimensional. Strategy, quality, safety, operational processes, and information technology form a coherent management system focused on creating value for patients. At the same time, a significant research gap is evident. The literature, particularly domestic literature, focuses on selected aspects of management, such as systemic reforms, Lean Healthcare, and knowledge management, while attempts to integrate them within a unified theoretical model are less common.

3. “Healthy Future”

The "Healthy Future" strategy is one of the key guiding documents for healthcare policy in Poland, setting a framework for the development of the healthcare system in the medium and long term. This strategy, introduced by the Act of December 6, 2006, on the Principles of Development Policy (consolidated text: Journal of Laws of 2021, item 1057, of 2022, item 1079, 1846), is part of a broader framework for strategic public health management, the aim of which is to increase the system's efficiency, improve the quality of services, and strengthen its resilience to demographic and epidemiological challenges.

The development of the "Healthy Future" strategy was a response to a number of significant systemic challenges, including an aging population, the growing number of chronic diseases, inequalities in access to services, and staffing and financial constraints within the system. Experiences related to the COVID-19 pandemic further spurred its development, highlighting the need to increase the flexibility and adaptability of the healthcare system. This strategy is also strongly linked to European Union policy, particularly in the areas of digital transformation, strengthening coordinated care, and improving the efficient use of public resources.

The "Healthy Future" strategy is based on several key pillars that guide the healthcare system. The first is the development of patient-centered care, particularly strengthening primary care and coordinated care. The goal is to ensure continuity of treatment and improve the patient experience through better integration of healthcare services. The second key area is the digital transformation of the healthcare system. This includes the development of e-health, the interoperability of information systems, and the use of medical data in decision-making processes. Digitalization is seen as a key factor in increasing the efficiency and accessibility of healthcare services. Another pillar of the strategy is the development of medical personnel. The document highlights the need to increase the number of healthcare professionals, improve working conditions, and strengthen competencies, particularly in the areas of new technologies and management. An equally important element is improving the quality and safety of healthcare services. The strategy assumes the development of quality monitoring systems, process standardization, and the implementation of tools for assessing treatment outcomes.

The "Healthy Future" strategy aligns with a modern approach to healthcare system management, characterized by the integration of various levels of governance and a focus on health value. This document moves away from a fragmented approach to reforms in favor of a comprehensive system transformation. From a strategic management perspective, linking health goals with financing mechanisms and performance measurement systems is particularly important. The strategy assumes a shift towards a value-based healthcare model, in which the relationship between health outcomes and costs is crucial.

However, it should be emphasized that despite the conceptual coherence of the "Healthy Future" strategy, its effective implementation is associated with a number of challenges. The most important include institutional constraints, staff shortages, system fragmentation, and the need to coordinate activities between different levels of public administration. Ensuring an appropriate system for monitoring and evaluating the strategy's implementation is also a significant challenge. Without effective evaluation mechanisms, it is difficult to ensure the achievement of the assumed goals and to implement necessary adjustments.

In summary, the "Healthy Future" strategy is a comprehensive concept for transforming Poland's healthcare system, responding to contemporary demographic, technological, and organizational challenges. Its significance extends beyond the operational dimension, providing a foundation for the long-term development of the system and improving the health of society.

4. Methods

Due to the conceptual nature of the study and the objective of developing a theoretical model explaining the relationship between integrated management systems and strategy implementation in healthcare organizations, a structured literature review was adopted as the primary research method. This approach was selected because the identified research problem concerns the integration of concepts originating from different research streams, including strategic management, integrated management systems, quality management, and healthcare management.

The literature selection process was conducted in several stages. First, publications addressing integrated management systems, strategic management, healthcare management, quality management, organizational integration, and strategy implementation were identified. Both international and Polish scientific literature were included in order to capture the evolution of concepts and to consider the specific institutional context of the Polish healthcare system. Preference was given to peer-reviewed journal articles, academic monographs, and widely recognized theoretical works representing the major streams of research.

The selection criteria included: thematic relevance to integrated management systems, organizational strategy, or healthcare management; scientific quality of the publication, reflected by publication in recognized scientific journals or academic publishers; conceptual or theoretical contribution to the analysed issues and relevance to the research objective of explaining the relationship between management system integration and strategy implementation. Priority was given to recent publications reflecting current developments in the field, while seminal theoretical works were included to provide the conceptual foundations of the analysis.

The analytical procedure consisted of four stages. First, the identified literature was reviewed to determine the main theoretical approaches and definitions relating to integrated management systems and organizational strategy. Second, a comparative analysis was conducted to identify similarities and differences between competing concepts and management models. Third, the results of the literature analysis were synthesized to identify the main dimensions linking strategy, organizational processes, resources, and management systems. Finally, deductive reasoning was applied to develop a conceptual model explaining how an integrated management system may support strategy implementation in healthcare organizations.

The analysis was complemented by a review of strategic documents, particularly the Polish "Healthy Future" strategy, in order to relate the theoretical findings to the current strategic framework of the national healthcare system. The document analysis served as contextual support rather than an independent empirical investigation.

The adopted methodological approach is exploratory and conceptual. Its purpose is not to empirically verify hypotheses but to integrate dispersed theoretical knowledge, identify existing research gaps, and develop a coherent conceptual framework that may serve as a basis for future empirical studies.

5. Conceptual model

This study is theoretical and conceptual in nature, and its goal is to identify and structure the relationship between management system integration and the implementation of a healthcare facility's strategy. The research approach adopted is based on a qualitative analysis of the relevant literature, as well as deductive and synthetic methods. This mechanism is presented in Figure 1.

The discussion presented above outlines the direction for research in this area. Therefore, it is advisable to propose a conceptual model based on a systems and process approach, according to which a healthcare facility is treated as a complex organizational system integrating strategic goals, operational processes, and resources. The model assumes that an integrated management system serves as a strategy implementation mechanism, not merely a tool for formally integrating standards.

This model incorporates three key assumptions:

- strategy determines the direction of the organization's activities,
- integrated Management System integrates processes and resources around strategic goals,
- organizational effects are the result of coherence between these elements.

It should be emphasized that the proposed model is layered and encompasses four basic levels:

The strategic level, which includes the following elements:

- strategic goals (e.g., quality of care, accessibility, efficiency),
- development directions resulting from the strategy (e.g., "Healthy Future"),
- stakeholder expectations (patients, regulator, staff).

The function of this level is to define what a given healthcare facility wants to achieve.

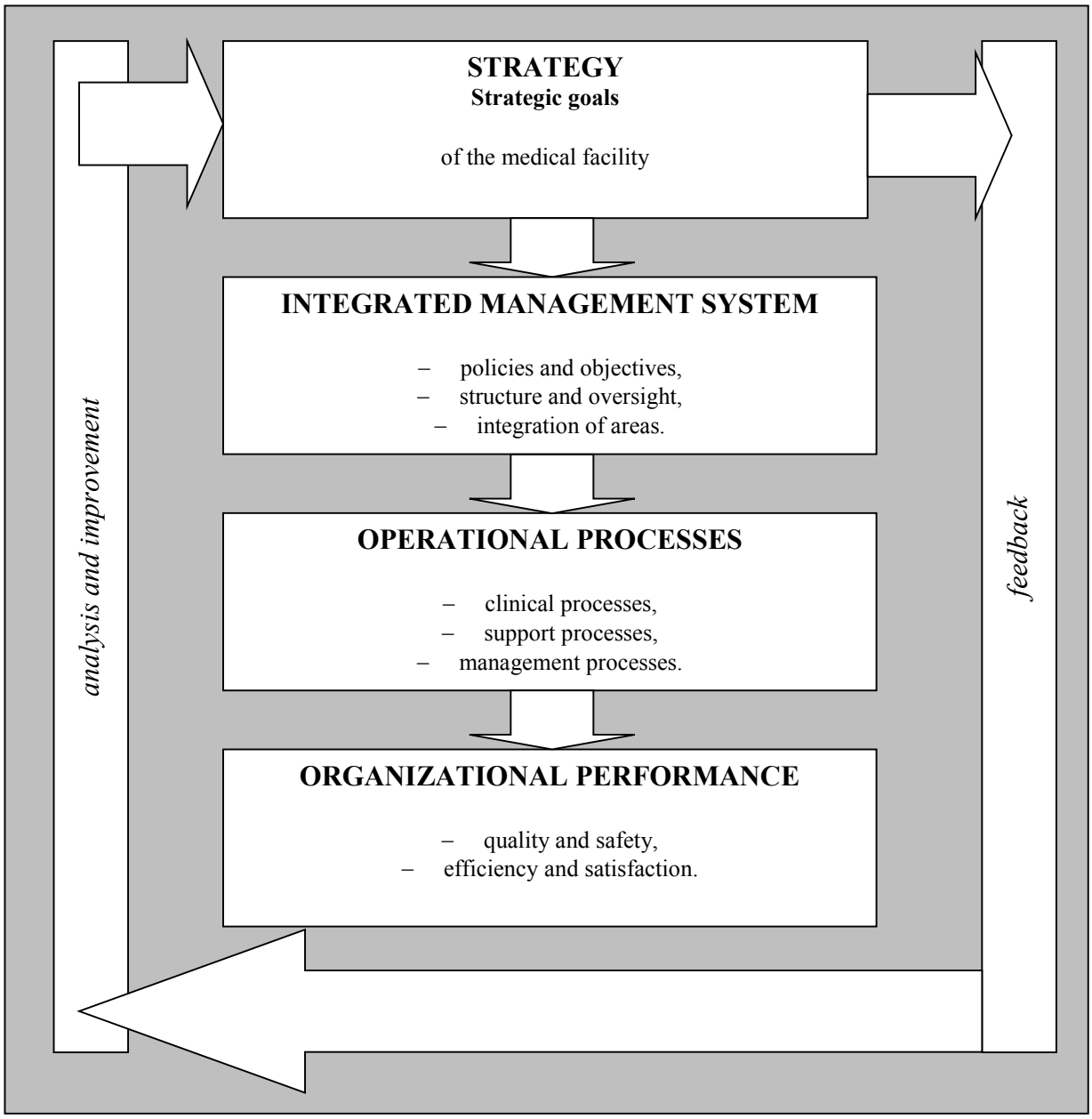


Figure 1. A model of the relationship between organizational culture and the integration of management systems in healthcare facilities.

Source: Own study.

The systemic level, which includes:

- integrated policies and goals,
- management structure,
- mechanisms for supervision and improvement (e.g., audits, KPIs),
- integration of areas: quality, safety, environment, and IT.

The function of this level is to translate the adopted strategy into the management system.

The process level, focusing on:

- clinical processes (healthcare services),
- supporting processes (IT, HR, procurement),
- management processes (planning, control, improvement).

The function of this level is to operationalize the strategy through actions.

Outcome level:

- health outcomes (treatment outcomes),
- quality and patient safety,
- cost-effectiveness,
- stakeholder satisfaction.

The function of this level is to evaluate the effectiveness of the strategy and the Integrated Management System.

A key element of the model are integrating mechanisms that connect all levels, including:

- process management, ensuring the coherence of activities,
- information systems, integrating data and supporting decisions,
- metrics and KPIs (e.g., Balanced Scorecard), linking strategy with operations,
- organizational culture, which conditions actual integration (not just formal integration).

In the proposed approach, an integrated management system is not merely a "set of standards" but serves as a platform for strategy implementation, integrating various dimensions of management into a single, coherent system. Therefore, it can be concluded that the presented model addresses the research gap identified in the previous discussion: the lack of a comprehensive approach combining strategy, quality, processes, and the healthcare management system.

6. Discussion

The conceptual model developed in this study is generally consistent with previous research on integrated management systems and strategic management in healthcare. At the same time, it extends existing knowledge by proposing a comprehensive framework linking strategy implementation with integrated management systems. Integrated management systems are no longer perceived solely as a tool for the formal integration of norms and standards, but are increasingly serving as a platform for implementing organizational strategy. In this context, linking operational processes, resources, and mechanisms for supervision and improvement with strategy becomes particularly important.

At the same time, the literature points to a significant research gap: the lack of comprehensive models integrating various management areas, such as quality, safety, processes, and strategic management. The conceptual model proposed in this article attempts to address this gap by presenting integrated management systems as a mechanism that unites the strategic, systems, and operational levels. This approach is particularly important in the healthcare sector, where system fragmentation and a multitude of regulations lead to duplication of activities and administrative burden, thus generating unnecessary costs.

It is worth emphasizing that the effectiveness of management system integration is strongly dependent on organizational factors, such as organizational culture, staff competencies, and the level of development of information systems. The mere formal integration of standards (e.g., ISO, accreditation) does not guarantee improved results unless accompanied by genuine integration of processes and goals. In this context, a process-based approach and a focus on patient value, consistent with the concept of value-based healthcare, are particularly important.

The discussion also confirms that implementing the "Healthy Future" strategy requires coherent management tools to enable its operationalization. An integrated management system can play a key role in this regard, but its implementation, unfortunately, often encounters institutional, organizational, and resource barriers. This indicates the need for further empirical research on the degree of management system integration and its impact on the efficiency and quality of healthcare.

The proposed conceptual model is consistent with previous studies indicating that integrated management systems should be viewed as organizational management architectures rather than merely integrated sets of standards. This observation supports the process-oriented approach proposed by Asif et al. (2009, 2010), who emphasized the integration of organizational processes and governance mechanisms. Similarly, Nunhes et al. (2019) argued that integrated management systems should be based on common management principles rather than isolated standards.

However, unlike most previous studies, which primarily analyse integrated management systems from the perspective of quality, environmental management or operational integration (Karapetrovic, 2002; Wilkinson, Dale, 1999; Chountalas, Lagodimos, 2024), the proposed model explicitly links IMS with the implementation of organizational strategy in healthcare facilities. In this sense, the integrated management system is conceptualised not only as an operational management tool but also as a mechanism supporting strategic execution.

The proposed approach is also consistent with recent healthcare management research emphasizing integrated care, value-based healthcare and system-wide coordination (Hafiz et al., 2024; De Mattia et al., 2024). These studies underline the importance of integrating organizational processes to improve patient outcomes. The present paper extends these observations by proposing a conceptual mechanism explaining how strategic objectives may be translated into operational activities through an integrated management system.

The findings also confirm observations made in the Polish literature, where issues such as New Public Management, Lean Healthcare, knowledge management or quality improvement are usually analysed separately (Frączkiewicz-Wronka, Austen, 2011; Klich, 2014; Korczak, 2018; Rydlewska-Liszkowska, 2015). The proposed model attempts to integrate these perspectives within one coherent theoretical framework.

7. Conclusions and implications

Based on the analysis, it can be concluded that the integration of management systems is one of the key directions of development for modern healthcare organizations. An integrated management system enables the streamlining and standardization of processes, reduction of duplication of activities, and increased operational efficiency of healthcare entities. Based on this, the following conclusions can be drawn from this study:

- an integrated management system should be treated as a tool for implementing a strategy, not merely a set of standards and procedures,
- the integration of processes, resources, and goals promotes improved quality and safety of healthcare,
- a lack of a coherent approach to system integration leads to inefficiency and excessive organizational burden,
- the effectiveness of implementing an integrated management system depends on organizational factors, including organizational culture, competencies, and information systems.

At the same time, it should be emphasized that the integration process is associated with numerous challenges, such as resource constraints, regulatory complexity, and the need to coordinate multiple stakeholders. Despite these difficulties, the benefits of implementing an integrated management system, including, in particular, improved service quality, operational efficiency, and risk reduction, justify further action in this direction.

Consequently, it is justified to conduct further empirical research on the level of integration of management systems in healthcare entities and to develop universal implementation models that could support management practice in healthcare.

Despite its theoretical contribution, the study has several limitations that should be acknowledged. First, the proposed model has a conceptual character and has not yet been empirically validated in healthcare organizations. Second, the literature review, although structured and comprehensive, was limited to publications considered the most relevant to the research objective and therefore may not encompass all perspectives reported in the international literature. Third, the analysis was conducted primarily from the perspective of healthcare management systems and did not address detailed organizational differences

between various types of healthcare providers. Nevertheless, the study contributes to the existing body of knowledge by integrating previously dispersed research streams concerning strategic management, integrated management systems, quality management, and healthcare management into one coherent conceptual framework. The proposed model extends previous studies by conceptualising the integrated management system as a strategy implementation mechanism rather than solely as an operational management tool. This perspective may support both future empirical research aimed at validating the proposed relationships and practical applications in healthcare organizations seeking to align strategic objectives with management processes. Consequently, the model may serve as a theoretical foundation for developing implementation frameworks, performance measurement systems, and maturity assessment models supporting integrated healthcare management.

References

1. Aiwerioghene, E., Lewis, J., Rea, D. (2024). Maturity models for hospital management: A literature review. *International Journal of Health Planning and Management*, *39(2),* 455-472.
2. Ansoff, H.I. (1965). *Corporate strategy*. McGraw-Hill.
3. Asif, M., de Bruijn, E.J., Fisscher, O.A.M., Searcy, C., Steenhuis, H.J. (2009). Process embedded design of integrated management systems. *International Journal of Quality & Reliability Management, 26*(3), 261-282.
4. Asif, M., Fisscher, O.A.M., de Bruijn, E.J., Pagell, M. (2010). Integration of management systems: A methodology for operational excellence and strategic flexibility. *Operations Management Research, 3*(3-4), 146-160.
5. Barr, H. (2024). Understanding integrated care. *Journal of Integrated Care*, *32(1),* 5-12.
6. Bugdol, M., Jedynak, P. (2015). *Zintegrowane systemy zarządzania*. Warszawa: Difin.
7. Cachata, D., Ferreira, A.M., Ventura-Silva, J.M.A., Sousa, P., Martins, M.M.F.P.S. (2024). The integration of information technology in the management and organization of nursing care in a hospital environment: A scoping review. *International Journal of Environmental Research and Public Health, 21*(8), 968.
8. Chandler, A.D. (1962). *Strategy and structure: Chapters in the history of the industrial enterprise*. MIT Press.
9. Chountalas, P., Lagodimos, A.G. (2024). Integrated management systems: Developments and future research directions. *Total Quality Management & Business Excellence, 35*(1-2), 1-15.

10. Czerw, A., Pajewska, M., Partyka, O. (2023). Value-based healthcare jako koncepcja zarządzania systemem ochrony zdrowia w Polsce. *Przegląd Epidemiologiczny*, *77(2),* 215-225.
11. De Mattia, E., Lettieri, E., Masella, C., Furlan, M., Carrus, G. (2024). Moving from principles to practice: A scoping review of value-based healthcare (VBHC) implementation strategies. *BMC Health Services Research, 24*, 1123.
12. Frączkiewicz-Wronka, A., Austen, A. (2011). New Public Management w sektorze ochrony zdrowia – uwarunkowania i kierunki zmian. *Zarządzanie Publiczne*, *2(14),* 23-35.
13. Grant, R.M. (2022). *Contemporary strategy analysis* (11th ed.). Wiley.
14. Grzesiak, S., Grzesiak, M. (2010). *Zintegrowane systemy zarządzania jakością, środowiskiem i bezpieczeństwem pracy*. Łódź: Wydawnictwo Politechniki Łódzkiej.
15. Hafiz, O., Goodwin, N., Amlani, A., Lewis, R.Q., McCarthy, D., Nolte, E. (2024). Examining the use and application of the WHO Integrated People-Centred Health Services framework in research globally: A systematic scoping review. *International Journal of Integrated Care, 24*(1), 1-15.
16. Hajiyeva, A., Jarl, J., Saha, S. (2025). The effectiveness of quality management interventions in reducing hospital-associated infections in adult patients: A systematic literature review. *International Journal of Infectious Diseases, 154*, 107837.
17. Huebner, C. (2022). Strategic management in healthcare: A call for long-term and systems-thinking in an uncertain system. *Journal of Health Organization and Management*, *36(5),* 589-603.
18. Ispas, L., Mironeasa, C., Silvestri, A. (2023). Risk-based approach in the implementation of integrated management systems: A systematic literature review. *Sustainability, 15*(13), 10251.
19. Johnson, G., Scholes, K., Whittington, R. (2020). *Exploring strategy: Text and cases* (12th ed.). Pearson.
20. Jørgensen, T.H., Remmen, A., Mellado, M.D. (2006). Integrated management systems – Three different levels of integration. *Journal of Cleaner Production, 14*(8), 713-722.
21. Karapetrovic, S. (2002). Strategies for the integration of management systems and standards. *The TQM Magazine, 14*(1), 61-67.
22. Karapetrovic, S., Willborn, W. (1998). Integration of quality and environmental management systems. *The TQM Magazine, 10*(3), 204-213.
23. Klich, J. (2014). Nowe zarządzanie publiczne w ochronie zdrowia – ujęcie teoretyczne i praktyczne. *Problemy Zarządzania*, *12(3),* 45-60.
24. Korczak, K. (2018). Systemy informacyjne w zarządzaniu wiedzą w ochronie zdrowia. *Roczniki Kolegium Analiz Ekonomicznych SGH*, *46*, 23-35.
25. Krupski, R. (2008). *Zarządzanie strategiczne: Koncepcje – metody*. Wrocław: Wydawnictwo Akademii Ekonomicznej we Wrocławiu.

26. Kvint, V. (2009). *The global emerging market: Strategic management and economics*. Routledge.
27. Łukasiński, W. (2012). *Projakościowe zarządzanie organizacją*. Kraków: Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie.
28. Łukasiński, W. (2016). *Dojrzałość jakościowa organizacji*. Kraków: Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie.
29. Łunarski, J. (2011). *Zintegrowane systemy zarządzania*. Rzeszów: Wydawnictwo Politechniki Rzeszowskiej.
30. Mintzberg, H. (1987). The strategy concept I: Five Ps for strategy. *California Management Review, 30*(1), 11-24.
31. Mintzberg, H. (1994). *The rise and fall of strategic planning*. Free Press.
32. Nunhes, T.V., Bernardo, M., Oliveira, O.J. (2019). Guiding principles of integrated management systems: Towards unification of research and practice. *Journal of Cleaner Production, 210*, 977-993.
33. Obłój, K. (2007). *Strategia organizacji: W poszukiwaniu trwałej przewagi konkurencyjnej*. Warszawa: PWE.
34. Porter, M.E. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press.
35. Porter, M.E. (1985). *Competitive advantage: Creating and sustaining superior performance*. Free Press.
36. Prenestini, A., Lega, F., Masella, C. (2024). Keep-or-drop multidimensional control systems in professional organisations: Evidence on the use of the balanced scorecard in healthcare. *Health Services Management Research, 37*(2), 89-101.
37. Rydlewska-Liszkowska, I. (2015). Lean management w ochronie zdrowia – możliwości i ograniczenia. *Problemy Zarządzania*, *13(2),* 89-102.
38. Simion Ludușanu, D.G., Covasa, M., Toma, S.I., Maftei, G.A., Bodescu, D., Costea, C.F., Popescu, D., Cojocaru, E. (2025). Integrated quality and environmental management in healthcare: Impacts, implementation, and future directions toward sustainability. *Sustainability, 17*(11), 5156.
39. Talero-Sarmiento, L.H., Rodríguez-Soto, C.Y., Ceballos-Santamaría, G., Ospina-Mateus, H. (2024). A literature review on Lean healthcare: Implementation strategies, challenges, and future research directions. *Cogent Business & Management, 11*(1), 2411857.
40. Ustawa z dnia 6 grudnia 2006 r. o zasadach prowadzenia polityki rozwoju (t.j. Dz.U. z 2021 r. poz. 1057, z 2022 r., poz. 1079, 1846).
41. Vella Bonanno, P., Srulovici, E., Mira, J.J., Strametz, R., Tella, S., Marinkovic, V., Rafaeli, A., Tumelty, M.E., Pitz, A., Guerra Paiva, S., Venesoja, A., Buttigieg, S.C. (2025). A framework for integrated safety in safety-management systems in healthcare. *Safety Science, 180*, 106123.

42. Ward, C., Phiri, E.R.M., Goodman, C., Nyondo-Mipando, A.L., Malata, M., Manda, W.C., Mwapasa, V., Powell-Jackson, T. (2025). What is the relationship between hospital management practices and quality of care? A systematic review of the global evidence. *Health Policy and Planning, 40*(3), 409-421.
43. Wilkinson, G., Dale, B.G. (1999). Integrated management systems: An examination of the concept and theory. *The TQM Magazine, 11*(2), 95-104.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

ANALYSIS OF SELECTED MARKETING ELEMENTS IN SHAPING A COMPANY'S IMAGE

Zbigniew SKUZA[1], Marzena OGÓREK[2*], Jacek OLCZAK[3]

[1] Czestochowa University of Technology, Faculty of Production Engineering and Materials Technology, Department of Production Management; zbigniew.skuza@pcz.pl, ORCID: 0000-0002-4528-9456
[2] Czestochowa University of Technology, Faculty of Production Engineering and Materials Technology, Department of Production Management; marzena.ogorek@pcz.pl, ORCID: 0000-0003-1627-1422
[3] Student of Management and Production Engineering; Czestochowa University of Technology, Faculty of Production Engineering and Materials Technology, Department of Production Management;
* Correspondence author

Purpose: The aim of the article is to analyse and present a marketing strategy for product placement in the high-end segment, based on data from a furniture company. In addition, the article identifies the key role of trade show in building brand image and the company's market position.
Design/methodology/approach: The article is exploratory in nature and focuses on the process of shaping the image of a product intended for the luxury goods market. The data on turnover, profit, orders and promotional expenditure made it possible to analyse the strategy adopted by the company. The article also includes a review of the literature related to this issue.
Findings: The study demonstrated that the process of placing a product on the industrial goods market requires a carefully planned, long-term and costly strategy.
Originality/value: The article proposes viewing a luxury product as the result of a series of carefully considered actions.
Keywords: Marketing, promotion, product placement, high-end segment.
Category of the paper: Case study.

1. Introduction

The decade spanning 2015-2025 has gone down in the history of marketing as a time of fundamental transformation, with the technology, the ubiquity of data and the evolution of consumer attitudes completely changing the rules of the game. The traditional approach based on mass communication faded, giving way to a strategy focused on individual experiences and real needs of specific individuals. The main driving force behind these changes was advancing digitalisation, which opened the door to the collection and processing of vast data sets. It was precisely through the analysis of these data that marketing ceased to rely on intuition and

began to be based on hard facts, known as data-driven marketing. This allowed companies to attain unprecedented precision in defining their target groups and building fully personalized messages. At the same time, brands began to place enormous emphasis on accurate mapping of the entire customer journey, taking care over the quality of interaction at every touchpoint with the brand in order to build lasting relationships and ensure the highest standard of experience at every stage of the purchasing process (Boudet et al., 2019; Kotler et al., 2016).

The contemporary evolution of marketing has placed particular emphasis on customer experience management, where the product is no longer the only point of reference, and the emotions and impressions accompanying the entire relationship with the brand have become important. The cornerstone of this strategy is the omnichannel model, giving full synergy and consistency in messaging between the digital world and physical retail locations. Attention should be drawn to the important fact that social media platforms such as Facebook, Instagram and TikTok have played a key role in building genuine brand engagement. At the same time, these processes have been bolstered by rapid automation and the implementation of AI, which — thanks to customer relationship management systems (HubSpot, Salesforce) — has enabled precise relationship management and personalized communication on a mass scale. This technological revolution has been completed by the widespread use of chatbots and advanced predictive algorithms, which not only streamlined service standards but also allowed brands to accurately anticipate consumers' future needs (Kotler et al., 2021; Lemon, Verhoef, 2016).

Alongside technological progress, this decade has seen the rise of influencer marketing and the popularisation of user-generated content, allowing brands to build a far more authentic image and reach niche audiences. Micro-influencers have become crucial in this process; by building deeper trust with their audiences, they have often proven more effective than major celebrities, forcing brands to be more honest and transparent in their communications. This shift towards authenticity coincided with the growing importance of value-based marketing and the idea of corporate social responsibility, as today's customers attach great importance to companies' ethical standards, their commitment to environmental sustainability, and their genuine engagement in addressing social issues. As a result, companies integrated sustainable development strategies into their core brand messaging, transforming marketing from a simple sales instrument into the foundation of long-term relationships with customers based on trust and shared values (Berger, 2014; Godin, 2018; Kotler et al., 2016).

Contemporary marketing techniques have focused on attracting audiences through valuable content such as blogs and webinars, which has allowed brands to build an expert image and use storytelling to engage customers. At the same time, performance marketing — which allows for precise measurement of specific results — and growth hacking, or rapid testing of innovative ideas to drive dynamic growth, have gained enormous importance. The entire landscape has been dominated by the digital world, with SEO and search engine marketing campaigns, email marketing, and the extremely popular video marketing in the form of short

videos on TikTok or Instagram becoming the standard. This modern marketing approach has been complemented by interactive tools, such as quizzes and the blending of the real and digital worlds, which, combined with widespread automation and personalization, enable brands to effectively build lasting loyalty and close relationships with consumers (Dave Chaffey, 2019; IAB Polska, 2025; Ryan, Jones, 2012).

Over the past decade, the rapid growth of marketing in the Polish furniture sector has been driven by international expansion (private labels, diversification of sales markets), large-scale digitalization, and the pursuit of a competitive advantage on the international stage. As one of the world's leading exporters in the industry, Poland has moved away from competing solely on price in favour of building the image of "Polish furniture" as a synonym for high quality, modern design and reliability. Strategic promotional activities, carried out in cooperation with institutions such as the Polish Investment and Trade Agency, are based on participation in prestigious trade shows and precise tailoring of the offering to the specific cultural needs of global audiences, which helps build a cohesive and recognizable national brand (Polska Agencja Inwestycji i Handlu, 2025a, 2025b).

Modern marketing in the furniture industry is based on a strong customer focus, manifested in the flexible adaptation of the product portfolio to rapidly evolving interior design trends and individual preferences of buyers. Product offering personalization has become a key pillar of a competitive advantage; thanks to thorough market research, it allows companies to precisely address the specific expectations of diverse customer groups. At the same time, manufacturers are placing a strong emphasis on omnichannel strategies that integrate digital channels with traditional brick-and-mortar retail to ensure a consistent customer experience and convenience at every stage of the complex purchasing journey. The use of advanced customer journey analysis (viewing the company through the eyes of the customer) and user behavior tracking tools enables companies to optimise the customer experience, creating a seamless transition from seeking inspiration online to finalizing a transaction in-store (IAB Polska, 2025; Polska Agencja Inwestycji i Handlu, 2025b).

Marketing in the furniture sector is based on the synergy between traditional methods and modern communication channels, with a key focus on participation in prestigious international trade shows, professional public relations activities, and strategic collaboration with architects and interior designers. The industry is increasingly focusing on content marketing, using inspiring videos, interior design guides and social media to build lasting relationships with customers and boost their engagement. On a global scale, the internationalisation is supported by reliable industry reports and market analyses which — often distributed with the support of institutions such as the Polish Investment and Trade Agency — build the credibility of domestic manufacturers among foreign business partners. Such an integrated range of promotional tools not only boosts the recognition of specific brands but also effectively positions the entire Polish furniture industry as a modern, professional sector ready for global challenges (Polska Agencja Inwestycji i Handlu).

To summarize the above, the past decade has been a period of radical transformation for the Polish furniture industry, in which the traditional sales approach has given way to advanced analytics and strategies focused on building deep relationships with customers. The foundation of modern marketing here is the close integration of digitalisation processes with dynamic foreign expansion, which has allowed to successfully establish Polish design as a global synonym for high quality and innovation. By adopting a philosophy based on precisely mapping the customer experience and responding flexibly to trends, the industry has not only cemented its position as one of the world's leading exporters but has also transformed one-way communication into an authentic dialogue with consumers. As a result, the market success of today's furniture manufacturers now depends on skillfully combining modern promotional tools with the creation of real value, making this sector one of the most progressive and strategic areas of the national economy (Dave Chaffey, 2019; Godin, 2018; Kotler et al., 2021; Polska Agencja Inwestycji i Handlu, 2025a).

2. Development of the Furniture Sector in Poland in 2015-2025

The furniture industry is one of the pillars of the Polish manufacturing sector and is of strategic macroeconomic importance, as evidenced by Poland's rise to become the world's second-largest furniture exporter in 2025. This heavily export-oriented industry sells as much as 60–80% of its production on foreign markets, which, on the one hand, reflects its global expansion and, on the other, its heavy dependence on international economic conditions. The foundation of this success, which was particularly evident between 2015 and 2019 — when the sector recorded robust average annual production growth of 7-8% — was based on relatively low labour costs, economies of scale and full integration into the European Union's single market. In addition, this rapid growth and building a sustainable competitive advantage during the period under analysis were driven by substantial capital expenditures, extensive modernisation of machinery, and the ongoing automation of manufacturing processes (Chrostowski, 2025; Eurostat, 2026; Jagodziński, 2025; Polska Branża Meblarska w 2024 Roku - Eksport, Wyzwania i Nowe Perspektywy, 2025). The years 2020-2023 were marked by considerable turbulence. The initial decline caused by the COVID-19 pandemic was offset relatively quickly by a sharp increase in demand, driven by the widespread adoption of remote work and a shift in consumer spending toward household refurbishments. Nevertheless, 2023 saw a drastic collapse, resulting in a year-on-year decline in production of around 6.8%. This decline was a direct result of the energy crisis, a sharp rise in raw material prices and wage pressures, all of which were linked to a Europe-wide economic slowdown (Chrostowski, 2025; Credit Agricole Bank Polska, 2025; Polska Branża Meblarska w 2024 Roku - Eksport, Wyzwania i Nowe Perspektywy, 2025).

The 2024-2025 period brought the long-awaited stabilization and signs of recovery to the furniture market, as evidenced by a 3.4% year-over-year increase in production in 2025, which followed a previous 4-5% decline in 2024, when the value of sold production stood at approximately PLN 64 billion (Jagodziński, 2025; Polska Branża Meblarska w 2024 Roku - Eksport, Wyzwania i Nowe Perspektywy, 2025). Although this positive momentum signals the industry's gradual adaptation to new market realities, the earlier crisis strongly affected companies' financial condition. In 2023-2024, the operating margin shrank to around 5.2%, while constantly rising labour costs remain a permanent barrier to development and a factor limiting profitability compared with the period before 2020 (Credit Agricole Bank Polska, 2025; Jagodziński, 2025; Polska Branża Meblarska w 2024 Roku - Eksport, Wyzwania i Nowe Perspektywy, 2025). Despite these internal cost pressures, the sector's key pillar, i.e. exports, shows considerable structural resilience; after a temporary collapse in 2023-2024, 2025 brought a renewed revival in external demand, driven mainly by European Union markets (generating around 80% of shipments, of which 30-35% to Germany), as well as the United Kingdom, France, the Czech Republic and the USA (Eurostat, 2026; Forbes Polska, 2025; Jagodziński, 2025; Polska Branża Meblarska w 2024 Roku - Eksport, Wyzwania i Nowe Perspektywy, 2025). Importantly, dynamic international expansion — representing a major leap compared with the baseline export value of EUR 8.8 billion in 2015 — allows Poland to maintain a deeply positive trade balance on a permanent basis, despite the fact that furniture imports from Asia and the EU are also rising rapidly (from EUR 1.5 billion in 2015 to EUR 3.63 billion in 2024), which drastically intensifies price competition on the domestic market (Eurostat, 2026; Ministerstwo Rozwoju i Technologii, 2024; Polska Branża Meblarska w 2024 Roku - Eksport, Wyzwania i Nowe Perspektywy, 2025).

3. An Analysis of Selected Marketing Elements of a Furniture Company

The furniture company under review is part of a diversified family-owned business. According to EU and Polish law, it is a small business (< 50 employees: < EUR 10 million) that has been in operation since 2000. Taking into account its technological facilities (e.g. paint shop), full production capacity was achieved in 2014. Since then, the company owner has sought to position its products in the high-end segment. Figure 1 presents the product life cycle for the case under discussion.

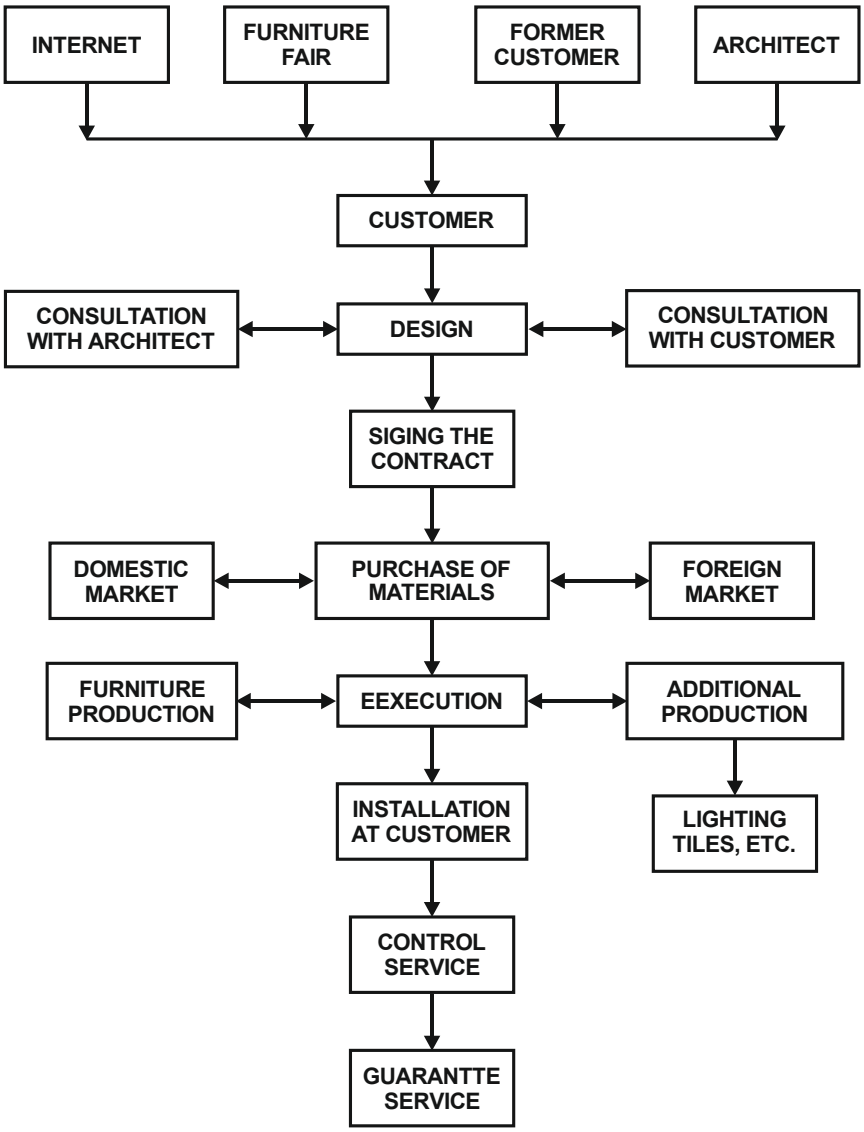


Figure 1. Execution of the work process – furniture manufacturing.

Source: own elaboration.

In the early stages of the company's development, marketing activities were primarily based on the Internet — search engine optimization, Instagram, and Facebook. Later on, the word-of-mouth marketing took effect, and satisfied customers gradually built the company's brand. The continuous expansion of the offering, up to the point of furnishing entire homes, forced the company to establish contacts with architects. Currently, collaboration on joint projects involves both foreign and domestic locations, such as: Zurich, Como, Oslo, Munich, as well as Gdańsk, Gdynia, Łódź, Częstochowa, Wrocław, Warsaw (six designers), Płock, Łowicz and Sochaczew. Participation in specialist furniture trade shows, in turn, contributed to the idea of opening eight showrooms (franchises), including in Warsaw, Gdańsk, Poznań and Częstochowa.

Depending on the type of order, the company prepares a detailed action plan either on its own or in collaboration with an architect. In each case, it is consulted in detail with the client. At this stage, stakeholders determine not only the type of furniture and materials, but also the layout, taking into account the individual needs and characteristics of the potential user (e.g. height, intended use of shelves, accessories, etc.). Consultations end up with the signing of a contract and setting of a price that remains fixed until the order is completed.

The unique nature of each design requires the purchase of specific materials and accessories. Purchases are made both on the domestic and foreign markets (e.g. timber from China, India, Brazil, etc.). In order to meet clients' various wishes, the company also works with 17 suppliers of kitchen and bathroom fittings.

The completion process of a given order itself takes from 1.5 to 6 months and depends on the specification (entire house, kitchen, bathroom, dressing room, etc.) and the scope of the work (installation, tiles, floors, ceilings, lighting, etc.). According to manufacturers' declarations, the warranty for fittings such as Blum is 17 years, for accessories 5 years, and for furniture from 2.5 to 8 years. Additionally, servicing is carried out after 0.5 years and after 2 years in order to remove any minor defects.

Figures 2-4 present company data showing its revenue, profit, and number of orders for the years 2024-2025. Individual figures were expressed as percentages relative to the values from January 2024.

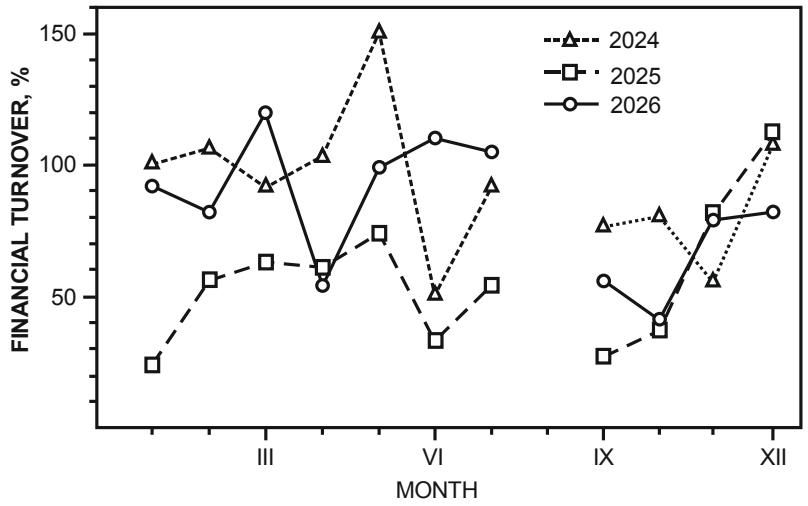


Figure 2. Percentage ratio of the company's turnover in 2024-2026 compared to January 2024.
Source: own elaboration.

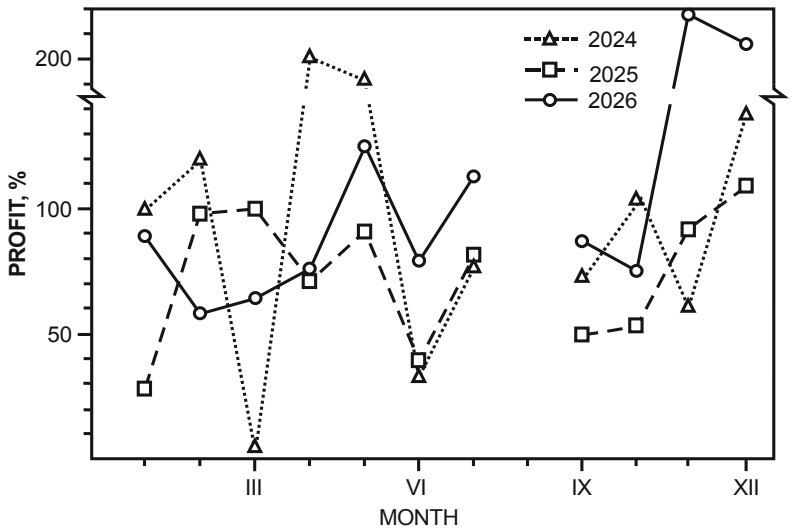


Figure 3. Percentage ratio of the company's profits in 2024-2026 compared to January 2024. Source: own elaboration.

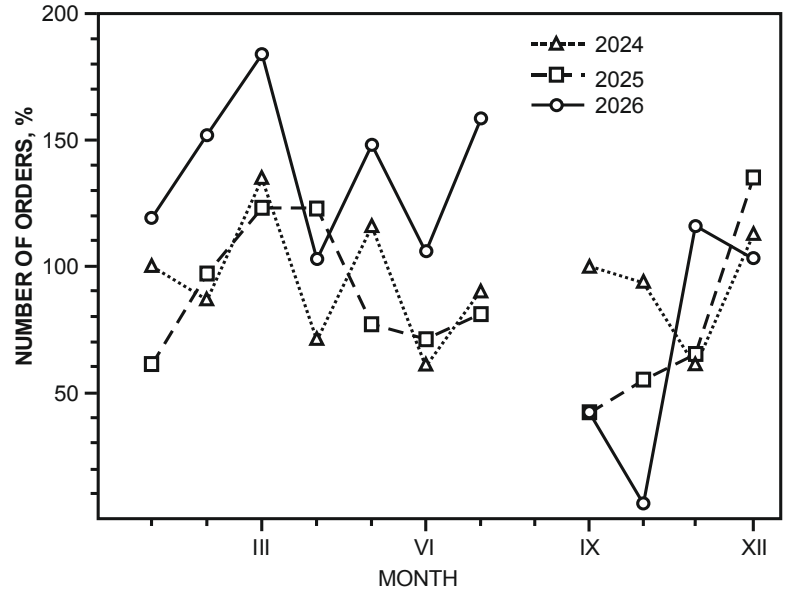


Figure 4. Percentage ratio of the company's number of orders in 2024-2026 compared to January 2024. Source: own elaboration.

As can be seen from the figures presented, both turnover and profit peaked in 2024 and, conversely, hit their lowest point in 2025. The figures for 2026 are based on actual data as of March 31. The following months (August — the holiday month) already include booked orders, the completion of which depends, for example, on the date a given investment is to be commissioned for use. With this in mind, it can be concluded that the current year will be the best in the entire period under consideration. New projects in the coming months may only reinforce this trend. Particular attention should be paid to the fact that these changes may have occurred as a result of the company's promotion at the Warsaw Home 2025 trade show (22-25 October). These are the largest international professional trade show in Central and Eastern Europe (stands, catalogues, events, etc.) presenting furniture, kitchen and bathroom equipment, and design.

Until now, the company has relied exclusively on online channels — its website, Facebook, and Instagram — as its primary form of active promotion. Presenting its offering at such a prestigious industry event required a significant organizational effort. Financial expenditures played a particularly important role here, including: exhibition space rental, designer, transportation, accommodation, setup, booth construction, lighting, kitchen (display), dressing room (display), accessories (BLUM, PECA, REJS), sofa, wallpaper, carpet, flowers, an advertising banner, a photographer, flyers, business cards, online promotion, catering, company uniforms, and a sponsored interview in a newspaper.

In total, all costs related to participation in the trade show and its accompanying events amounted to approximately PLN 800,000. These expenses — particularly when compared to past promotional costs (2024/2025: approx. PLN 60,000) — are more than a dozen times higher and significantly burden the company's overall balance sheet.

Positioning products in the high-end segment requires the adoption of an appropriate strategy. The company is aware of this and is gradually implementing a coherent 4P marketing mix concept:

- product – top quality, the finest materials, partly handcrafted workmanship, attention to detail, limited production,
- price – competitive (raised after the trade show), conveys the product's exclusivity,
- place – limited and based on direct contact with the customer; the creation of luxury showrooms is currently under way,
- promotion – maintaining good relations with former and current customers, building the brand image through the internet, catalogues and trade shows.

4. Summary

The furniture company under review, operating in the market, has prioritized quality of workmanship since its founding. The gradual development of a professional team, its integration (e.g., through joint, owner-financed family vacations to Tunisia), and the use of the finest materials allowed it to gradually build a luxury brand image and establish itself on the domestic market. Another crucial element of premium furniture manufacturers' promotion is collaboration with architects and interior designers, who are increasingly serving as opinion leaders and participating in customers' purchasing decisions. A specialist's recommendation increases the manufacturer's credibility and reduces perceived risk for buyers, especially in the case of high-value products (Kotler, Keller, 2016). Therefore, companies develop partnership programs, offer design support, and provide dedicated services to architectural firms.

Attention to customers, taking into account their needs and wishes, contributed to an increase in orders. In theory, word-of-mouth marketing and online promotion, as well as personalized offerings (Berginc, 2021), guaranteed orders that exhausted the company's limited production capacity. In the case of luxury and premium goods, positive user experiences are one of the most important sources of information used in the purchasing process. Informal recommendations are often perceived as more credible than traditional advertising, which fosters brand reputation and long-term customer loyalty (Rosen, 2009).

Participation in international trade fairs was another significant step in the company's development. Trade fairs serve not only a sales function but, above all, an image-building one, enabling the presentation of quality craftsmanship, design, and innovative technological solutions. At the same time, they serve as a platform for building business relationships and exchanging knowledge between manufacturers, designers, and end users, which is particularly important in the premium segment for building brand trust (Gębarowski, 2010).

References

1. Berger, J. (2014). *Contagious: How to Build Word of Mouth in the Digital Age*. Simon & Schuster. https://books.google.pl/books?id=jxpjLwEACAAJ
2. Berginc, J. (2021). The Need Recognition in Marketing of the Tailor-Made Furniture and Personalization Process of the Product through Design Management. *Mednarodno Inovativno Poslovanje = Journal of Innovative Business and Management*, *13*(1), 40-49. https://doi.org/10.32015/JIBM/2021.13.1.40-49
3. Boudet, J., Gregg, B., Rathje, K., Stein, E., Vollhardt, K. (2019). The future of personalization - and how to get ready for it. *McKinsey & Company*, *June*, 1-9. https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/the-future-of-personalization-and-how-to-get-ready-for-it
4. Chrostowski, G. (2025). *Rynek mebli łapie oddech. Produkcja i eksport przyspieszają*. Puls Biznesu. https://www.pb.pl/rynek-mebli-lapie-oddech-produkcja-i-eksport-przyspieszaja-1253688
5. Credit Agricole Bank Polska (2025). *Polski eksport mebli nabiera tempa*.
6. Dave Chaffey, F.E.-C. (2019). *Digital Marketing*. Pearson.
7. Eurostat (2026). *International trade in goods - statistics on specific products: Furniture*. European Commission. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_trade_in_goods
8. Forbes Polska (2025). Polski sektor meblarski i jego hity eksportowe: Analiza perspektyw rynkowych. *Forbes*, *1*. https://www.forbes.pl/meble
9. Gębarowski, M. (2010). *Współczesne targi: Skuteczne narzędzie komunikacji*

marketingowej. Regan Press.
10. Godin, S. (2018). *This Is Marketing: You Can't Be Seen Until You Learn to See*. Penguin Publishing Group. https://books.google.pl/books?id=B8JyDwAAQBAJ
11. IAB Polska. (2025). *Raport Strategiczny: Internet 2024/2025*.
12. Jagodziński, A. (2025). *Kompendium polskie meble - październik 2025*. https://pfr.pl/artykul/kompendium-polskie-meble-pazdziernik-2025
13. Kotler, P., Kartajaya, H., Setiawan, I. (2016). *Marketing 4.0: Moving from Traditional to Digital*. Wiley. https://books.google.pl/books?id=jN9mDQAAQBAJ
14. Kotler, P., Kartajaya, H., Setiawan, I. (2021). *Marketing 5.0: Technology for Humanity*. Wiley. https://books.google.pl/books?id=S9YPEAAAQBAJ
15. Kotler, P., Keller, K.L. (2016). *Marketing Management* (15th ed.). Pearson.
16. Lemon, K.N., Verhoef, P.C. (2016). Understanding Customer Experience Throughout the Customer Journey. *Journal of Marketing*, *80*(6), 69-96. https://doi.org/10.1509/jm.15.0420
17. Ministerstwo Rozwoju i Technologii (2024). *Polski eksport wyrobów drzewnych i mebli*. https://trade.gov.pl/
18. Polska Agencja Inwestycji i Handlu (2025a). *Meble z {P}olski: solidna marka w zmieniającym się świecie*. https://www.trade.gov.pl/aktualnosci/meble-z-polski-solidna-marka-w-zmieniajacym-sie-swiecie/
19. Polska Agencja Inwestycji i Handlu (2025b). *Raport branżowy: polski sektor meblarski w liczbach i trendach*.
20. *Polska branża meblarska w 2024 roku - eksport, wyzwania i nowe perspektywy* (2025). https://www.trade.gov.pl/wiedza/polska-branza-meblarska-w-2024-roku-eksport-wyzwania-i-nowe-perspektywy/
21. Rosen, E. (2009). *The Anatomy of Buzz: How to Create Word of Mouth Marketing*. Crown Business.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

ASYMMETRY IN THE ALIGNMENT OF TAX POLICY WITH CORPORATE STRATEGY IN THE LIGHT OF EMPIRICAL RESEARCH

Marcin STĘPIEŃ

University of Technology Faculty of Management, Czestochowa; marcin.stepien@pcz.pl,
ORCID: 0000-0003-4590-3935

Purpose: The aim of the article is to examine the coordination between corporate tax policy and business strategy, identify the factors influencing this coordination, and analyse perceptual differences between managers and tax and accounting specialists across enterprises of different sizes.
Design/methodology/approach: The study is based on a quantitative analysis of survey data collected from managers and tax and accounting specialists employed in medium-sized and large enterprises in Poland. Nine areas of integration between tax policy and corporate strategy were assessed. The Mann-Whitney U test, the chi-square test, and a descriptive analysis of percentage distributions were applied.
Findings: The results showed that the coordination of tax policy with business strategy varies by enterprise size and respondent group. Assessment patterns were more homogeneous among respondents from large enterprises, whereas greater variability was observed among respondents from medium-sized enterprises. These findings should be interpreted as differences in perceived alignment rather than as direct evidence of higher tax-management maturity. A perceptual gap was also identified, as managers assessed tax-policy integration more positively than tax and accounting specialists. The findings further indicate a perceptual asymmetry in the assessment of tax-policy alignment across organizational groups and enterprise-size categories.
Research limitations/implications: The main limitation of the study is its cross-sectional character and the fact that it relies on respondents' self-reported assessments. Future research should incorporate objective data as well as comparative and longitudinal studies.
Practical implications: The results indicate the need for stronger integration of the tax function with strategic planning, improved internal communication, and the implementation of tools such as the Tax Control Framework, particularly in medium-sized enterprises.
Social implications: The study may support the development of corporate tax transparency and accountability and provide grounds for public and industry policies promoting tax compliance and good management practices.
Originality/value: The originality of the article lies in its organizational and perceptual approach to the coordination of tax policy with business strategy. The article fills a research gap by demonstrating the existence of a perceptual gap between managers and specialists, as well as the importance of enterprise size for the maturity of tax management.
Keywords: corporate strategy, corporate tax policy.
Category of the paper: Research paper.

1. Introduction

The issue of integrating tax policy with the strategic objectives of an enterprise continues to be addressed in the literature primarily from an economic and financial as well as legal and tax perspectives. The dominant stream of research focuses on the effective tax rate, tax avoidance, firm value, and the financial consequences of tax decisions (Desai, Dharmapala, 2009; Hanlon, Heitzman, 2010). A similar research orientation can be found in OECD studies, where the emphasis is placed on the level of corporate taxation, effective tax rates, and tax transparency in an international context (OECD, 2022). As a result, the prevailing approach highlights the measurable outcomes of tax policy, leaving its organizational determinants and implementation mechanisms relatively underexplored.

Much less frequently, the subject of analysis includes the organizational, managerial, and behavioral aspects of tax management, encompassing the way tax objectives are communicated, their understanding by different groups of employees, and the coordination of the tax function with other areas of management. Meanwhile, the body of research on corporate governance and tax avoidance clearly indicates that the organization of supervision, the structure of responsibility, and the relations between internal stakeholders affect the scope and nature of a firm's tax-related activities (Kovermann, Velte, 2019; Daszczyńska-Ciborowska, 2024; Hambrick, Fredrickson, 2001). This means that tax policy should not be understood solely as a set of fiscal decisions, but rather as an element of the strategic management system, the effectiveness of which also depends on communication processes, the perception of objectives, and the level of internal integration.

It is precisely at this point that the research gap becomes apparent. Previous studies have focused mainly on corporate decisions and their financial consequences, while neglecting the cognitive and communicative dimension of tax strategy implementation, which may determine the actual effectiveness of the adopted solutions (Hanlon, Heitzman, 2010; Kovermann, Velte, 2019). Therefore, the question remains insufficiently explored as to whether the formally declared coordination of tax policy with strategic objectives is reflected in management practice and whether it is perceived in a similar way by representatives of different organizational levels and functions within the enterprise.

This premise leads to the following research objective, which is to determine the extent to which corporate tax policy is coordinated with strategy, and which organizational, managerial, cognitive, and structural factors influence the level of this coordination. Addressing this issue is justified by the need to complement the dominant financial-legal approach in the literature with a managerial perspective that takes into account the internal diversity of assessments and experiences related to the implementation of tax policy. It therefore becomes particularly important to determine whether there is a perceptual gap between managerial staff and tax and accounting specialists in assessing the degree of alignment between tax policy and strategy,

and whether enterprise size differentiates the level of organizational maturity in the area of tax management. An objective formulated in this way aligns with the current stream of research on the relationship between the tax function, governance mechanisms, and the long-term value of the enterprise (Desai, Dharmapala, 2009; Kovermann, Velte, 2019).

Adopting such a research perspective enables the identification of the asymmetry between the declared level of strategic alignment and its actual operationalization within the organizational structure. It may reasonably be expected that managers, assessing the phenomenon from the strategic perspective, will perceive the integration of tax policy with enterprise objectives more optimistically than specialists responsible for its practical application. The empirical identification of this phenomenon makes an important contribution to management research, as it extends the existing understanding of tax policy by adding a perceptual, managerial, and organizational dimension, rather than limiting it solely to financial and regulatory dimensions.

In the present study, asymmetry is understood as a systematic difference in the assessments expressed by different organizational groups, namely managerial staff and tax and accounting specialists, as well as between medium-sized and large enterprises with regard to the perceived degree of alignment between corporate tax policy and business strategy. Thus, asymmetry is conceptualized as a perceptual and organizational phenomenon rather than a financial one. It does not refer to information asymmetry in the classical economic sense but rather to differences in the perception of tax-policy alignment resulting from organizational roles and the degree of formalization of managerial processes (Özleblebici, Çetin, 2015). This understanding is consistent with the managerial perception perspective, which assumes that organizational actors occupying different roles may interpret the same strategic processes in different ways because they rely on different responsibilities, experiences, and decision-making contexts.

2. The Importance of Coordinating Corporate Tax Policy with Its Strategy

Tax policy constitutes an integral element of a company's financial strategy, and its proper coordination with strategy is one of the fundamental conditions for building a sustainable competitive advantage and maintaining the company's financial stability (Guziejewska, Witczak, 2024). The literature emphasizes that tax policy should not be understood solely as an instrument for reducing fiscal burdens, but as a strategic management tool supporting the achievement of long-term objectives (Mikrut, Poznańska, 2009). This perspective remains consistent with the broader stream of research on corporate taxation, in which tax decisions are analysed through the lens of firm value, governance structure, and regulatory risk (Desai, Dharmapala, 2009; Hanlon, Heitzman, 2010). From this perspective, tax policy is not only

an element of financial policy, but also part of a broader system of strategic decisions concerning cost structure, investments, sources of financing, and relations with the institutional environment.

The coordination of tax policy and strategy means aligning the fiscal objectives of the company with its strategic objectives, such as increasing market value, expansion, innovativeness, or maintaining financial liquidity. This requires consistency between the tax function and the basic areas of management, especially finance, investments, and the company's operational structure. Consequently, decisions concerning the choice of the form of taxation, capital structure, location of activities, or the method of intra-group settlements should be considered not only from an accounting perspective, but primarily from a strategic one. Such an approach justifies the aim of the study, which is to examine the extent to which corporate tax policy is coordinated with strategy and which organizational, managerial, cognitive, and structural factors affect the level of this coordination. This approach allows moving beyond the dominant financial-legal approach in the literature and to take into account the organizational dimension of tax management.

A fundamental condition for the effective coordination of tax policy with corporate strategy is appropriate corporate governance. Research indicates that supervisory mechanisms, including the activity of the supervisory board and the audit committee, reduce the propensity for aggressive tax planning and promote greater stability of tax decisions (Lanis, Richardson, 2011; Kovermann, Velte, 2019). At the same time, the alignment of tax oversight with the company's strategic profile is of particular importance. Hsu, Moore, and Neubaum (2018) demonstrated that financial experts serving on the audit committee vary their approach to overseeing tax planning depending on the company's strategy. The relationship between governance and taxation is therefore not universal, but conditional. The consistency of tax policy with corporate strategy is thus determined not only by legal regulations, but also by the quality of supervisory structures, the competencies of governing bodies, and the way responsibility for tax decisions is organized.

Another important dimension of coordination remains tax risk management, which is increasingly treated as an integral part of the enterprise risk management system (Dubiel, 2024). The literature emphasizes that tax policy should take into account not only efficiency objectives, but also the level of acceptable risk, the company's ability to monitor legal changes, and the quality of internal control mechanisms. In this context, the concept of the tax control framework has become increasingly important, understood as a set of procedures and organizational solutions enabling the assessment of the compliance of tax-related activities with corporate and regulatory objectives. The need for such an approach is reinforced by contemporary international reforms, especially OECD initiatives aimed at counteracting base erosion and global minimum taxation (OECD, 2021, 2022). This means that a company should treat tax policy as a strategic risk management area, rather than solely as a domain of formal compliance.

The importance of coordinating tax policy with corporate strategy becomes particularly evident under conditions of internationalization of business activities and the development of the digital economy. The global minimum tax, in force in Poland since 1 January 2025 pursuant to the Act of 6 November 2024, implemented under OECD/G20 Pillar Two framework, compels multinational groups to undertake more advanced tax planning and to ensure greater transparency in reporting (OECD, 2021; Podkówka, 2023). At the same time, decisions concerning the location of functions, assets, and risks, as well as the allocation of value within cross-border structures, must be made with due regard to BEPS principles and new requirements concerning the taxation of income in jurisdictions where economic value is actually created. In this sense, the boundaries between operational, financial, and tax strategy become blurred, and the coordination of these areas is becoming indispensable for maintaining regulatory compliance and reducing tax risk.

The coordination of tax policy with strategy also includes transfer pricing planning, financing structure, and withholding tax management. In the Polish legal system, the requirement that transfer prices be consistent with the actual course of transactions and the profile of functions, assets, and risks has been expressed, inter alia, in Article 11c of the Corporate Income Tax Act, while the limits of permissible tax planning are also defined by the anti-avoidance clause contained in Article 119a of the Tax Ordinance. From a management perspective, this means the need to synchronize tax policy with the map of management processes and with the way value is created within the company. Consistency between the value chain and the tax structure reduces regulatory risk, promotes organizational transparency, and enhances the company's capacity for long-term planning.

The literature also points to differences in the level of tax maturity depending on enterprise size. In the small and medium-sized enterprise sector, tax decisions are more often made on an ad hoc basis and do not always stem from a formally adopted strategy, which may lead to inconsistencies between financial and tax objectives (Mikrut, Poznańska, 2009). In larger companies, by contrast, which possess more formalized management structures, a planned approach to taxation and its stronger embedding in the system of strategic planning can be observed more frequently. The tax awareness of managers and specialists is also of significant importance in this respect, because the level of economic knowledge and understanding of tax consequences affects the quality of strategic decisions and the degree to which they are integrated with the company's long-term development objectives. From the perspective of the aim of the study, this justifies the need to examine whether enterprise size differentiates the level of maturity in tax management and whether it affects how the alignment of tax policy with strategy is perceived.

An important dimension of the coordination of tax policy also includes the transparency of the company's operations. The Polish literature indicates that the obligation to publish information on tax strategy did not always result in an actual increase in tax management maturity, but was sometimes carried out in a formal and declarative manner (Podkówka, 2023).

At the same time, research on corporate tax responsibility and on the relationship between governance and tax avoidance shows that taxes are increasingly perceived as an element of corporate reputation and of more broadly understood corporate responsibility (Kovermann, Velte, 2019). In this perspective, a responsible approach to taxation aligns with the logic of ESG, influencing both the assessment of regulatory risk and the social legitimization of corporate activities.

To conclude, the coordination of tax policy with corporate strategy is multidimensional in nature. It encompasses economic, managerial, organizational, institutional, and ethical aspects. The higher the level of organizational maturity, the quality of governance, and tax awareness, the greater the consistency and effectiveness of tax policy management. This means that taxes are no longer merely a financial category and become an element of organizational culture and a tool for implementing the company's development strategy. In this sense, tax policy is not merely an element of fiscal compliance, but an instrument for shaping a company's long-term value and its sustainable development.

3. Research methodology

The adopted research methodology was designed to achieve the aim of the study, which was to determine the extent to which corporate tax policy is coordinated with strategy and which organizational, managerial, cognitive, and structural factors affect the level of this coordination. Since the analysis considered both respondents' self-reported assessments and differences in the perceptions of specific phenomena between two professional groups, a quantitative research approach was therefore appropriate, based on a survey and statistical analysis of the results. Such a procedure allows for capturing assessment patterns, compare groups of respondents, and identify relationships between selected characteristics of the entities under study and the way the alignment of tax policy with corporate strategy is perceived (Creswell, 2014).

The empirical material consisted of responses obtained from two categories of respondents: representatives of the managerial staff of the surveyed enterprises and tax and accounting specialists. The selection of these groups was methodologically justified, because the former is responsible for shaping and supervising corporate strategy, while the latter directly participates in the operational implementation and execution of tax policy. Adopting such a perspective made it possible to examine not only the formal level of alignment of tax policy with strategy, but also to reveal potential perceptual differences between the strategic and operational levels of management. From the point of view of management science, this solution was particularly important because it allowed the capture of the intra-organizational dimension of tax policy coordination, which has been less frequently analysed in the literature.

The research instrument was a survey in which respondents assessed selected aspects of the alignment of tax policy with corporate strategy. A five-point response scale was applied, allowing respondents to rate their opinions from the lowest to the highest. This type of scale is widely used in social and management research because it enables the operationalization of attitudes, opinions, and assessments in a comparable way that can be easily subjected to statistical analysis (Jamieson, 2004). The study assessed, among other things, the level of coordination between strategy and tax policy goals, the inclusion of tax goals in operational plans, the identification of factors affecting tax policy, the level of management knowledge about tax policy instruments, and the degree to which tax policy is aligned with the needs of internal and external stakeholders. The scope of the questions indicates that the study was multidimensional in character and addressed strategic, operational, and communication-related aspects.

The use of a survey as the primary method of data collection was justified for several reasons. First, it makes it possible to collect data from a larger number of respondents in a standardized manner, which increases the comparability of the results obtained. Second, it enables capturing subjective assessments and perceptions of organizational phenomena that would be difficult to measure solely on the basis of secondary data. Third, in the case of the issue of the alignment of tax policy with corporate strategy, it was particularly important to understand how the processes under study are perceived by those responsible for shaping and implementing them. Such a solution corresponds to the logic of research on perception and organizational attitudes, where the focus is not so much on the formal facts themselves as on how they are interpreted by organizational participants.

In the statistical analysis, the Mann–Whitney U test was used to assess differences between groups of enterprises of different sizes, namely medium-sized and large enterprises. The application of this test was justified by the nature of the data, because the response scale was of an ordinal type and the compared groups were independent. The Mann-Whitney U test is recommended in situations where the aim of the analysis is to compare two independent groups without the need to assume the normality of the distribution of variables (Creswell, 2014).

The second important analytical tool was the chi-square test of independence, applied to examine the relationship between the respondent group and the assessment of selected aspects of the alignment of tax policy with corporate strategy. This test is commonly used to analyse relationships between qualitative variables, especially when the researcher wishes to determine whether the response distributions differ significantly between the groups studied (McHugh, 2013). In the present study, the test allowed for confirming statistically significant differences between the assessments of managerial staff and those of tax and accounting specialists with regard to the coordination of strategy and tax policy objectives, the inclusion of tax goals in operational plans, and the identification of factors affecting tax policy. In addition, the contingency coefficient was calculated, allowing the assessment of the strength of the

relationship between the variables analysed. As a result, the study was not limited solely to establishing the existence of a relationship, but also made it possible to determine its intensity.

An important element of the methodology was also the descriptive analysis of percentage distributions, presented in Tables 2–5. This allowed for a more detailed interpretation of the results obtained and for capturing the structure of respondents' assessments. The application of this procedure was justified because statistical significance tests alone do not show the direction and distribution of opinions, whereas percentage analysis allows for precisely indicating the extent to which particular respondent groups assigned high, medium, or low ratings to specific phenomena. As a result, it was possible not only to confirm the existence of differences between groups, but also to describe their substantive nature. Such a combination of statistical and descriptive analysis increases the interpretive value of quantitative research. The adopted research procedure made it possible not only to answer the question of whether tax policy is coordinated with strategy, but also to indicate that the level of this coordination is perceived differently by managerial staff and specialists, and that its maturity is related to enterprise size.

At the same time, it should be emphasized that the adopted methodology has certain limitations, which should be taken into account when interpreting the results. First, the study was based on respondents' declarations, which entails the risk of subjective assessment bias, social desirability effects, or inflated ratings by respondents identifying with the company's policy. Second, the response scale used was ordinal in nature, which limits the scope of possible analyses and does not allow the results to be fully treated as interval data. The methodological literature points out that data from Likert scales should be interpreted with caution, especially when inferring the strength of relationships or mean differences between groups (Jamieson, 2004). Third, the study was cross-sectional in nature, and therefore presented the state of assessments at a specific point in time, without the possibility of observing changes over time. This means that it is not possible to draw causal conclusions regarding the impact of regulatory or organizational changes on the level of coordination of tax policy.

An additional limitation is the lack of use of objective financial and tax indicators, such as the effective tax rate, the number of tax disputes, the level of tax adjustments, or audit results. Basing the study solely on survey data means that it primarily describes respondents' perceptions of the phenomena under study, rather than their material outcomes. This does not, however, reduce the cognitive value of the study; rather, it indicates its specific scope: the study concerned the organizational and cognitive dimension of the coordination of tax policy, rather than its strictly financial consequences. Finally, it should be noted that the structure of the sample, including sectoral differences between enterprises, which were not taken into account as a separate differentiating factor, may also have influenced the results obtained.

Despite the indicated limitations, the adopted research methodology was adequate to the aim of the study and enabled the collection of valuable data on the perceived alignment of tax policy with corporate strategy. Its strength lay in the combination of quantitative analysis with descriptive interpretation, as well as in taking into account the perspectives of two groups of

respondents performing different organizational roles. As a result, it was possible to demonstrate that the phenomenon under study has not only a formal and strategic dimensions, but also a cognitive, communicative, and organizational one.

4. Research results

The study showed that the degree of coordination between tax policy and corporate strategy varies by both enterprise size and respondents' professional group. This means that the phenomenon under study is not homogeneous, but depends on the level of organizational maturity and on the perspective from which the integration of tax policy with strategic processes is evaluated. First, it should be noted that the results of the Mann–Whitney U test revealed significant differences between medium-sized and large enterprises (Table 1).

Table 1.
Results of the Mann-Whitney U test for the assessment of the alignment of tax policy with business strategy by enterprise size

Item	ENTERPRISE SIZE	
	medium-sized enterprises	**large enterprises**
Open and transparent dialogue on tax policy	U = 13000.000; Z = -11.480; p = 0.000	U = 17.000; Z = -0.934; p = 0.350
Tax policy aligned with management needs	U = 14161.000; Z = -10.853; p = 0.000	U = 24.000; Z = 0.000; p = 1.000
Tax policy aligned with tax authority expectations	U = 18838.500; Z = -8.130; p = 0.000	U = 14.000; Z = -1.502; p = 0.133
Management verifies alignment of business and tax strategy goals	U = 14354.000; Z = -10.741; p = 0.000	U = 22.500; Z = -0.207; p = 0.836
Tax policy goals included in operational plans	U = 14077.000; Z = -10.879; p = 0.000	U = 20.000; Z = -0.562; p = 0.574
Factors affecting tax policy identified	U = 12558.000; Z = -11.776; p = 0.000	U = 12.000; Z = -1.654; p = 0.098
Management understands the impact of tax policy on organizational units	U = 11938.500; Z = -12.410; p = 0.000	U = 13.000; Z = -1.494; p = 0.135
Management knows instruments for building tax policy	U = 13007.000; Z = -11.631; p = 0.000	U = 19.500; Z = -0.600; p = 0.548
Management continuously verifies tax policy alignment	U = 13014.000; Z = -11.600; p = 0.000	U = 14.000; Z = -1.352; p = 0.176

Note. U – Mann-Whitney U statistic; Z – standardized test statistic; p – asymptotic significance level (two-tailed). The table presents the results of comparisons between medium-sized and large enterprises in selected dimensions of tax policy alignment with business strategy.

Source: Own elaboration based on survey results.

In the case of medium-sized enterprises, all analysed areas related to the alignment of tax policy with strategy were statistically significant. This included, among other things, the openness of dialogue on tax policy, the alignment of tax policy with the needs of management and tax authorities, the inclusion of tax objectives in operational plans, the identification of factors affecting tax policy, as well as the level of management knowledge

regarding the instruments and implications of tax policy (Table 1). This means that in medium-sized enterprises, the assessments of these dimensions are more differentiated, and the level of coordination between tax policy and strategic objectives is not stable.

The results presented in Table 1 indicate that no statistically significant differences were observed among the assessed dimensions in large enterprises. However, this finding should be interpreted with caution. The absence of statistical significance does not automatically imply a higher level of tax-management maturity or a stronger integration of tax policy into the corporate strategy. Rather, it indicates that the responses obtained from large enterprises were more homogeneous than those from medium-sized enterprises within the analysed sample. Demonstrating a higher level of organizational maturity would require additional analyses based on group medians, rank distributions, or objective indicators reflecting the effectiveness and maturity of the corporate tax management system. Median values and rank distributions were not analysed in the present study because the primary objective was to compare overall response patterns using non-parametric significance tests.

The analysis of the distribution of responses across all respondents indicated that the overall alignment of tax policy with corporate strategy was generally assessed positively (Table 2). High and very high ratings predominated in the three key dimensions, namely the alignment between corporate strategy goals and tax policy goals, the inclusion of tax policy goals in operational plans, and the identification of factors affecting tax policy. The highest proportion of the maximum ratings was observed for the alignment between corporate strategy goals and tax policy goals.

Table 2.
Assessment of selected dimensions of tax policy alignment with business strategy by all respondents (%)

Item	ASSESSMENT				
	1	2	3	4	5
Alignment of business strategy goals with tax policy goals	3.0	2.4	12.8	30.4	51.4
Inclusion of tax policy goals in operational plans	2.4	2.4	14.0	31.2	50.0
Identification of factors affecting tax policy	3.0	3.8	15.0	32.4	45.8

Note. 1 – very low assessment; 5 – very high assessment. Percentages refer to all surveyed respondents.

Source: Own elaboration based on survey results.

However, dividing the responses by respondent groups revealed clear perceptual differences. Managerial staff were much more likely to give very high ratings (Table 3). In all analysed areas, the majority of managers indicated that tax policy was well coordinated with the enterprise's strategic objectives, that these objectives were included in operational plans, and that the enterprise identified the factors affecting the implementation of its tax policy (Table 3). These responses indicate a highly positive assessment of the level of integration between tax policy and strategic management.

Table 3.
Assessment of selected dimensions of tax policy alignment with business strategy by managerial staff (%)

Item	ASSESSMENT				
	1	2	3	4	5
Alignment of business strategy goals with tax policy goals	0.8	0.8	6.8	15.6	76.0
Inclusion of tax policy goals in operational plans	1.6	0.0	7.6	15.2	75.6
Identification of factors affecting tax policy	1.2	0.8	8.8	14.8	74.4

Note. 1 – very low assessment; 5 – very high assessment. Percentages refer to managerial staff only.

Source: Own elaboration based on survey results.

A different picture emerges from the responses of tax and accounting specialists. In this group, moderately high ratings predominated, while the proportion of the highest ratings was significantly lower than among managerial staff (Table 4). Specialists were more likely to select responses indicating a medium or high level, while they less frequently assigned the highest ratings to the phenomena under study (Table 4). Such a distribution of responses suggests a more cautious and more critical assessment of the actual level of integration of tax policy with the enterprise's strategic objectives.

Table 4.
Assessment of selected dimensions of tax policy alignment with business strategy by tax and accounting specialists (%)

Item	ASSESSMENT				
	1	2	3	4	5
Alignment of business strategy goals with tax policy goals	5.2	4.0	18.8	45.2	26.8
Inclusion of tax policy goals in operational plans	3.2	4.8	20.4	47.2	24.4
Identification of factors affecting tax policy	4.8	6.8	21.2	50.0	17.2

Note. 1 – very low assessment; 5 – very high assessment. Percentages refer to tax and accounting specialists only.

Source: Own elaboration based on survey results.

Additionally, the analysis of the strategic importance of selected goals related to the implementation of tax policy showed that managerial staff more often than specialists regarded such activities as the coordination of corporate strategy goals and tax policy goals, their inclusion in operational plans, and the identification of factors affecting tax policy as important or very important (Table 5). Specialists also recognized the importance of these areas, but their assessments were clearly more restrained (Table 5).

Table 5.
Assessment of selected dimensions of tax policy alignment with business strategy by tax and accounting specialists (%)

Item	ASSESSMENT				
	1	2	3	4	5
Alignment of business strategy goals with tax policy goals	5.2	4.0	18.8	45.2	26.8
Inclusion of tax policy goals in operational plans	3.2	4.8	20.4	47.2	24.4
Identification of factors affecting tax policy	4.8	6.8	21.2	50.0	17.2

Note. 1 – very low assessment; 5 – very high assessment. Percentages refer to tax and accounting specialists only.

Source: Own elaboration based on survey results.

The results of the chi-square tests confirmed that the differences between managerial staff and tax and accounting specialists were statistically significant (Table 6). This applied to all three main areas used to assess the maturity of the alignment of tax policy with enterprise operations: verifying the consistency between strategy and tax policy goals, including the implementation of tax goals in operational plans, and identifying the factors affecting tax policy (Table 6). The contingency coefficients indicated moderately strong relationships, which means that belonging to a particular professional group significantly influenced the assessment of the phenomenon under study (Table 6).

Table 6.
Chi-square tests for differences in the perception of tax policy alignment maturity between managerial staff and tax/accounting specialists

Item	ASSESSMENT			
	Chi-square	**df**	**asymptotic significance (two-tailed)**	**contingency coefficient**
Management verifies whether business strategy goals are aligned with tax strategy goals	122.357	4	0.000	0.443
All planned implementations of tax strategy goals are included in operational plans	134.524	4	0.000	0.460
The enterprise has identified factors affecting the implemented tax strategy	167.155	4	0.000	0.501

Note. df – degrees of freedom. The contingency coefficient indicates the strength of association between respondent group and assessment.

Source: Own elaboration based on survey results.

Based on the results obtained, it can therefore be concluded that enterprises declare a relatively high level of coordination between tax policy and strategic objectives, although the level of this assessment is clearly differentiated. Assessment patterns were more homogeneous among respondents from large enterprises than among respondents from medium-sized enterprises (Table 1), whereas a noticeable perceptual gap exists between managers and tax specialists (Tables 3 - 6) in assessing the perceived level of integration between tax policy and business strategy.

5. Discussion

The results obtained confirm that tax policy should not be analysed solely as a fiscal instrument or an area of regulatory compliance, but rather as an element of the company's strategic management. The literature indicates that research on corporate taxation has long focused primarily on the effective tax rate, tax avoidance, investments, capital structure, and firm value, whereas the organizational and perceptual aspects of tax management have been much less frequently addressed (Hanlon, Heitzman, 2010). These results address this research

gap, showing that the alignment of tax policy with corporate strategy also has a clear intra-organizational dimension.

When interpreting the findings, it is important to clearly distinguish between the declared alignment of corporate tax policy with business strategy and the actual level of tax-management maturity. Since the study was based on respondents' subjective assessments, the results primarily reflect participants' perceptions of organizational processes. Consequently, they do not provide direct evidence of the actual effectiveness of the corporate tax management system or the extent to which tax policy is embedded in operational practice. Assessing the actual maturity of tax management would require the use of objective indicators, such as the effective tax rate, the number of tax disputes, tax adjustments, tax audit results, or the degree of formalization of Tax Control Framework procedures.

Of particular importance is the fact that no significant differences were recorded in the areas under analysis in large enterprises, whereas in medium-sized enterprises these differences were clearly statistically significant. This finding may suggest a greater degree of consistency in respondents' assessments in large enterprises. However, it should not be interpreted as direct evidence of higher organizational maturity, which would require additional analyses based on objective indicators of tax-management practices. Nevertheless, previous studies indicate that well-developed corporate governance mechanisms, formalized management structures, and effective oversight systems may support more consistent tax-management practices in larger organizations (Kovermann, Velte, 2019). In this context, the findings of the present study may be regarded as consistent with the existing literature, although they should be interpreted with appropriate methodological caution. Kovermann and Velte (2019) indicate that corporate governance mechanisms may not only increase the propensity for tax avoidance, but also limit it to a level at which the benefits are not outweigh the associated risks. This means that the quality of governance affects not only the level of tax burdens, but also the organization of the tax function within the enterprise.

The research results also reveal a clear perceptual gap between managerial staff and tax and accounting specialists. Managers were significantly more likely to assess the level of integration of tax policy with strategic objectives as very high, whereas specialists gave more moderate ratings. This difference may indicate that the strategic level of the enterprise tends to perceive the integration of tax policy in a more declarative and project-oriented manner, while the operational level evaluates it through the prism of implementation practice, procedural compliance, and everyday experience related to the fulfilment of tax obligations. This finding contributes to the existing body of knowledge, because the literature has more often focused on the relationship between tax policy, firm value, and agency conflicts than on the internal diversity of assessments within the enterprise. Desai and Dharmapala (2009) demonstrated that the effect of tax avoidance on firm value depends on the quality of governance, which confirms that taxes should also be analysed from the perspective of management quality, and not only through the prism of fiscal benefits.

The results obtained are also consistent with the Polish literature on corporate tax strategy. Mikrut and Poznańska (2009) indicated that tax strategy constitutes one of the functional strategies of the enterprise and should be embedded in a broader system of managerial decisions. In light of the research conducted, however, it becomes clear that the mere formal recognition of tax policy as part of a functional strategy does not yet guarantee its actual integration at the organizational level. The results suggest that, particularly in medium-sized enterprises, difficulties may arise in translating strategic declarations into coherent operational activities.

It is also noteworthy that managers emphasized the strategic importance of coordinating tax policy goals with corporate objectives more strongly than specialists. This may mean that management assigns high declarative importance to tax policy, whereas specialists more often perceive the practical limitations related to the implementation of these assumptions. The dichotomy of the phenomenon under study may be interpreted as a manifestation of information asymmetry or a communication gap within the enterprise. Research on the relationship between corporate strategy and tax oversight has shown that the effectiveness of oversight over tax planning depends on the competencies and roles of the persons involved in control processes, as well as on the strategic profile of the enterprise (Hsu et al., 2018). In this context, the results obtained indicate that differences in the perception of tax policy coordination may be the result not only of differences in expertise of knowledge, but also of differences in organizational position and scope of responsibility.

The research results may also be interpreted in light of contemporary regulatory changes. OECD indicates that the development of international rules counteracting base erosion and the implementation of solutions related to global minimum taxation increase the need for a more integrated approach to corporate taxation (OECD, 2021, 2022). In such circumstances, the coordination of tax policy with the business model, organizational structure, and reporting processes becomes not only a matter of efficiency, but also a condition for reducing regulatory risk. From this perspective, it may be assumed that larger enterprises are better prepared for this type of integration, which has been confirmed by the results obtained.

As a result, this research introduces a new element into the literature, namely the intra-organizational and perceptual dimension of the alignment of tax policy with strategy. It shows that the effective integration of tax policy does not boil down to its formal inclusion in strategic documents, but also requires consistency of interpretation, communication quality, and real embeddedness in management practice. This means that taxes should be analysed not only as a financial category, but also as an element of organizational culture, responsibility structures, and coordination processes within the enterprise.

6. Conclusion

The conducted theoretical and empirical considerations lead to the conclusion that corporate tax policy should not be understood solely as an instrument for fulfilling fiscal obligations or as a tool for reducing tax burdens. It properly belongs within strategic management, because the way tax policy is shaped and implemented affects not only regulatory compliance and financial performance, but also the organization of managerial processes, internal relationships within the enterprise, and the ability to achieve long-term objectives. Such a perspective requires moving beyond the dominant financial-legal approach in the literature toward a view that takes into account the organizational, cognitive, and communicative determinants of coordinating tax policy with corporate strategy.

The literature review indicated that previous research on tax policy focused primarily on the effective tax rate, tax aggressiveness, regulatory compliance, and the impact of tax decisions on firm value. By contrast, the organizational dimension of this phenomenon remained much less explored, especially the question of how different groups of organizational participants perceive the degree of alignment between tax policy and strategy, and how enterprise size affects the maturity of such coordination. Thus, the research gap concerned not so much the mere presence of tax policy within the management system, but rather the extent to which it is actually embedded in organizational practice and the differences in how it is perceived by actors performing different roles within the enterprise.

The results of the empirical study made it possible to partially fill this gap. It was demonstrated that the coordination of tax policy with strategy varies in nature and depends both on enterprise size and on the respondents' position within the organizational structure. Large enterprises were characterized by more consistent assessment patterns. However, these findings should be interpreted as reflecting greater homogeneity of respondents' perceptions rather than constituting direct evidence of higher tax-management maturity. In medium-sized enterprises, by contrast statistically significant differences were observed across the assessed dimensions, indicating a lower level of formalization, stability, and integration of tax processes with strategy. At the same time, a clear perceptual gap was revealed between managerial staff and tax and accounting specialists. Managers assessed the level of integration of tax policy with strategic objectives more highly, whereas specialists formulated more cautious and moderate evaluations. This means that the formal presence of tax policy within the management system does not necessarily imply an equally high level of its operational implementation and internalization in organizational practice.

The findings should be interpreted as an assessment of the perceived alignment between corporate tax policy and business strategy rather than as a direct measure of the actual maturity of tax management. Although the reported assessments constitute an important indicator of organizational functioning, their validation requires the use of objective financial and tax-related data in future research.

The scientific value of the study lies in changing the analytical perspective. Rather than being limited to a financial-legal approach, the paper presents tax policy as an area of integrated strategic management, in which not only regulatory compliance and economic efficiency matter, but also communication quality, level of knowledge, structure of responsibility, and the maturity of management processes. In this sense, the study contributes to management science by highlighting the perceptual and organizational dimension of tax policy coordination. Its particularly significant result is the identification of the phenomenon of a perceptual gap between the strategic and operational levels of the organization, and the proposal of the category of perceptual maturity of tax policy coordination, understood as the degree of consistency in the assessments of different organizational groups regarding the integration of tax policy with corporate strategy.

The study also has clear practical value. It shows that effective coordination of tax policy with strategic objectives is not merely a function of formal procedures, but requires the development of internal communication mechanisms, the building of a culture of tax responsibility, and the implementation of supervision and control tools such as the Tax Control Framework. The results obtained may serve as a point of reference both for enterprises seeking to increase the maturity of their tax management, and for public institutions and industry environments interested in promoting transparency, compliance, and tax responsibility.

References

1. Creswell, J.W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks: SAGE Publications.
2. Daszczyńska-Ciborowska, A. (2024). Szanse i zagrożenia związane z minimalnym podatkiem CIT. *Finanse i Prawo Finansowe, 1(34),* pp. 15-32.
3. Dębniak, P. (2018). Optymalizacja podatkowa jako element zarządzania finansami przedsiębiorstwa. *Finanse, Rynki Finansowe, Ubezpieczenia*, *No. 91,* pp. 151-160. Retrieved from: https://wnus.usz.edu.pl/frfu/pl/issue/730/article/9334/, 10.03.2026.
4. Desai, M.A., Dharmapala, D. (2009). Corporate tax avoidance and firm value. *Review of Economics and Statistics*, *Vol. 91, Iss. 3*, pp. 537-546. https://doi.org/10.1162/rest.91.3.537
5. Dubiel, N. (2024). *Zarządzanie ryzykiem podatkowym*. edu-Libri.

6. Guziejewska, B., Witczak, I. (2024). W poszukiwaniu efektywnego i optymalnego opodatkowania spółek: CIT estoński. *Optimum. Economic Studies, 2(116),* pp. 96-114. DOI: 10.15290/oes.2024.02.116.05
7. Hambrick, D.C., Fredrickson, J.W. (2001). Are You Sure You Have a Strategy? *Academy of Management Executive, 15(4)*, pp. 48-59.
8. Hanlon, M., Heitzman, S. (2010). A review of tax research. *Journal of Accounting and Economics*, *Vol. 50, Iss. 2-3*, pp. 127-178. https://doi.org/10.1016/j.jacceco.2010.09.002
9. Hsu, P.-H., Moore, J.A., Neubaum, D.O. (2018). Tax avoidance, financial experts on the audit committee, and business strategy. *Journal of Business Finance & Accounting*, *Vol. 45*, Iss. 9-10, pp. 1293-1321. https://doi.org/10.1111/jbfa.12352
10. Jamieson, S. (2004). Likert scales: How to (ab)use them. *Medical Education*, *Vol. 38, Iss. 12*, pp. 1217-1218. https://doi.org/10.1111/j.1365-2929.2004.02012.x
11. Kovermann, J., Velte, P. (2019). The impact of corporate governance on corporate tax avoidance: A literature review. *Journal of International Accounting, Auditing and Taxation*, *Vol. 36*, p. 100270. https://doi.org/10.1016/j.intaccaudtax.2019.100270
12. Lanis, R., Richardson, G. (2011). The effect of board of director composition on corporate tax aggressiveness. *Journal of Accounting and Public Policy*, *Vol. 30, Iss. 1*, pp. 50-70. https://doi.org/10.1016/j.jaccpubpol.2010.09.003
13. McHugh, M.L. (2013). The chi-square test of independence. *Biochemia Medica*, *Vol. 23, Iss. 2*, pp. 143-149. https://doi.org/10.11613/BM.2013.018
14. Mikrut, A., Poznańska, A. (2009). Strategia podatkowa przedsiębiorstwa. *Zeszyty Naukowe Małopolskiej Wyższej Szkoły Ekonomicznej w Tarnowie*, *Vol. 13, Iss. 2,* pp. 225-238. https://doi.org/10.25944/znmwse.2009.02.225238
15. OECD (2021). *Tax Challenges Arising from the Digitalisation of the Economy – Global Anti-Base Erosion Model Rules (Pillar Two): Inclusive Framework on BEPS* (Report). Paris: OECD Publishing. https://doi.org/10.1787/782bac33-en
16. OECD (2022). *Corporate Tax Statistics: Fourth Edition* (Report). Paris: OECD Publishing. https://doi.org/10.1787/5c8d8887-en
17. Özleblebici, Z., Çetin, Ş. (2015). *The role of managerial perception within strategic management: An exploratory overview of the literature*. *Procedia - Social and Behavioral Sciences, 207*, 296-305. https://doi.org/10.1016/j.sbspro.2015.10.099
18. Podkówka, S. (2023). *Obligatoryjna i jawna strategia podatkowa, spojrzenie z perspektywy przedsiębiorstwa i organu podatkowego*. *Organizacja i Kierowanie*, *Vol. 193, Iss. 2*, pp. 137-151. https://doi.org/10.33119/OiK.2023.193.2.8
19. Sullivan, G.M., Artino, A.R. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Medical Education*, *Vol. 5, Iss. 4,* pp. 541-542. https://doi.org/10.4300/JGME-5-4-18

20. Ustawa z dnia 6 listopada 2024 r. o opodatkowaniu wyrównawczym jednostek składowych grup międzynarodowych i krajowych (Dz.U. poz. 1685 z późn.zm.).
21. Witczak, I. (2023). Strategia podatkowa jako determinanta kreowania wartości przedsiębiorstwa. *Przegląd Prawno-Ekonomiczny, No. 1*, pp. 103-120. https://doi.org/10.31743/ppe.13744

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 253

REGULATORY APPROACHES IN SELECTED COSMETICS MARKETS IN THE CONTEXT OF INSTITUTIONAL DISTANCE, INSTITUTIONAL VOIDS AND COMPLIANCE

Katarzyna SYTNIEWSKA

University of Economics in Katowice; katarzyna.sytniewska@edu.uekat.pl, ORCID: 0009-0006-2993-5928

Purpose: The aim of this article is to analyze and compare selected regulatory systems governing cosmetics markets in the context of institutional distance, institutional gaps and compliance mechanisms and to determine how differences in regulatory frameworks shape institutional conditions in international cosmetics markets.
Design/methodology/approach: The paper is based on a literature review. The study draws on academic publications indexed in databases such as Elsevier, Springer, and ResearchGate. The analysis focuses on theoretical contributions related to institutional distance, institutional voids, and compliance, as well as on studies describing regulatory frameworks in selected cosmetics markets.
Findings: The analysis shows that regulatory systems in the examined regions differ significantly in terms of formalization and enforcement. The EU represents a highly formalized and preventive regulatory model, the USA demonstrates an evolutionary shift from self-regulation toward increased formalization, while ASEAN reflects a harmonized but unevenly enforced regulatory framework. These differences are reflected in varying levels of institutional distance and the presence of institutional voids, particularly in relation to regulatory consistency and enforcement mechanisms.
Research limitations/implications: The study is based on a literature review and does not include primary empirical data. Future research could extend the analysis by incorporating empirical case studies of firms operating across different regulatory environments.
Practical implications: The findings may support cosmetics companies operating internationally in understanding differences in regulatory environments across key markets. The study highlights the importance of compliance mechanisms in managing regulatory risk and adapting organizational processes to varying institutional conditions. This may contribute to more effective compliance strategies.
Originality/value: This paper provides a structured interpretation of regulatory diversity across three major global regions and contributes to international business and regulatory studies by linking institutional theory with compliance practices in the context of cosmetics companies operating in international markets.
Keywords: cosmetics market, institutional distance, institutional voids, compliance.
Category of the paper: research paper.

1. Introduction

The international expansion of cosmetics companies is increasingly shaped by the complexity of foreign market regulations. Differences in the legal frameworks governing product safety, market authorizations, and compliance obligations create a heterogeneous institutional environment that significantly impacts companies operating across borders. As a result, cosmetics companies entering foreign markets must not only adapt to consumer preferences and competitive conditions but also to varying regulatory and compliance requirements.

In this context, the European Union (EU) is one of the most regulated cosmetics markets in the world. The EU system is characterized by a preventive approach to product safety, extensive documentation requirements and a high degree of institutional formalization. While this ensures a high level of consumer protection and regulatory predictability, it also creates significant barriers to market entry, particularly for non-EU companies, which often operate under less stringent regulations. For example, companies from Asian and North American markets often face significant difficulties in adapting upon entering the EU market due to differences in regulatory structure, responsibility allocation and enforcement mechanisms. These differences illustrate the importance of the concepts of institutional distance and institutional gaps, which help explain the complexities of operating in different regulatory environments.

The aim of this article is to analyze and compare selected regulatory systems governing cosmetics markets in the context of institutional distance, institutional gaps and compliance mechanisms. The study is based on a literature review conducted using academic databases such as Elsevier, Springer, and ResearchGate. The analysis includes academic publications on institutional distance, institutional gaps and compliance, as well as studies on the regulatory frameworks in selected cosmetics markets. On this basis, the following research questions are addressed:

- What regulatory approaches operate in the selected cosmetic markets?
- How does the degree of formalization of regulatory systems relate to the predictability of the legal environment and the compliance costs borne by cosmetics companies?

2. Theoretical foundations of institutional distance and institutional voids

Distance constitutes a fundamental concept in the theory of institutional trade and international business (Ciszewska-Mlinarič, Wąsowska, 2012, p. 5). Although it is commonly associated with physical or geographical separation, in the context of international management the concept has a much broader meaning. S. Beugelsdijk, B. Ambos and P.C. Nell noticed that distance should be understood as a construct whose significance depends on the theoretical perspective within which it is analysed (Beugelsdijk, Ambos, Nell, 2018). Consequently, within transaction cost theory, distance may be interpreted as a source of additional costs whereas in agency theory it may constitute a cause of control and monitoring problems. From the perspective of international management distance should therefore not be viewed merely as a measure of differences but rather as a factor influencing specific organizational decision-making mechanisms.

The multidimensional nature of the concept of distance is emphasized in numerous typologies developed within the international business literature. One of the most influential approaches is P. Ghemawat's CAGE framework (Ghemawat, 2001). This acronym refers to four dimensions of distance that firms must take into account when entering or operating in foreign markets: cultural, administrative, geographical and economic distance. The framework provides a structured analytical tool enabling the identification of the costs associated with conducting business abroad as well as the recognition of institutional gaps (Judijanto, 2025, p. 143). Moreover, the CAGE framework has been applied in the analysis of both developed and emerging economies with particular emphasis on the internationalization processes of firms originating from emerging markets (Ye, Don, Alam, 2023).

From the perspective of this study institutional distance is of particular importance. In broad terms, it is defined as the difference between the institutional profiles of two countries, typically the home country and the host country of a multinational enterprise (Kostova, 1996). The concept may also be understood as a measure of the compatibility of the quality of institutions operating within both countries (Long et al., 2023). T. Kostova et al. indicate that, within the scientific literature, institutional distance may be analysed from the perspective of three theoretical approaches: organizational institutionalism, institutional economics and comparative institutionalism which are discussed in Table 1.

Table 1.
Institutional distance in different theoretical perspectives

Comparative feature	Organizational institutionalism	Institutional economics	Comparative institutionalism
Disciplinary roots	Sociology	Economics	Political economy and political sociology
Definition	Refers to Scott's three institutional pillars. Institutional distance between countries consists of differences in the regulative, cognitive and normative dimensions	Refers to differences in the quality of institutional environments and the extent to which they support efficient economic coordination. Two types of institutional distance are distinguished: formal (relating to laws and rules) and informal (relating to values, norms and beliefs)	Institutional distance is understood as the difference between institutional configurations of individual countries or between institutional clusters that shape the functioning of economies and organizations. In this approach distance does not refer only to individual parameters but to the overall character of a country, including independencies between legal, market, social and political structures
Mechanism of action	Legitimacy: companies must adapt to local requirements and social expectations in order to gain acceptance	Transaction costs: emphasis is placed on reducing uncertainty and risk. Institutional distance increases transaction costs arising from inefficiencies or limited effectiveness of market mechanisms	Fit: companies align their resources with the institutional configurations of the host country

Source: (Kostova et al., 2020).

Referring to the CAGE framework, institutional distance may be interpreted through a formal and informal lens, consistent with the assumptions of institutional economics. In the former case, it is therefore associated with administrative and economic distance. In contrast, from an informal perspective, cultural distance becomes particularly relevant (Ye, Don, Alam, 2023) which in the literature is most frequently analysed with reference to Hofstede's cultural dimensions as well as data from the *Global Competitiveness Report of the World Economic Forum* (Silva, Ogasavara, Pereira, 2023). Theoretical studies on institutional distance often highlight a key relationship, namely that the higher the institutional distance, the more difficult it is to transfer business practices and routines from headquarters to foreign subsidiaries. This is confirmed by the study conducted by X. Lu, S.J.M. Boo and X. Liu. According to them, despite suggestions regarding a potentially positive impact of institutional distance on subsidiary performance, the prevailing view in the literature is that greater institutional distance reduces the efficiency of multinational enterprise subsidiaries due to the additional costs of conducting business abroad arising from institutional differences (Lu, Boo, Liu, 2024).

In the context of institutional distance, institutional voids are also frequently discussed. They refer to the absence or insufficient development of key formal institutions, such as political, financial or regulatory structures which are essential for the efficient functioning of markets (Palepu, Khanna, 1998). According to J. Barbar, however, this definition is not sufficient. In contemporary terms, institutional voids should be understood more broadly as conditions that restrict market access and hinder its functioning, thereby directly affecting firms' activities (Barbar, 2025, pp. 69-70). According to U. Stephan, L.M. Uhlaner and C. Stride (2025), institutional voids can be classified according to the type of institution involved in Table 2. Similarly to high institutional distance, institutional voids are also treated in international management research as constraints that require organizations to develop new adaptive responses (Doh et al., 2017). With reference to the cosmetics industry context, institutional voids may manifest themselves in the form of insufficient cosmetic safety standards, a lack of adequate supervisory mechanisms, underdeveloped certification or accreditation systems or incomplete consumer protection regulations.

Table 2.
Institutional voids according to the type of institution

Type of void	Description
Constitutional void	Occurs when a country lacks the rule of law or an effective property rights protection system. Under such conditions, transaction costs increase and certain social groups may be excluded from the market
Governmental void	Occurs when the role of the state in providing citizens with basic social needs is limited or entirely absent. As a consequence, overall economic productivity may be weakened
Normative void	Occurs when there is a lack of cultural and social norms that facilitate cooperation
Cognitive void	Arises from cultural differences and variations in market participation patterns. However, it does not block economic activities; instead, it shapes the way it is conducted

Source: (Stephan, Uhlander, Stride, 2025).

3. The role of compliance

Compliance is an interdisciplinary concept that relates not only to law, management and economics but also to psychology, philosophy and medicine. However, in relation to the subject matter of this article, the discussion presented herein will primarily refer to the first three disciplines. According to the adopted research perspective, compliance is understood as adherence to rules and conformity with established norms (Kovalchuk, Morenchenko, Bibik, 2023, p. 18). It encompasses all measures and methods aimed at ensuring compliance with rules of conduct, including those extending beyond statutory law, such as ethical principles and

best practices (Janik, 2020, p. 26). The literature frequently highlights the strategic dimension of compliance. It strengthens organizational structures by eliminating irregularities that may result in legal sanctions or reputational damage while in the long term enhancing organizational culture and increasing a firm's competitiveness (Szpringer, 2016, p. 94). A similar view is presented by J. Olszewski, who argues that properly implemented compliance, also understood as an institutional determinant, leads to multiple benefits, including more effective management processes, enhanced organizational credibility and increased transparency and security (Olszewski, 2022, p. 671).

The origins of compliance are commonly associated with business practices in the United States. M.W. Kuliński notes that the development of this concept began with the adoption of the first federal laws regulating the American market (Kuliński, 2020, p. 125). A major turning point occurred in 1977, when compliance mechanisms were formally regulated through the adoption of the Foreign Corrupt Practises Act (Barcik, 2016, p. 11). Today, researchers emphasize the evolutionary nature of compliance and firms' strategies for regulatory adherence. In the context of multinational enterprises, such practices include centralized compliance frameworks, comprehensive compliance programs, continuous monitoring and auditing, proactive risk management and litigation avoidance. Detailed information regarding the individual compliance strategies is presented in Table 3.

Table 3.
Compliance strategies

Strategy	Key activities	Objectives
Centralized compliance frameworks	- integration of global standards with local regulations, - coordination of activities between headquarters and host-country teams.	To ensure the harmonization of organizational practices while simultaneously accounting for differing legal requirements across countries
Comprehensive compliance programs	- development of clear rules and policies, - regular employee training, - establishment of reporting procedures for violations.	To foster an ethical and responsible organizational culture while ensuring that all employees are aware of their obligations
Continuous monitoring and auditing	- regular review of risk indicators, - independent internal audits, - assessment of the effectiveness of procedures.	To enable early detection of gaps in the system, increase transparency and facilitate the rapid implementation of corrective actions
Proactive risk management	- identification of threats (risk registers, checklists), - qualitative and/or quantitative analyses, - scenario planning.	To prevent the escalation of legal issues, ensure business continuity and mitigate the impact of unforeseen events
Litigation avoidance	- use of ADR clauses (arbitration, mediation), - stakeholder dialogue, - ongoing legal advisory support.	To reduce litigation costs, accelerate conflict resolution and maintain a stable business environment

Source: (Latilo et al., 2024).

The compliance strategies presented in Table 3 acquire particular significance in the context of cosmetics companies due to the extensive regulatory obligations concerning product safety and consumer protection. Unlike many other industries, cosmetics manufacturers must ensure continuous compliance not only during product development but also throughout the entire product life cycle. Consequently, centralized compliance frameworks facilitate the coordination of product notifications, technical documentation and regulatory requirements across different jurisdictions, while allowing firms to adapt to country-specific legal provisions regarding cosmetic ingredients and labeling. Comprehensive compliance programs support the preparation and maintenance of Product Information Files (PIFs), Cosmetic Product Safety Reports (CPSRs) and other regulatory documentation required before products are placed on the market. At the operational level, continuous monitoring and auditing include regular verification of Good Manufacturing Practice (GMP) compliance, supplier qualification, product documentation and post-market surveillance, including the reporting of serious undesirable effects where required by law. Proactive risk management further enables cosmetics firms to monitor emerging toxicological evidence, assess the safety of cosmetic ingredients and implement product reformulations following regulatory amendments or new scientific findings. Litigation avoidance strategies complement these activities through comprehensive documentation, effective corrective actions and continuous demonstration of regulatory compliance, thereby reducing legal and reputational risks. Collectively, these compliance strategies help multinational cosmetics companies manage regulatory diversity across international markets, mitigate institutional voids and reduce the challenges associated with institutional distance.

4. Regulatory approaches of selected cosmetics markets in the context of institutional distance and compliance activities

For cosmetics companies operating internationally, one of the major challenges involves functioning within diverse regulatory systems existing across different regions of the world. These differences concern not only the degree of regulatory formalization or the scope of institutional supervision but also approaches to product safety responsibility and mechanisms of legal enforcement. Consequently, they directly affect the conditions for conducting business activities in foreign markets, the level of market entry barriers and the scope of adaptation measures undertaken by cosmetic companies. These regulatory differences are closely related to the occurrence of institutional distance and institutional voids which determine the scope of implemented compliance mechanisms.

Accordingly, this article analyses three regulatory systems: public regulation characteristic of the EU countries, the self-regulatory model associated with the US and the regulatory harmonization approach applied, among others in Malaysia. The selection of these examples is deliberate and results from the need to present distinct approaches to cosmetic market regulation functioning across global markets. The analysed systems represent varying levels of regulatory formalization, the scope of responsibility imposed on business entities and the role of supervisory institutions, thereby enabling a comparison of different institutional conditions and the related compliance requirements.

To enable a systematic comparison of the analysed regulatory systems, the concepts of institutional distance and institutional voids are operationalized using selected regulatory criteria. Institutional distance is assessed through differences in the degree of regulatory formalization, the scope of compliance obligations imposed on manufacturers, the role and powers of supervisory authorities and the consistency of regulatory enforcement. Greater divergence across these dimensions indicates a higher level of institutional distance between regulatory systems. Institutional voids are examined with reference to the availability and effectiveness of formal regulatory mechanisms supporting market governance. Particular attention is paid to the existence of mandatory product notification systems, documentation requirements, Good Manufacturing Practice (GMP) obligations, product safety assessment procedures, post-market surveillance and adverse event reporting, as well as the consistency of regulatory enforcement. Institutional voids are considered more pronounced where these mechanisms are absent, incomplete or unevenly enforced, thereby increasing uncertainty for firms operating in international markets. These criteria provide a common analytical framework for comparing the regulatory approaches adopted in the EU, the United States and ASEAN, while simultaneously explaining differences in compliance requirements imposed on cosmetics manufacturers.

In the EU, as mentioned, the dominant model is public regulation characterized by a high level of formalization and compliance mechanisms (Gautam et al., 2022). This system is based on the requirement to demonstrate product safety prior to market entry, which is reflected in extensive documentation and control obligations. Key elements include, among others, the obligation to apply Good Manufacturing Practice (GMP) standards, notify products through the Cosmetic Products Notification Portal (CPNP), prepare a Cosmetic Product Safety Report (CPSR), and maintain a Product Information File (PIF). The latter two are not one-off activities. They must be updated on an ongoing basis, especially in the event of a formulation change or the emergence of new information about the product, such as the detection of banned substances (Ferreira et al., 2022). The high level of regulatory formalization in the EU limits the occurrence of institutional voids and implies a high degree of predictability in the regulatory environment. However, it simultaneously generates significant compliance costs for companies. From the perspective of international firms, particularly those originating from countries with less stringent regulatory frameworks, compliance with EU requirements may

necessitate substantial organizational and procedural adjustments. Consequently, the EU model places considerable emphasis on proactive compliance measures, including continuous documentation management, regulatory monitoring, and systematic risk assessment throughout the product lifecycle.

A different system is represented by the US where for a long time the dominant model was based on self-regulation and limited state intervention in the cosmetic market. Until recently, the regulatory framework was primarily based on the Federal Food, Drug, and Cosmetic Act (1938) and the Fair Packaging and Labeling Act (1966) which established a limited scope of mandatory regulatory requirements for cosmetic products. Prior to the entry into force of the Modernization of Cosmetics Regulation Act (MoCRA) in 2022, the system was characterized by a relatively low level of formalization and a limited scope of regulatory obligations imposed on companies. An important role was played by the Voluntary Cosmetic Registration Program which was voluntary in nature and did not constitute a mandatory market control instrument. As a result, regulatory oversight by the U.S. Food and Drug Administration (FDA) was limited, and many compliance-related activities remained voluntary in nature. Cosmetic companies were not required to comply with GMP or report adverse events to the FDA (Patel et al., 2025). From an institutional perspective, this regulatory configuration generated significant institutional voids, particularly in the areas of product safety monitoring, standardized compliance requirements and post-market surveillance mechanisms.

The introduction of MoCRA represented a major shift towards greater system formalization and a strengthened role of the Food and Drug Administration, including requirements such as facility registration, adverse event reporting, and GMP compliance (FDA, 2022). In addition, MoCRA significantly expanded the enforcement powers of the FDA, including the ability to request product recalls in cases of misbranding or safety concerns. These changes contributed to a partial reduction of institutional voids by establishing more structured mechanisms of market oversight and product safety control. Nevertheless, several regulatory gaps remain. In particular, the classification of cosmetic products may overlap with drug regulation depending on their intended use (Rebbaniboni et al., 2024), while the US system still lacks a comprehensive database of permitted cosmetic ingredients and standardized testing methods for detecting asbestos contamination in talc-containing products (Stoiber, Fitzgerald, Leiba, 2020).

The third model under consideration is harmonization. This model represents an intermediate solution between the European and American systems. While it incorporates a number of formal regulatory requirements similar to those found in the European Union, it is simultaneously based on regional coordination mechanisms intended to ensure regulatory consistency across multiple regions. Harmonization is characteristic of the Association of South-East Asian Nations (ASEAN), including Malaysia, where the cosmetics market is supervised by the Ministry of Health through the National Pharmaceutical Regulatory Agency (NPRA). A major regulatory milestone was the implementation of the ASEAN Cosmetic

Directive and the introduction of a notification system in 2008, aimed at aligning national regulations with regional standards applied across ASEAN member states (Othman et al., 2024). The harmonization model incorporates a range of compliance requirements, including product notification, maintenance of product documentation, adherence to GMP standards, adverse event reporting, and product safety assessments based on ingredients, chemical structure, and exposure levels. In this respect, the ASEAN framework shares several characteristics with the European regulatory approach. At the same time, however, it remains less formalized than the EU system and allows for greater variation in implementation and enforcement across member states. Importantly, despite the existence of harmonized regulatory standards, cases of non-compliance among cosmetic manufacturers continue to be reported in practice. This suggests that institutional voids remain present and that regulatory harmonization does not automatically guarantee uniform enforcement or full compliance with legal requirements (Othman et al., 2024).

5. Summary

The functioning of cosmetic companies in an international context is strongly determined by the diversity of regulatory systems operating in different regions of the world. These differences concern not only the degree of regulatory formalization, but also the scope of corporate responsibility as well as the mechanisms of supervision and law enforcement, which directly translates into the level of institutional distance and the occurrence of institutional voids. The comparative analysis demonstrates that these two concepts provide a useful analytical framework for explaining how regulatory heterogeneity shapes the operating conditions of multinational cosmetic companies.

In this context, particular importance should be attached to the comparison of three regulatory models: the EU system of public regulation, the US model evolving from self-regulation towards greater formalization, and the regulatory harmonization system applied within ASEAN. Each of these models generates different operating conditions for cosmetic companies, varying both in terms of the predictability of the regulatory environment and the scope of compliance requirements. The findings indicate that a high level of regulatory formalization reduces the risk of ambiguity and institutional voids, while simultaneously increasing adaptation costs for companies. In contrast, systems with a lower degree of formalization provide greater operational flexibility, but are associated with higher regulatory uncertainty and the need for a more adaptive approach to compliance requirements. These results confirm that institutional distance is primarily driven by differences in regulatory formalization, enforcement intensity and supervisory capacity across jurisdictions.

Consequently, compliance should be understood not only as a tool for ensuring adherence to legal regulations, but also as an essential element of corporate functioning within diverse institutional environments. It encompasses activities related to regulatory risk management, monitoring of legal changes, maintenance of documentation, and ongoing adjustment of organizational procedures, thereby constituting a key component of operating under conditions of institutional distance. At the same time, the analysis shows that compliance mechanisms serve as a practical response to institutional voids by reducing uncertainty, improving regulatory predictability and facilitating international market entry for cosmetics companies.

References

1. Barbar, J. (2025). Government ownership in the MENA region: the roles of institutional voids, sociocultural norms and control-enhancing mechanisms. *Emerald Publishing Limited, Vol. 25, No. 8*, 68-100.
2. Barcik, A. (2016). Mechanizm compliance - pytanie o miejsce i zasadniczość w strategiach CSR współczesnych organizacji. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 419,* 9-20.
3. Beugelsdijk, S., Ambos, B., Nell, P.C. (2018). Conceptualizing and Measuring Distance in International Business Research: Recurring Questions and Best Practice Guidelines. *Journal of International Business Studies JIBS, 49(9),* 1113-1137.
4. Ciszewska-Mlinarič, M., Wąsowska, A. (2012). Znaczenie dystansu w procesie internacjonalizacji przedsiębiorstw. *Management and Business Administration. Central Europe, Vol. 20, No. 6,* 3-22.
5. Doh, J.P., Rodrigues, S.S.B., Saka-Helmhout, A., Makhija, M. (2017). International business responses to institutional voids. *Journal of International Business Studies, 48(3),* 293-307.
6. Ferreira, M., Matos, A., Couras, A., Marto, J., Ribeiro, H. (2022). Overview of cosmetic regulatory frameworks around the world. *Cosmetics, Vol. 4, No. 9*.
7. Gautam, P., Ghanghas, D., Mittal, P., Gupta, V., Dhiman, K. (2022). Regulatory framework of cosmetics in the European Union. *Toxicology Communications, 4(3),* 1-4.
8. Ghemawat, P. (2001). Distance still matters: The hard reality of global expansion. *Harvard Business Review, Vol. 79, No. 8*, 137-147.
9. Janik, A. (2020). Compliance - przedmiot, zakres i środki ochrony. *Studia Ecologiae et Bioethicae, 18,* 27-41.
10. Jiang, Y. (2023). The Impact of Covid-19 on the Cosmetics Industry. *Advances in Economics, Management and Political Sciences, 11(1)*, 277-283.

11. Judijanto, L. (2025). Bibliometric Analysis of Research on the CAGE Distance Framework in International Business. *The Eastasouth Management and Business, 4(01),* 143-151.
12. Kostova, T. (1996). *Success of the Translational Transfer of Organizational Practices within Multinational Companies*. University of Minnesota.
13. Kostova, T., Beugelsdijk, S., Scott, W.R., Kunst, V.E., Chua, C.H., van Essen, M. (2020). The construct of institutional distance through the lens of different institutional perspectives: Review, analysis, and recommendations. *Journal of International Business Studies, 51(4)*, 467-497.
14. Kovalchuk, O., Morenchenko, K., Bibik, D. (2023). The essence and characteristics of compliance: definition, functions, goals, ethical foundations, place in the organizational structure of the enterprise. *Economics. Finances. Law, No. 1,* 18-22.
15. Kuliński, M.W. (2020). Geneza i rozwój unormowań compliance. *Myśl Ekonomiczna i Polityczna, 68(1),* 122-142.
16. Latilo, A., Uzougbo, N.S., Ugwu, M.C., Odura, P. (2024). Strategies for corporate compliance and litigation avoidance in multinational enterprises. *World Journal of Advanced Science and Technology, 6(1),* 73-87.
17. Long, N.T., Gam, N.T., Hong, V.V., Hoang, N.B. (2023). The Role of Cultural and Institutional Distances in International Trade. *Emerging Science Journal, 7(2),* 507-519.
18. Lu, X., Boo, S.J., Liu, X. (2024). Is the relationship between institutional distance and subsidiary performance moderated by top management team? Evidence from Chinese multinational enterprises. *Humanities and Social Sciences Communications, 11, 103,* 1-15.
19. Olszewski, J. (2022). Compliance jako prewencyjna forma informowania. *Acta Universitatis Wratislaviensis, 4101*, 667-677.
20. Othman, Y., Mustaffa, M.S.A., Mahat, I.R., Ab Malib, M., Awang, M.N. (2024). Evaluating the Efficacy of Cosmetic Product Safety Regulations in Malaysia: The Role of the National Pharmaceutical Regulatory Agency (NPRA) and Industry Compliance. *Information Management and Business Review, Vol. 16, No. 3*, 855-864.
21. Palepu, K. G., Khanna, T. (1998). Institutional voids and policy challenges in emerging markets. *Brown Journal of World Affairs, 5(1),* 71-78.
22. Patel, Z.R., Patel, K., Zaveri, M. (2025). A Paradigm Shift in U.S. FDA Cosmetic Regulations: Modernization of Cosmetics Regulation Act (MoCRA). *Journal of Chemical Health Risks, 15(4)*, 1937-1941.
23. Rebbaniboni, N., Amarapalli, D., Parveen, A., Prasanthi, D. (2024). Comprehensive Cosmetic Regulations comparison of selected Emerging markets with US. *International Journal of Drug Regulatory Affairs, 12(4)*, 33-42.
24. Silva, F., Ogasavara, M., Pereira, R. (2023). Institutional distances and equity-based entry modes: a systematic literature review. *Management Review Quarterly, 74(4).*

25. Stephan, U., Uhlaner, L.M., Stride, C. (2025). Institutions and social entrepreneurship: a hierarchy of institutions to revisit institutional voids, support, and configurations. *Journal of International Business Studies*.
26. Stoiber, T., Fitzgerald, S., Leiba, N.S. (2020). *Asbestos Contamination in Talc-Based Cosmetics: An Invisible Cancer Risk.* Environmental Health Insights.
27. Turcu, O., Brancu, C. (2025). *Cosmetics Industry Performance in the European Union: A Comparative Analysis.* Proceedings of the International Conference on Business Excellence, 2267-2276.
28. Ye, X., Don, M.S., Alam, F. (2023). The Impacts of Institutional Distance on the Location of China's Outward Foreign Direct Investments in ASEAN: An Empirical Research Based on CAGE Distance Framework. *International Journal of Global Economics and Management, Vol. 1, No. 1*, 55-69.

SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF THE SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANISATION AND MANAGEMENT SERIES NO. 253

FROM REACTIVE DIGITALISATION TO RESIDENT-CENTRED SERVICES: MUNICIPAL TRANSFORMATION IN THE CONTEXT OF ESG

Karolina SZYMANIEC-MLICKA

University of Economics in Katowice, Department of Public Management;
karolina.szymaniec-mlicka@uekat.pl, ORCID: 0000-0002-7500-4925

Purpose: The purpose of this paper is to assess the digital maturity of municipal offices and identify key barriers limiting their transition from reactive digitalisation towards a resident-oriented model of digital public service delivery. The study also aims to indicate which organisational dimensions require priority managerial attention in local public administration
Design/methodology/approach: The research is based on a quantitative survey conducted using the CAWI method amongst 200 employees of municipal offices. The questionnaire was developed on the basis of the Digital Maturity Assessment Tool and covered five dimensions of digital maturity: governance and leadership, people and culture, capacity and capability, innovation, and technology. The analysis was carried out using frequency analysis and cross-tabulation
Findings: The results present a multidimensional profile of the perceived digital maturity of the surveyed municipal offices, with dominant features of the informal/reactive and transitional levels rather than a single synthetic score. Technology appears as a relatively more developed dimension compared with the other areas, but this result should be interpreted cautiously because IT is still frequently perceived mainly as technical support for individual departments. The greatest challenges concern people and culture, as well as innovation. The findings also reveal a significant strategic gap: 75.5% of the surveyed offices do not have a formally defined digital strategy, despite reporting some technological advancement.
Research limitations/implications: The study is based on self-reported data from employees of municipal offices, which may limit the objectivity of the assessment. Future research should include comparative studies between different types of municipalities, longitudinal analysis, and qualitative interviews with decision-makers and residents.
Practical implications: The results indicate the need to formalise digital strategies, strengthen digital leadership, develop staff competences, and shift digitalisation efforts from isolated technological projects towards integrated, resident-oriented service design.
Social implications: Improving digital maturity in municipal offices may increase the accessibility, transparency, responsiveness and quality of public services, thereby strengthening residents' trust in local government.
Originality/value: This paper contributes to research on digital maturity in public sector organisations by focusing on the municipal level, which remains less explored than central government or private enterprises. The findings may support local authorities, public managers and researchers interested in the digital transformation of public administration.

Keywords: digital maturity; digital transformation; municipal offices; public administration; ESG.
Category of the paper: Research paper.

1. Introduction

The digitalisation of the public sector has become one of the key drivers of administrative modernisation, as it influences the way public services are delivered, communication with residents, and the organisation of internal processes. Against the backdrop of technological developments characteristic of Industry 4.0 and Government 4.0, public authorities are increasingly using digital solutions not only to automate procedures, but also to enhance accessibility, transparency and operational efficiency (Naqvi, Munoz, 2020; Kitsios, Kamariotou, Mavromatis, 2023). At the same time, the current transformation of public administration is increasingly viewed through the lens of a dual transformation, combining digitalisation with the goals of sustainable development and responsible governance. This signifies a shift in focus from the mere implementation of technological solutions to the capacity of public organisations to utilise digitalisation as a tool for building more resilient, transparent and socially beneficial institutions.

In this context, the ESG perspective takes on significant importance, as it allows digital technologies to be analysed not only through the prism of organisational efficiency, but also in terms of environmental responsibility, social inclusivity and the quality of corporate governance. For local government, this means assessing whether digital solutions enhance long-term public value, improve the quality of relations with residents and support more informed management of local development (Lu, Xu, Zhu, Sun, 2024; Luo, Tian, Wang, Han, 2024). Digitalisation is therefore neither a neutral nor a purely technical process, but rather part of a broader organisational change that should lead to greater accessibility of services, better use of data, greater transparency of operations and increased trust in public institutions.

One concept that helps assess an organisation's readiness for such a transformation is digital maturity. This encompasses not only the level of ICT usage but also the ability to integrate digital tools with strategy, organisational structure, processes, staff competencies and a culture of change management (Chanias, Hess, 2016; Teichert, 2019). In the case of public organisations, a multidimensional approach is of particular importance, as the effectiveness of digitalisation depends both on technical infrastructure and on leadership, competencies, organisational culture and a user-centred approach to public services (Kafel, Wodecka-Hyjek, Kusa, 2021; Aristovnik, Ravšelj, Murko, 2024).

Existing models and studies of digital maturity have tended to focus on businesses or the national level, paying less attention to the specific characteristics of local public organisations. Meanwhile, local authority offices serve as the direct point of contact between residents and the

administration; therefore, their ability to design and develop digital services is of significant importance for the quality of service, the efficiency of processes and building trust in public institutions. Assessing digital maturity at the local authority level therefore allows us to identify not only the level of technological advancement, but also the strategic, organisational and cultural barriers limiting the transition from reactive measures to a resident-centred model.

The aim of this article is to assess the level of digital maturity in local authorities and to identify the areas posing the greatest challenges in the digital transformation process. The survey was conducted using the CAWI method on a sample of 200 municipal authority staff, employing a questionnaire based on the five pillars of maturity: governance and leadership, people and culture, resources and potential, innovation, and technology. The results obtained make it possible to determine the level of digital advancement of the surveyed units as perceived by employees and to formulate recommendations supporting the development of a more coherent and resident-centred model of digitalisation in local administration.

2. An organisation's digital maturity

An organisation's digital maturity refers to its ability to systematically utilise digital technologies to streamline processes, improve efficiency and enhance its capacity for adaptation. This concept goes beyond the mere implementation of ICT tools, encompassing strategy, leadership, staff competencies, organisational culture and the ability to manage change (Chanias, Hess, 2016; Teichert, 2019). Research indicates that a higher level of digital maturity fosters innovation, organisational learning and resilience to disruptions, with particular emphasis placed on the role of digital leadership (Jidon, Hanapiah et al., 2023; Robertson, Botha et al., 2022). An assessment of digital maturity should be multidimensional and take into account technological, organisational and environmental factors alike. The literature emphasises the importance of strategy, processes, competencies, organisational culture, data management and user-centricity as key dimensions of digital transformation (Aras, Büyüközkan et al., 2023; Aristovnik, Ravšelj et al., 2024; Kadoić, Jaques et al., 2024). At the same time, it is pointed out that existing assessment models often focus on manufacturing firms and large organisations, taking less account of the specific characteristics of the public sector and e-government (Re, Ghezzi et al., 2023; Vavură, Matei et al., 2024). With regard to public organisations, assessing digital maturity is of particular importance, as it allows for an evaluation of the extent to which public authorities are prepared to effectively implement digital services, improve the quality of service delivery to citizens, and enhance the transparency and efficiency of their operations. The digital transformation of public administration requires not only appropriate infrastructure, but also strong leadership, digital skills among staff, a supportive organisational culture, and the capacity for strategic change

management (Barry, Assoul et al., 2022; Hernawan, Wijaya et al., 2024). In this context, assessing digital maturity serves as a starting point for identifying barriers and designing measures to support the transition from reactive digitalisation to a model that is more focused on residents' needs.

Digital maturity is also increasingly analysed in the context of the green transition and ESG principles, as digital technologies can support more sustainable, transparent and responsible organisational management. The environmental dimension of digitalisation involves, amongst other things, reducing paper consumption, minimising the need for physical visits to local government offices, improving resource management, and the ability to monitor the impact of public policies using data. The social dimension relates to increasing the accessibility of digital services, combating digital exclusion and designing user-centred solutions. The governance dimension, in turn, encompasses transparency, data security, accountable decision-making and the use of information in evidence-based management processes. Research conducted in the organisational sector indicates that digital transformation can have a positive impact on ESG performance by improving the quality of information, strengthening governance mechanisms, developing green innovations and enhancing staff competencies (Lu et al., 2024; Luo et al., 2024; Wu, Li, 2023; He, Chen, 2024). In the case of local government, this means that digital maturity should not be assessed solely in terms of ICT infrastructure, but also in terms of the authority's ability to create more accessible, efficient and environmentally responsible public services.

3. Research methodology and objectives

The main scientific objective of the study was to assess the perceived level of digital maturity of public organisations, using municipal offices as a case study, by addressing the following research questions: (P1) What is the level of perceived digital maturity of the surveyed municipal offices according to management staff? (P2) Which areas of the office's operations pose the greatest challenge in the digitalisation process? (P3) To what extent do the surveyed municipal offices have a formally defined digital strategy, and how does this correspond with the declared level of development in the technology area? (P4) What barriers (financial, competence-related and attitudinal) are identified as key obstacles to the implementation of modern e-services?

The survey was conducted using a questionnaire developed on the basis of the Digital Maturity Assessment Tool model. This tool goes beyond a purely technological definition of digitalisation and adopts a holistic approach to organisational transformation.

In this study, digital maturity is understood as the maturity perceived by employees of municipal offices, rather than as an objectively verified level of organisational maturity. Respondents' answers are self-reported and reflect their knowledge, experience and perception of how the office operates. They are not equivalent to an audit of strategic documents, IT systems, internal procedures or e-service quality indicators. For this reason, the findings should be related to internally perceived digital advancement, which constitutes an important, but incomplete, approximation of actual organisational maturity.

The structure of the tool is based on an analysis of five pillars of maturity: 1. Governance and leadership: examines management support and the existence of a digital strategy; 2. People and culture: assesses employees' readiness for change and the culture of innovation; 3. Capacity and capability: analyses the availability of budget, training and internal policies; 4. Innovation: measures the ability to redefine services using modern technologies; 5. Technology: assesses infrastructure, systems integration and their accessibility to users.

Maturity scale (from Minimal to Transformed):

- Level 1: Minimal – The organisation shows little or no commitment to digital processes. Digitalisation is viewed primarily as a cost rather than an investment. There is no formalised strategy, and IT activities are limited to the bare minimum (e.g. having a simple website without interactive features).
- Level 2: Informal and reactive (Informal and reactive) – Management is beginning to recognise the value of digital solutions, but activities are uncoordinated. The first, isolated digital projects are emerging in individual departments. Innovations are monitored, but are treated with great caution and a fear of risk. There is no systematic approach to staff training.
- Level 3: Transitional – The organisation already has a defined digital strategy and is beginning to implement it in a structured manner. Roles and responsibilities for digitalisation are clearly defined. Key IT systems are being integrated with business processes. The authority is beginning to proactively engage residents through digital channels.
- Level 4: Customer-driven – Digital services are designed with the user's (resident's) needs in mind, rather than solely for the convenience of the authority. The digital strategy is fully integrated with operational planning. The organisation places a strong emphasis on multichannel approaches and a consistent customer experience. Data (KPIs) are regularly monitored and used to optimise services.
- Level 5: Transformed - Digitalisation is fully embedded in the organisation's vision and DNA. A 'digital-first' culture prevails at all levels. New services are designed as digital by default. Senior management not only supports, but actively leads the transformation. The organisation is agile, able to rapidly adopt innovations and continuously optimise processes thanks to user feedback.

The study employed the CAWI (Computer-Assisted Web Interviewing) technique, administering the questionnaire to employees of local authority offices. The characteristics of the research sample are presented in Table 1.

Table 1.
Demographic and structural characteristics of the research sample (N = 200)

Demographic and structural variable	Categories analysed	Sample size (n)	Percentage (%)	Cumulative percentage (%)
Gender of respondents	Female	92	46.0%	46.0%
	Male	108	54.0%	100.0%
Age of respondents	26–35 years	29	14.5%	14.5%
	36–45 years	70	35.0%	49.5%
	46–55 years	75	37.5%	87.0%
	56–65 years	25	12.5%	99.5%
	Over 66	1	0.5%	100.0%
Education	Secondary	10	5.0%	5.0%
	Post-secondary	9	4.5%	9.5%
	Higher	181	90.5%	100.0%
Official position	Top-level management (presidents, mayors, commune heads, secretaries)	23	11.5%	11.5%
	Middle management (directors, managers, heads of departments)	105	52.5%	64.0%
	Specialists	72	36.0%	100.0%
Type of municipality represented	Rural	102	51.0%	51.0%
	Rural-urban	57	28.5%	79.5%
	Urban	41	20.5%	100.0%
Self-assessment of digital skills (Scale from 1 to 5)	Level 1 (Low – no evidence)	0	0.0%	0.0%
	Level 2	4	2.0%	2.0%
	Level 3	78	39.0%	41.0%
	Level 4	97	48.5%	89.5%
	Level 5 (Expert in digital competence)	21	10.5%	100.0%
Having a digital strategy (Formalised document)	Yes	20	10.0%	10.0%
	No	151	75.5%	85.5%
	I don't know	29	14.5%	100.0%

Source: Author's own analysis based on empirical data.

This table presents the gender breakdown of the sample of 200 local authority employees. The distribution is relatively balanced, with a slight predominance of men, who account for 54% of the sample (108 people), whilst women account for 46% (92 people). The data indicate that the sample consists mainly of middle-aged people. The largest groups are respondents aged 46–55 (37.5%) and 36–45 (35%). Younger people (aged 26–35) account for 14.5% of the respondents, whilst employees aged over 56 make up a total of 13% of the sample. The sample is characterised by a very high level of formal education. As many as 90.5% of respondents hold a higher education qualification. The remainder comprise those with secondary education (5%) and post-secondary education (4.5%). More than half of the sample are directors, managers, and heads of departments (52.5%), which provides a managerial perspective.

High and medium ratings dominate the assessment of digital competences: 48.5% rate themselves as '4', and 39% as '3'. Only 2% of respondents rated their skills as low (a '2'), whilst 10.5% consider themselves experts (a '5'). The survey covered various local government bodies, with a predominance of rural municipalities, which account for 51% of the sample. Responses to the question regarding whether the organisation has a digital strategy indicate a low level of formalisation of digital activities. As many as 75.5% of the surveyed local authorities do not have a formally defined digital strategy, whilst only 10% confirm its existence. The remaining 14.5% of respondents have no knowledge on this subject

4. Results of the empirical research – digital maturity of local authorities

The respondents' answers to 25 questions, grouped into five areas of analysis, are presented below – Table 2.

Table 2.
A synthetic matrix for assessing the digital maturity of local authorities (N = 200)

Assessment area	Maturity level	Summary of questionnaire statement	NZ (%)	RNZ (%)	ANI (%)	RZ (%)	ZG (%)
Governance and leadership	Level 1 (Minimum)	Lack of management commitment; piecemeal digital projects.[1]	32.0	30.5	14.5	18.5	4.5
	Level 2 (Reactive)	Management recognises the value; innovation is seen as a risk; occasional collaboration.[1]	13.5	32.0	16.5	32.0	6.0
	Level 3 (Transitional)	Strategy implemented; clear roles; proactive engagement of residents.[1]	10.5	18.5	24.0	39.5	7.5
	Level 4 (Oriented)	Fully integrated digital strategy; continuous monitoring of KPIs.[1]	17.0	24.5	27.0	23.0	8.5
	Level 5 (Transformed)	Digital strategy is woven into the vision; senior management actively leads the change.[1]	14.5	20.0	34.5	26.0	5.0
People and culture	Level 1 (Minimum)	Lack of interest in e-services; resistance from staff despite grassroots efforts.[1]	27.5	34.5	21.5	15.0	1.5
	Level 2 (Reactive)	Resistance to change due to risk aversion; a small group of IT staff.[1]	22.0	25.0	27.0	23.5	2.5
	Level 3 (Transitional)	Strategy adopted by the public; understanding of the benefits for the authority and the public.[1]	16.5	30.0	29.0	21.5	3.0
	Level 4 (Oriented)	Staff accept the strategy and drive cultural change for residents.[1]	13.5	27.0	32.0	22.0	5.5
	Level 5 (Transformed)	All staff are digitally proficient; no need for a dedicated IT team.[1]	16.5	29.5	34.0	17.5	2.5

Cont. table 2.

Resources and potential	Level 1 (Minimum)	No IT budget; no digital policies, documentation, or training.[1]	38.5	30.5	23.0	6.5	1.5
	Level 2 (Reactive)	Some processes have been developed; staff have received partial training in e-services.[1]	5.0	19.5	27.0	43.5	5.0
	Level 3 (Transitional)	Key procedures audited; budget adequate for current needs.[1]	5.0	18.0	32.0	38.5	6.5
	Level 4 (Oriented)	All policies defined; staff have the necessary resources and training.[1]	10.5	29.5	34.0	23.5	2.5
	Level 5 (Transformed)	Continuous optimisation of procedures; the budget fully supports digital channels.[1]	13.0	21.0	42.5	22.5	1.0
Innovation	Level 1 (Minimum)	No analysis of service delivery methods or digital benefits for citizens.[1]	33.5	32.5	23.5	9.5	1.0
	Level 2 (Reactive)	Digitisation of only those processes that are straightforward and cost-effective.[1]	2.0	19.0	47.0	27.5	4.5
	Level 3 (Transitional)	Processes reviewed and prioritised for migration to digital channels.[1]	7.5	29.5	33.0	27.0	3.0
	Level 4 (Oriented)	Residents' needs drive innovation; a culture of experimentation in IT.[1]	8.0	27.5	45.0	18.5	1.0
	Level 5 (Transformed)	Implementation of modern management structures and practices tailored to the digital model.[1]	6.0	23.0	28.0	34.5	8.5
Technology	Level 1 (Minimum)	No IT involvement in digital channels; no IT strategy, or a flawed one.[1]	33.5	29.5	20.5	14.5	2.0
	Level 2 (Reactive)	Basic IT support; focus on departmental solutions.[1]	3.5	14.0	28.0	46.5	8.0
	Level 3 (Transitional)	IT as a strategic partner; full integration of systems with objectives.[1]	7.0	24.5	26.5	33.0	9.0
	Level 4 (Oriented)	Proactive IT team; responsiveness and accessibility standards for e-services.[1]	6.5	20.0	25.5	31.0	17.0
	Level 5 (Transformed)	IT strategy integrated with the vision; systems shaped by residents.[1]	10.0	22.0	30.5	30.0	7.5

Key: NZ – I disagree, RNZ – I rather disagree, ANI – Neither agree nor disagree, RZ – I rather agree, ZG – I agree (weight 5).

Source: Compiled by the author based on empirical data.

In the area of governance and leadership, the results indicate that organisations are moving away from a state of complete passivity; the majority of respondents (62.5%) disagree with the statement that senior management is not involved. Nevertheless, risk aversion is strongly evident in the decision-making process, as 38% of respondents confirm that innovations are monitored but perceived mainly as a threat, which limits interdepartmental cooperation to sporadic activities. The largest group of respondents (39.5% 'somewhat agree') identify their local authority with the third level of maturity, characterised by having a clear digital strategy and proactively engaging residents. At the same time, the full integration of digitalisation into the organisation's vision and active leadership in the transformation (level 5) remains a minority view, receiving only 5% of full endorsements. An analysis of the 'people and culture' pillar reveals that, although organisations do not show extreme resistance to change (62% of negative responses), the process of building a digital culture faces significant mental barriers. One of these is the limited scope of digital projects, in which only a small group of staff are

involved, as confirmed by nearly a quarter of respondents. Achieving widespread digital proficiency among staff remains a clear challenge; only 2.5% of respondents fully agree with the statement that all employees possess the skills to eliminate the need for a dedicated IT team. The predominant neutral stance (34%) in this regard suggests uncertainty as to the actual level of staff preparedness for a full-scale transformation. With regard to resources and potential, the data point to a relatively favourable budgetary and training situation, as many as 69% of respondents deny a lack of funds for digitalisation. Most public authorities are at an informal or transitional stage, where processes are partially documented and staff participate in piecemeal training (43.5% of responses). Although key policies are identified and audited (38.5% of responses), the continuous optimisation of procedures and the full alignment of the budget to support modern digital channels (level 5) is a marginal phenomenon, fully confirmed by just 1% of respondents. The area of innovation shows that local authorities most often opt to digitise 'easy and cost-effective' processes, as stated by 32% of respondents, whilst a high proportion (47%) hold a neutral stance. A significant shortcoming is the low degree of focus on residents' actual needs as the main driver of innovation – fewer than 20% of respondents agree with this statement. An interesting sign of structural change, however, is the fact that 43% of respondents recognise the implementation of new management practices and structures adapted to the requirements of the digital model (level 5), which may indicate an ongoing internal reorganisation of local authorities. The last of the analysed pillars, technology, appears as a relatively more advanced area compared with the other dimensions; however, this does not imply full technological maturity or strategic integration of IT with the functioning of the office. The largest group of respondents (54.5% of 'somewhat agree' and 'agree' responses combined) still identify IT primarily as technical support for individual departments, which corresponds to level 2. At the same time, 42% of respondents perceive the IT department as a strategic partner, and 48% recognise the proactive role of IT teams in ensuring the responsiveness and accessibility of services. These results therefore point rather to developing technological potential than to a completed transformation. Declarations concerning the direct shaping of IT systems by residents' needs and their integration with the organisational vision should be treated as an indication of the direction of change, rather than as evidence that the highest level of maturity has been fully achieved.

Relating the above results to research question P3, it is necessary to point to the discrepancy between the low level of formalisation of digital strategy and the relatively higher assessment of selected aspects of the technology area. Only 10% of respondents confirmed that their office had a formally defined digital strategy, whilst 75.5% indicated its absence and 14.5% had no knowledge on this subject. At the same time, in the technology area, 42% of respondents perceive the IT department as a strategic partner, and 48% recognise its proactive role in ensuring the responsiveness and accessibility of services. However, these results coexist with the persistence of a reactive understanding of IT, since 54.5% of respondents still identify it primarily as technical support for individual departments. This means that, in the surveyed

offices, technological development may take place partly independently of a formally adopted digital strategy and may have a local, operational or task-oriented character.

5. Discussion

The results obtained should be interpreted in the light of studies indicating that digital maturity is not merely a measure of an organisation's saturation with ICT technologies, but a multidimensional capacity to combine technology with strategy, organisational structure, processes, staff competencies and a culture of change management (Chanias, Hess, 2016; Teichert, 2019; Kafel, Wodecka-Hyjek, Kusa, 2021; Aristovnik, Ravšelj, Murko, 2024). From this perspective, the findings show that municipal offices are in a phase of transition from reactive digitalisation towards a more structured model of operation; however, this transition is not yet fully systemic. At the same time, it should be emphasised that these conclusions refer to employees' perceptions rather than to an organisational audit; they therefore show how digital transformation is recognised within the surveyed units.

A particularly important finding is the strategic gap visible in the low level of formalisation of digital strategy. As many as 75.5% of respondents indicated that the office they represented did not have a formally defined digital strategy. This is consistent with the literature, which emphasises that effective digital transformation requires not only the implementation of IT tools, but also coherent governance, digital leadership and the alignment of technological initiatives with organisational objectives (Barry, Assoul, Souissi, 2022; Hernawan, Wijaya et al., 2024). Similarly, digital maturity models point to the need to assess both the organisational and process levels, since fragmented technology implementations may not lead to the actual transformation of the whole organisation (Tubis, 2023).

The results concerning people and culture, as well as innovation, confirm the importance of soft factors in the digital transformation of administration. The relatively weaker assessments of staff readiness for change, the culture of experimentation and orientation towards residents' needs are consistent with studies linking digital maturity with leadership, organisational learning and the ability to develop innovation (Jidon, Hanapiah et al., 2023; Robertson, Botha et al., 2022). This means that the development of technical infrastructure should be complemented by competence-building programmes, employee participation mechanisms and practices of co-designing services with residents.

Technology emerges in the study as the relatively most advanced dimension; however, this result requires cautious interpretation. On the one hand, some respondents perceive IT departments as strategic partners and recognise their proactive role in ensuring the responsiveness and accessibility of services. On the other hand, the largest group of responses indicates that IT is still often understood mainly as technical support for individual departments.

This means that technological development is not yet fully integrated with strategy, processes and the design of services around residents' needs. This result reinforces the argument found in the literature that point-based digitalisation may produce local improvements, but does not automatically mean a high level of maturity of the whole organisation (Aras, Büyüközkan et al., 2023; Tubis, 2023).

Including the ESG perspective further extends the interpretation of the results beyond the dimension of administrative efficiency. The digitalisation of municipal offices may support environmental goals by reducing paper-based document circulation and the number of physical visits to offices, social goals by increasing service accessibility and counteracting digital exclusion, and governance goals by improving transparency, data security and the use of information in decision-making processes. Research on the relationship between digital transformation and ESG performance indicates that digital technologies can strengthen information quality, green innovation, human capital and governance mechanisms (Lu, Xu, Zhu, Sun, 2024; Luo, Tian, Wang, Han, 2024; Wu, Li, 2023; He, Chen, 2024). In local administration, however, this potential will be realised only if digitalisation is linked to public goals and residents' needs, rather than being limited to the technical modernisation of the office's back office.

The contribution of the study lies in empirically showing that, at the municipal level, digital transformation is uneven: selected technological elements develop faster than strategy, organisational culture and resident-centred innovation. The results complement the gap identified in the literature, according to which digital maturity models and studies more often refer to enterprises or the central level than to local public organisations. At the same time, the self-reported nature of the data remains a limitation of the study. In future research, it would be valuable to compare employees' perceptions with an analysis of strategic documents, an audit of IT systems, indicators of e-service use and residents' opinions, which would make it possible to distinguish more fully between perceived digital maturity and actual organisational maturity.

6. Summary

The study indicates that the digital maturity of public organisations is a complex, multidimensional process involving not only the implementation of technology, but above all changes in management, organisational culture and staff competencies. A high level of such maturity is associated with greater innovation, efficiency and resilience to crises, enabling the optimisation of services and increased transparency in administration. The response profile indicates the dominance of features characteristic of level 2 (informal and reactive) and level 3 (transitional), without reducing the results to a single synthetic index. Most offices have moved

beyond the minimal stage, although activities still often remain uncoordinated and isolated. Although 39.5% of respondents declare the implementation of certain assumptions of a digital strategy, the full embedding of technology in the organisational vision (level 5) remains marginal, confirmed by only 5% of respondents. The greatest challenges concern the people and culture, and innovation pillars. In organisational culture, risk aversion predominates, and digital processes involve only a small group of employees. In the sphere of innovation, the problem is the lack of resident orientation: only 18.5% of respondents believe that citizens' needs and expectations drive changes in service delivery. Selected aspects of technology were assessed relatively higher than other areas, particularly the proactive role of IT departments in ensuring service responsiveness, recognised by 48% of respondents. At the same time, this result requires cautious interpretation, because 54.5% of respondents still perceive IT mainly as technical support for individual departments. The study also revealed a significant strategic gap: as many as 75.5% of the surveyed municipal offices do not have a formally defined digital strategy. This means that digitalisation in Polish municipal offices often develops in a point-based, bottom-up or reactive manner, without a coherent strategic framework, which may hinder the transition to a resident-centred model. Key barriers identified include attitudinal and cultural barriers (employee resistance to change, risk aversion and users' lack of trust in new solutions), competence-related barriers (shortage of IT specialists and insufficient digital proficiency among staff as a whole), and structural and financial barriers (outdated regulations and work procedures, internal bureaucracy and budgetary constraints that force a focus on 'easy and cheap' online processes rather than deep transformation).

In order to effectively transition from a reactive digitalisation model to a resident-centred (customer-driven) model, it is recommended that the digital transformation of local authorities be viewed not merely as a technological project, but as a tool for creating public value and implementing ESG principles. In the English-language literature, there is an increasingly strong emphasis on the fact that digitalisation and ESG should not be treated as two separate strands of organisational modernisation, but as mutually reinforcing mechanisms for responsible development. Digital transformation can support ESG outcomes by improving data quality, increasing transparency, reducing information asymmetry, fostering green innovation, enhancing resource management and strengthening staff competencies (Lu, Xu, Zhu, Sun, 2024; Luo, Tian, Wang, Han, 2024; Wu, Li, 2023; Wu, Li, Liu, Li, 2024). With regard to local government, this means that digital technologies are not an end in themselves, but a means of improving the accessibility of services, the quality of public decision-making, trust in institutions, and the authority's ability to respond to residents' needs.

A key step should be the formalisation and integration of the digital strategy, which cannot function as an isolated technical document but should be embedded within the municipality's development strategy, operational planning and local sustainable development goals. From an ESG perspective, this means that digital initiatives must be linked to three dimensions: environmental, social and governance. The environmental dimension includes, amongst other

things, reducing paper usage, optimising resource consumption, selecting energy-efficient ICT solutions, and developing digital services that reduce the need for physical visits to local authority offices. The social dimension concerns accessibility, inclusivity and the design of services that take into account people at risk of digital exclusion. The governance dimension encompasses transparency, data security, accountability for data-driven decisions, and monitoring the outcomes of the transformation. Research into the relationship between digitalisation and ESG indicates that digital solutions can primarily strengthen the governance dimension, as they improve the flow of information, process control, reporting and accountability for decision-making (Luo et al., 2024; Wu et al., 2024; Huang, 2025).

At the same time, there is a need for a shift in management attitudes towards digital leadership, understood as the ability to combine technological objectives with a commitment to the common good. Leaders should not view innovation solely through the prism of operational risk, but as a means of enhancing public value, service quality, citizens' agency, institutional resilience and trust in the administration. The literature emphasises that the impact of digital transformation on ESG depends not only on the implementation of technology itself, but also on an organisation's ability to translate data, digital tools and skills into tangible changes in processes and management (Lu et al., 2024; Liu, Chen, Hu, 2024). In local authorities, this means a need to move away from the logic of isolated, ad hoc digital projects towards managing a portfolio of initiatives, the outcomes of which are assessed in terms of their benefits for residents and the local community.

Another pillar of change is the systematic enhancement of skills and the transformation of organisational culture. We must move away from a model in which digitalisation is the sole responsibility of a small group of staff, towards building widespread digital literacy amongst the entire workforce. Research indicates that one of the mechanisms through which digital transformation enhances ESG performance is the development of human capital, including upskilling, changing the structure of competencies and increasing the organisation's ability to use data in decision-making processes (He et al., 2024; Yu, 2024). This is of particular importance in local government, as council staff act as intermediaries between technology and residents. Their digital skills influence not only the efficiency of the council's operations, but also the social accessibility of public services, the quality of communication and the reduction of digital exclusion.

In summary, digital transformation in local authorities requires a shift from a reactive model to a resident-centred model, but also a shift in focus from technology itself to the creation of public value and the implementation of ESG principles. This means investing not only in infrastructure, but above all in skills, organisational culture, data management, transparency and mechanisms for public participation. Only such an approach allows digitalisation to be treated as an element of responsible public governance, focused on long-term resilience, inclusivity and residents' quality of life.

References

1. Aras, A., Büyüközkan, G. (2023). Digital transformation journey guidance: A holistic digital maturity model based on a systematic literature review. *Systems, 11(4),* 213.
2. Aristovnik, A., Ravšelj, D., Murko, E. (2024). Decoding the digital landscape: An empirically validated model for assessing digitalisation across public administration levels. *Administrative Sciences, 14(3),* 41.
3. Barry, A.S., Assoul, S., Souissi, N. (2022). *Benchmarking of digital maturity models according to the dimension component.* In 2022 2nd International Conference on Innovative Research in Applied Science, Engineering and Technology (IRASET) (pp. 1-8). IEEE.
4. Chanias, S., Hess, T. (2016). How digital are we? Maturity models for assessing a company's status in the digital transformation. *Management Report, 2*, 1-14.
5. He, X., Chen, W. (2024). Digital transformation and environmental, social, and governance performance from a human capital perspective. *Sustainability, 16(11),* 4737.
6. Hernawan, Wijaya, I.D. (2024). An analysis of the challenges and opportunities for governance in Indonesia during the digital transformation of public organisations. *Proceedings of Research and Civil Society Dissemination, 2(1),* 236-243.
7. Huang, C. (2025). Digital transformation and corporate ESG performance: Research based on a capability-motivation dual framework. *PLOS ONE, 20(6),* e0325295.
8. Jidon, A.I.A., Hanapiah, M.H.M., Chandrakasan, C.P., Daud, P., Musa, O. (2023). The impact of leadership, innovation, and organisational learning on the digital maturity of organisations in Malaysia. *International Journal of Academic Research in Business and Social Sciences, 13(5),* 1592-1613.
9. Kadoić, N., Monllau Jaques, T., Lacueva Rueda, J. (2024). Measuring the digital maturity of organisations in the people care sector. *Sustainability, 16(20),* 9053.
10. Kafel, T., Wodecka-Hyjek, A., Kusa, R. (2021). A multidimensional model of digital maturity in public sector organisations. *Administration & Public Management Review, 37,* 27-40.
11. Kitsios, F., Kamariotou, M., Mavromatis, A. (2023). Drivers and outcomes of digital transformation: The case of public sector services. *Information, 14(1),* 43.
12. Liu, Z., Chen, Z., Hu, L. (2024). Can enterprise digital transformation improve ESG performance? *Managerial and Decision Economics, 45(7),* 5088-5103.
13. Lu, Y., Xu, C., Zhu, B., Sun, Y. (2024). Digitalisation and ESG performance: Evidence from China. *Business Strategy and the Environment, 33(2),* 352-368.
14. Luo, Y., Tian, N., Wang, D., Han, W. (2024). Does digital transformation enhance a firm's ESG performance? Evidence from an emerging market. *Emerging Markets Finance and Trade, 60(4),* 825-854.

15. Naqvi, A., Munoz, J.M. (Eds.) (2020). *Handbook of artificial intelligence and robotic process automation: Policy and government applications*. Anthem Press.
16. Re, N.U., Ghezzi, A., Balocco, R., Rangone, A. (2023). *Digital maturity models for SMEs: A systematic literature review.* Proceedings of the 25th International Conference on Enterprise Information Systems – Volume 2: ICEIS (pp. 530-537). SciTePress.
17. Robertson, J., Botha, E., Walker, B., Wordsworth, R., Balzarova, M. (2022). Fortune favours the digitally mature: The impact of digital maturity on the organisational resilience of SME retailers during COVID-19. *International Journal of Retail & Distribution Management, 50(8/9),* 1182-1204.
18. Teichert, R. (2019). Digital transformation maturity: A systematic review of the literature. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 67(6),* 1673-1687.
19. Tubis, A.A. (2023). Digital Maturity Assessment Model for the Organizational and Process Dimensions. *Sustainability, 15(20),* 15122. https://doi.org/10.3390/su152015122
20. Vavură, N.-M., Matei, G. (2024). Digital maturity models – A bibliometric exploration. *Proceedings of the International Conference on Business Excellence, 18(1),* 1115-1131.
21. Wu, S., Li, Y. (2023). A study on the impact of digital transformation on corporate ESG performance: The mediating role of green innovation. *Sustainability, 15(8),* 6568.
22. Wu, X., Li, L., Liu, D., Li, Q. (2024). Technology empowerment: Digital transformation and enterprise ESG performance—Evidence from China's manufacturing sector. *PLOS ONE, 19(5),* e0302029.
23. Yu, G. (2024). Digital transformation, human capital upgrading, and enterprise ESG performance: Evidence from Chinese listed enterprises. *Oeconomia Copernicana, 15(4),* 1465-1508.

REVIEWERS

PhD Judyta KABUS, Jan Dlugosz University in Czestochowa, Poland
Prof. Andrzej PACANA, Rzeszów Technical University, Poland
Prof. Bożena SKOTNICKA-ZASADZIEŃ, Silesian University of Technology, Poland
Prof. Radosław WOLNIAK, Silesian University of Technology, Poland